Collection:
Green, Max: Files, 1985-1988
Folder Title:
Strategic Defense Initiative VI (2 of 2)
Box: 26

The Strategic Defense Initiative:
Defense Technologies Study

THE STRATEGIC DEFENSE INITIATIVE

Defensive Technologies Study

THE STRATEGIC DEFENSE INITIATIVE

Defensive Technologies Study

Department of Defense

April 1984

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

RESEARCH AND ENGINEERING

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

On March 23, 1983, President Reagan challenged the scientific community of the United States to investigate whether new technologies could provide the means for countering the awesome threat of nuclear ballistic missiles.

Following his historic speech, the President directed an intensive study to define the technologies necessary for defending the United States and our allies from ballistic missile attack. We collected over 50 of our nation's top scientists and engineers and asked them to assess the feasibility of achieving this goal and to structure a research program to develop the technologies that could provide an effective defense against ballistic missiles. This report summarizes the results of their effort, the Defensive Technologies Study.

The principal finding of the Defensive Technologies Study Team was that, despite the uncertainties, new technologies hold great promise for achieving the President's goal of eliminating the threat of ballistic missiles to ourselves and our allies. Based on the technical recommendations of this study the United States has structured a focused research and technology program of the highest priority to pursue these new technologies. This Strategic Defense Initiative will provide future Presidents with an option to enhance our deterrence capability by basing it on a mix of offensive and defensive forces. The Strategic Defense Initiative will have three aspects as its hallmark: innovation, focused technology programs, and technical demonstration milestones.

Our scientists and engineers are aware, like the President, that we face significant technical challenges and uncertainties. Yet, as we move into the next decade, I am confident that our greatest asset, our people's ingenuity and creativity, will make the President's vision a reality. We will pursue the Strategic Defense Initiative with utmost vigor. I believe that within the technologies reviewed by the Defensive Technologies Study are the seeds of a safer world. We owe it to ourselves, our allies, and most of all to our children to meet the President's challenge.

R. D. DeLauer

CONTENTS

PREFACE

In March 1983 President Reagan established as a long-term national goal an end to the threat of ballistic missiles. He said that "we must thoroughly examine every opportunity for reducing tensions and for introducing stability into the strategic calculus on both sides." He asked the scientific community to give the United States "the means of rendering" the ballistic missile threat "impotent and obsolete."

Shortly after his address to the Nation, the President directed that an intensive analysis be conducted, to include a Defensive Technologies Study to identify the most promising approaches to effective defense against ballistic missiles and to describe a technically feasible research and development program. A study team was formed and worked under the leadership of Dr. James C. Fletcher. The team's report is summarized here.

SUMMARY AND CONCLUSIONS OF THE DEFENSIVE TECHNOLOGIES STUDY

The Defensive Technologies Study analyzed the technological feasibility of developing an effective defense against ballistic missiles and proposed programs in the areas of

- surveillance, acquisition, and tracking;
- directed energy weapons;
- conventional weapons;
- battle management, communications, and data processing;
- systems concepts;
- countermeasures and tactics.

Classified reports for each area and a *Summary, Defense Technology Plan* have been issued. Presented here is an unclassified overview of the summary report, with its principal findings.

The Study Team identified a long-term, technically feasible research and development plan. The goal of the study was to provide the basis for selecting the technology paths to follow when a specific defensive strategy is chosen. At the same time, near-term demonstrations of some system components were identified that could provide options for early deployment and meaningful levels of effectiveness against constrained threats. The plan also incorporates ideas for enhancing the defense of NATO and other allies.

The study reviewed, evaluated, and placed priorities on the technological issues underlying the ballistic missile defense of the United States and its allies. Also reviewed was a set of strategic defense system concepts and supporting technologies in various states of development. In addition, the study considered system concepts where technological attributes were not preeminent, for example, concepts constrained by fiscal considerations. The study did not consider defenses against threats other than ballistic missiles, such as bombers and cruise missiles or conventional forces; these issues are dealt with in other Department of Defense studies.

The Defensive Technologies Study Team identified a research and development program to allow knowledgeable decisions on whether, several years from now, to begin an engineering validation phase that, in turn, could lead to an effective defensive capability in the 21st century. Similarly, intermediate deployments could be feasible that would provide meaningful levels of defense, especially against constrained threats.

The Defensive Technologies Study concluded that

- powerful new technologies are becoming available that justify a major technology development effort offering future technical options to implement a defensive strategy;
- focused development of technologies for a comprehensive ballistic missile defense will require strong central management;
- the most effective systems have multiple layers, or tiers;
- survivability of the system components is a critical issue whose resolution requires a combination of technologies and tactics that remain to be worked out;
- significant demonstrations of developing technologies for critical ballistic missile defense functions can be performed over the next ten years that will provide visible evidence of progress in developing the technical capabilities required of an effective in-depth defense system.

ADVANCES IN DEFENSIVE TECHNOLOGIES

The ballistic missile threat has increased significantly over the past twenty years, so an appropriate question is: "What has happened to justify another evaluation of ballistic missile defense as a basis for a major change in strategy?" Advances in defensive technologies warrant such a reevaluation.

Two decades ago there were no reliable approaches to the problem of boost-phase intercept; however, multiple approaches now exist based on directed energy concepts such as particle beams and lasers and kinetic-energy target destruction mechanisms.

Intercept in midcourse was difficult twenty years ago because of no credible concepts for decoy discrimination, the intercept cost, and the collateral effects of nuclear weapons used for the interceptor warheads. Today, multispectral sensing of discriminants with laser

imaging and millimeter-wave radar, birth-to-death tracking, and direct-impact projectiles that have promise as inexpensive interceptors appear to eliminate the difficulties of midcourse intercept.

In the 1960s an inability to discriminate penetration aids at high altitudes and limited interceptor performance resulted in very small defended areas for each terminal site and required an unacceptably high number of interceptors for effective defense. Now, technological advances may offer ways to discriminate among incoming objects and to allow intercepts at high altitudes. When these improvements are coupled with the potential for boost-phase and midcourse intercepts to disrupt pattern attacks, the effectiveness of terminal defenses is significantly increased.

Likewise, 1960s technology in computer hardware and software and signal processing was incapable of supporting battle management of the multitiered defense. Because of technological advances, the needed command, control, and communications facilities in all likelihood will be realized.

Several new technologies and concepts emerged from the work of the Defensive Technologies Study Team that, considered with those already well known, illustrate how far defensive technology has progressed over the past two decades. For example, throughout the phases of a ballistic missile trajectory, there are many observables, and by using both active and passive sensors, a selection of them can be measured. That is, it is likely that discrimination can be done between a warhead and a decoy or debris as threatening objects proceed toward their targets. An active sensor works on the same principle as radar; a passive sensor relies on radiation emanating from the target. Some possible technologies the study identified for surveillance, acquisition, and tracking were active techniques such as thermal response of a target to a continuous-wave laser and passive techniques such as imaging with infrared sensors. Although any one sensor can be defeated, it is very difficult to defeat several operating simultaneously.

The study also identified several concepts for the intercept and destruction of targets. Kinetic-energy, or impact, devices include exoatmospheric and high endoatmospheric, nonnuclear, rocket-propelled projectiles and hypervelocity guns. Directed energy concepts with significant potential include ground- or space-based particle beams. Also identified were potential concepts for enhanced battle management and command, control, and communications as well as several different ways to ensure space systems survivability.

THE THREAT

Various potential threats were considered, ranging from an attack with fewer than 100 ballistic missiles and a few hundred warheads to a simultaneous launch attack with more than 3,000 missiles and over 30,000 warheads. The Study Team selected a defense-in-depth approach because of the stress imposed by a maximum, unconstrained ballistic missile offense. The critical technologies highlighted later are best understood in the context of this threat.

PROGRAM MANAGEMENT

The study concluded that a high priority should be placed on central management of the research and development program and there should be streamlined budgeting and contracting and effective security.

THE BALLISTIC MISSILE DEFENSE ENVIRONMENT

The four phases of a typical ballistic missile trajectory are shown in Figure 1. First, there is a boost phase when the first- and second-stage engines are burning and offering intense, highly specific observables. A post-boost, or bus deployment, phase occurs next, during which multiple warheads and penetration aids are released from a post-boost vehicle. Then, there is a midcourse phase when warheads and penetration aids travel on ballistic trajectories above the atmosphere. Finally, there is a terminal phase in which the warheads and penetration aids reenter the atmosphere and are affected by atmospheric drag.

A ballistic missile defense capable of engaging the target all along its flight path must perform certain key functions:

- *Rapid and reliable warning of an attack and initiation of the engagement.* This requires global, full-time surveillance of ballistic missile launch areas to detect an attack and define its destination and intensity, determine likely targeted areas, and provide data for hand-off to boost-phase intercept and post-boost vehicle tracking systems.
- *Efficient intercept and destruction of the booster and post-boost vehicle.* The defense must be capable of dealing with attacks ranging from a few tens of missiles to a massive, simultaneous launch. In attacking post-boost vehicles, the defense prefers to attack as early as possible to minimize the number of penetration aids deployed.
- *Efficient discrimination through bulk filtering of lightweight penetration aids.* The price to the offense in mass, volume, and investment for credible decoys should be high.
- *Enduring birth-to-death tracking of all threatening objects.* This enables unambiguous hand-over, with few errors, of reentry vehicles to designated interceptors.
- *Low-cost target intercept and destruction in midcourse.* There should be recognition of the assigned target in the midst of a large array of penetration aids and debris. The cost to the defense for interceptors should be less than the cost to the offense for warheads.
- *High endoatmospheric terminal intercept and destruction.* This involves relatively short-range intercept of each reentering warhead.
- *Battle management, communications, and data processing.* These elements coordinate the system components for effectiveness and economy of force.

It is generally accepted, on the basis of many years of ballistic missile defense studies and associated experiments, that an efficient defense against a high-level threat would be a multitiered defense-in-depth requiring all the capabilities listed above. For each tier there will be leakage, that is, threatening objects that have not been intercepted and hence move on to the next phase. For example, three tiers, each of which allows 10 percent leakage, yielding an overall leakage of 0.1 percent, are likely to be less costly than a single layer that is 99.9 percent effective. In addition, a multitiered defense is the optimum counter to structured attacks; any given offense response affects only one phase.

The defended area of a terminal-defense interceptor is determined, working backward in a ballistic missile trajectory, by how fast the interceptor can fly and how early it can be launched. Terminal-defense interceptors fly within the atmosphere, and their velocity is limited. How early they can be launched depends on the requirements for discrimination of the target from penetration aids and accompanying debris. Because the terminal defense of a large area requires many interceptor launch sites, the defense is vulnerable to saturation tactics.

It is desirable, therefore, to complement the terminal defense with area defenses that intercept at long ranges. Such a complement is found in a system for exoatmospheric intercepts in the midcourse phase.

Intercept outside the atmosphere requires the defense to cope with decoys designed to attract interceptors and exhaust the defending force prematurely. Fortunately, available engagement times in midcourse are longer than in other phases. The midcourse defensive system must provide both early filtering, or discrimination, of nonthreatening objects and continuing attrition of threatening objects if the defense is to minimize the pressure on the terminal system. Intercept before midcourse is attractive because starting the defense at midcourse accepts the potential of a large increase in targets from multiple independently targeted reentry vehicle and decoy deployment.

The ability to respond effectively to an unconstrained threat is strongly dependent on the viability of a boost-phase intercept system. For every booster destroyed, the number of objects to be identified and sorted out by the remaining elements of a layered ballistic missile defense system is reduced significantly. Because each future booster could be capable of deploying tens of reentry vehicles and hundreds of decoys, the leverage, or the advantage gained by the defense, may be 100 to 1 or more. A boost-phase system is itself constrained by the relatively short engagement times and the potentially large number of targets. Because of these constraints, an efficient surveillance and battle-management system is needed.

That phase of flight in which post-boost vehicle operations occur is a transition from boost phase to midcourse. In this phase the leverage gained by the defense decreases with time as decoys and reentry vehicles are deployed. On the other hand, the post-boost phase offers additional time for intercept by boost-phase weapons, and above all

an opportunity to discriminate between warheads and deception objects as they are deployed.

The phenomenology and required technology for each of these phases of a ballistic missile trajectory are quite different. In each phase of a ballistic missile flight, a defensive system must perform the basic functions of (1) surveillance, acquisition, and tracking and (2) intercept and target destruction.

SURVEILLANCE, ACQUISITION, AND TRACKING

Just as there are many tiers to the overall ballistic missile defense system, there can be more than one tier in each of the phases. These space-based surveillance, acquisition, and tracking components perform different tasks because the nature of a structured attack changes as the threatening objects proceed along their trajectories. To illustrate this point and also to indicate how the components of one phase may interact with those of another phase, two potential technologies will be described—(1) infrared sensors and laser designators for the midcourse phase and (2) infrared sensors and laser trackers for the terminal phase.

The surveillance, acquisition, and tracking function includes sensing information for battle management and processing signals and data for discrimination of threatening reentry vehicles from other objects. As each potential reentry vehicle is released from its post-boost vehicle, it begins ballistic midcourse flight accompanied by deployment hardware and possibly by decoys. Each credible object must be accounted for in a birth-to-death track, even if the price is many decoy false alarms. Interceptor vehicles of the defense must also be tracked.

The midcourse sensors must be able to discriminate between the threatening reentry vehicles that have survived through the post-boost deployment phase and nonthreatening objects such as decoys and debris. They must also provide reentry vehicle position and trajectory data for firing interceptors and assessing target destruction. Most reentry vehicles must be recognized, even if again there are many false alarms. Requirements are to track all objects designated as reentry vehicles and other objects that may be confusing to later tiers.

Space-based, passive, infrared sensors could provide a way to meet these requirements. They could permit long-range detection of cold bodies against the space background, rejection of simple lightweight objects, and birth-to-death tracking of designated objects. Laser trackers could provide imaging to determine if targets had been destroyed and precision tracking of objects as they continue through midcourse. As the objects proceed along their trajectories, data on them are handed off from sensor to sensor and track files on threatening objects are progressively improved.

The terminal phase is the final line of defense. The tasks of surveillance are to acquire and sort all objects that have leaked through early defense layers and to identify the remaining reentry vehicles. Such actions will, where possible, be based on hand-overs from the midcourse engagement. Objects include reentry vehicles shot at but not destroyed, reentry vehicles never detected, and decoys and other objects that were neither discriminated nor destroyed. These credible objects must be handed off to terminal-phase interceptors.

An innovative concept for the terminal phase is the airborne optical adjunct—a long-endurance platform that would be put into position on warning of attack—that would detect arriving reentry vehicles using infrared sensors, as those space-based sensors had done in midcourse, tracking those that were not previously selected. The airborne sensors would also provide the data necessary for additional discrimination. They could acquire and track objects in late exoatmospheric flight and observe interactions with the atmosphere from the beginning of reentry. Then, a laser or radar would precisely measure the position of each object and refine its track just before committing the interceptors.

INTERCEPT AND TARGET DESTRUCTION

A variety of mechanisms, including directed energy, can destroy a target at any point along its trajectory. The study identified several promising ones. An excimer laser, for example, can be configured to produce a single giant pulse that delivers a resulting shock wave to a target. The shock causes structural collapse. A continuous-wave or repetitively pulsed laser delivers radiant thermal energy to the target. Contact is maintained until a hole is burned through the target or the temperature of the entire target is raised to a damaging level. Examples included in this category are free-electron lasers, chemical lasers (hydrogen fluoride or deuterium fluoride), and repetitively pulsed excimer lasers. Another way to destroy a target is with a neutral-particle beam, which deposits sufficient energy within a target to destroy its internal components. Guns and missiles destroy their targets through kinetic-energy impact. Here, homing projectiles are propelled by chemical rockets or by hypervelocity guns, such as the electromagnetic gun based on the idea of an open solenoid.

Figures 2, 3, and 4 show ballistic missile defense during boost, midcourse, and terminal phases.

BATTLE MANAGEMENT

The purpose of battle management is to optimize the use of defense resources—it is a data-processing and communication system that includes the command, control, and communication facilities. Its tasks are situation monitoring, resource accounting, resource allocation, and reporting.

A layered battle-management system would correspond to the different layers of the ballistic missile defense system, with each layer being semiautonomous with its own processing resources, rules of engagement, sensor inputs, and weapons. During an engagement, data would be handed over from one phase to the next. Its exact architecture would be highly dependent on the mix of sensors and weapons and the geographical scope of the defensive system that it manages.

Sensors survey the field of battle, and their raw data are filtered to reduce the volume. Later processes organize these data according to the size of the object; information specific enough to determine its orbital parameters and positions as a function of time; and a listing of other data that bear on the identity, classification, and threat status of the object being tracked. In principle, all objects in the field of view of the sensors are candidates, and all objects that cannot readily be rejected as nonthreatening will appear in the file, which is the representation of the total battle situation.

The resources of the defense system include the sensors and weapons, the data-processing and communication gear, and the platforms or stations on which these and other components reside.

The allocation of defense system resources, both sensor and weapon, is a dynamic process that must be repeated with each significant change in the situation. Sensors must be assigned to sectors or to targets of interest at appropriate times to acquire necessary data, and weapons must be assigned to targets within a framework implemented by rules of engagement. An optimum allocation of resources involves extrapolating the present situation into the future and selecting a course of action that optimizes some quantity, for example, the number of targets destroyed. In each phase there are options available to the commander depending on the nature of the threat. The options also differ because events happen within different time frames.

Ultimately, data must be distributed to authorities external to the defense system to infer or sense the development of hostilities, determine a defense condition level and take appropriate actions with respect to weapons release, assist in inferring the attacker's intent, and evaluate the effectiveness of the defense and anticipate damage.

Developing hardware will not be as difficult as developing appropriate software. Very large (order of 10 million lines of code) software that operates reliably, safely, and predictably will have to be deployed. Fault-tolerant, high-performance computing will be necessary. It must be maintenance-free for ten years, radiation-hardened, able to withstand single-event upset, and designed to degrade gracefully. The main problem of network communication is managing networks of space-, air-, and ground-based resources. Other problems are real-time protocols and dynamic reconfiguration. In addition, specific ballistic missile defense algorithms, for example, target assignment, as well as a simulation environment for evaluating architectures will have to be developed.

SURVIVABILITY

Survivability is potentially a serious problem for the space-based components. The most likely threats to the components of a defense system are direct-ascent anti-satellite weapons; ground- or air-based lasers; orbital anti-satellites, both conventional and directed energy; space mines; and fragment clouds.

The approaches to enhancing survivability against a determined attacker are the classic ones that have been used to enhance the survivability of aircraft and surface ships: hardening, evasion, proliferation, deception, and active defense. Applying these functions in combinations will be necessary to counter the spectrum of potential attacks.

Ideally, the defense system should be designed to withstand an attack meant to saturate the system, that is, to survive an attack requiring the commitment of all defense system resources.

OFFENSIVE RESPONSES

In all considerations of offense versus defense, there is a continuing dynamic interaction. Each action can stimulate a countermeasure. In response to the development of a ballistic missile defense system, history indicates that a potential opponent will, in general, proceed in a straightforward manner with the lowest level of countering technology judged adequate. There would be continual work on possible technical responses, and it should be noted that each projected response involves a trade-off; for example, hardening of booster rockets means a reduced payload or range.

CRITICAL TECHNOLOGIES

The Defensive Technologies Study Team concentrated on critical technologies, that is, the technologies basic to the longest lead-time items in a multitiered, four-phase ballistic missile defense system capable of defending against a massive and responsive threat. The concern was primarily with the technologies that are paramount—the concepts whose feasibility will determine whether an effective defense is possible.

There are several critical technological issues that will probably require research programs of ten to twenty years:

- *Boost and post-boost phases.* As mentioned earlier, the ability to effectively respond to an unconstrained threat is strongly dependent on meeting it appropriately during the boost and bus deployment, or post-boost, phases. This is especially important for a responsive threat.

- *Threat clouds.* Large threat clouds—that is, dense concentrations of reentry vehicles, decoys, and debris in great numbers—must be identified and sorted out during the midcourse phase and high reentry.
- *Survivability.* It will be necessary to develop a combination of tactics and mechanisms ensuring the survival of the system's space-based components.
- *Interceptors.* By having inexpensive interceptors in the midcourse phase and in early reentry, intercept can be economical enough to permit attacks on threatening objects that cannot be discriminated.
- *Battle Management.* Tools are needed for developing battle-management software.

The study also identified five- to ten-year research programs dealing with other issues. One category is space logistics. In order of priority within this category, it is desirable to have

(1) a heavy-lift launch vehicle for space-based platforms of up to 100 metric tons;
(2) a capability to service the space components;
(3) a capability to make available, on orbit, sufficient materials for space-component shielding against attack;
(4) an ability to transfer items from one orbit to another.

In addition to these items, multimegawatt power sources for space applications would be required.

NEAR-TERM DEMONSTRATIONS AND DEPLOYMENTS

An informed decision on system development cannot be made before the end of the decade, but there may be reasons for near-term feasibility demonstrations that could be developed into elements of a total ballistic missile defense system. Unlike the boost and post-boost phases, the trade-offs between competing technological approaches for the midcourse and terminal phases are relatively well understood. Although we cannot yet pick detailed designs for the major components of the midcourse and terminal-phase defenses, the best generic approaches are known and the set of competing technologies is narrow. A number of near-term demonstrations could be done before

the end of the decade that typify technological milestones. Such demonstrations could include, among others,

- a space-based acquisition, tracking, and pointing experiment;
- a megawatt-class, visible-light, ground-based laser demonstration;
- an airborne optical adjunct demonstration;
- a high-speed, endoatmospheric, nonnuclear interceptor missile demonstration.

In the next five years, there are decision points that will affect the technologies available by 1990. Between 1990 and 2000 the United States may decide to provide increasing protection for its allies and itself by deploying portions of the complete four-phase system. Such deployments might be evolutionary, leading to the final, low-leakage system.

The members of the Defensive Technologies Study Team finished their work with a sense of optimism. The technological challenges of a strategic defense initiative are great but not insurmountable. By pursuing the long-term, technically feasible research and development plan identified by the Study Team and presented in this report, the United States will reach that point where knowledgeable decisions concerning an engineering validation phase can be made with confidence. The scientific community may indeed give the United States "the means of rendering" the ballistic missile threat "impotent and obsolete."

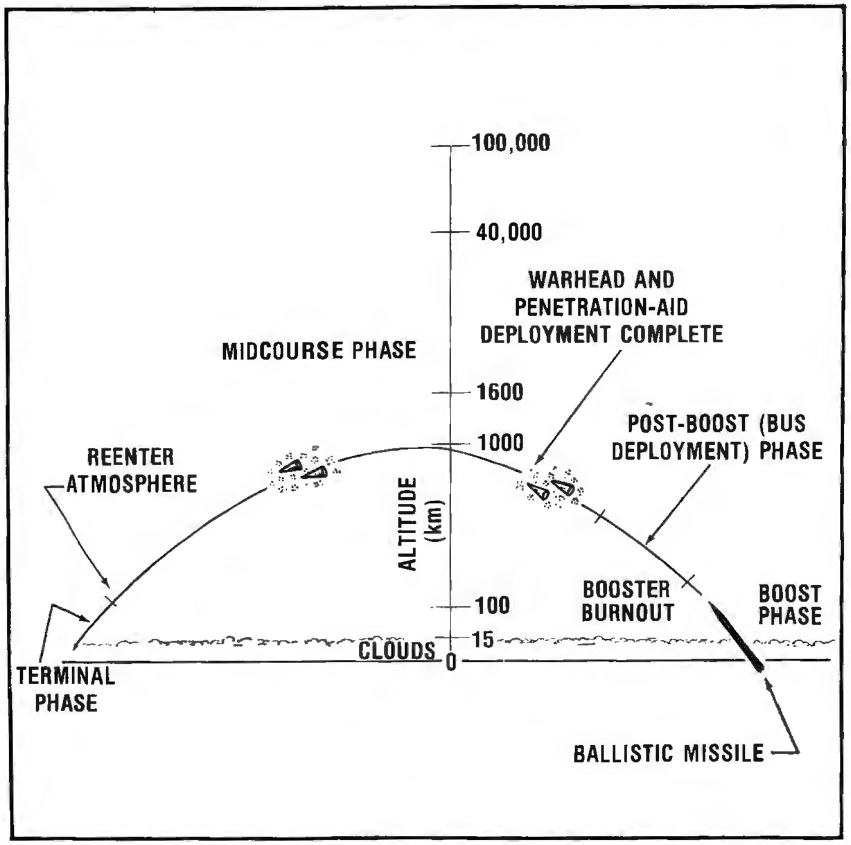


Figure 1. Phases of a typical ballistic missile trajectory. During the boost phase, the rocket engines accelerate the missile payload through and out of the atmosphere and provide intense, highly specific observables. A post-boost, or bus deployment, phase occurs next, during which multiple warheads and penetration aids are released from a post-boost vehicle. In the midcourse phase, the warheads and penetration aids travel on trajectories above the atmosphere, and they reenter it in the terminal phase, where they are affected by atmospheric drag.

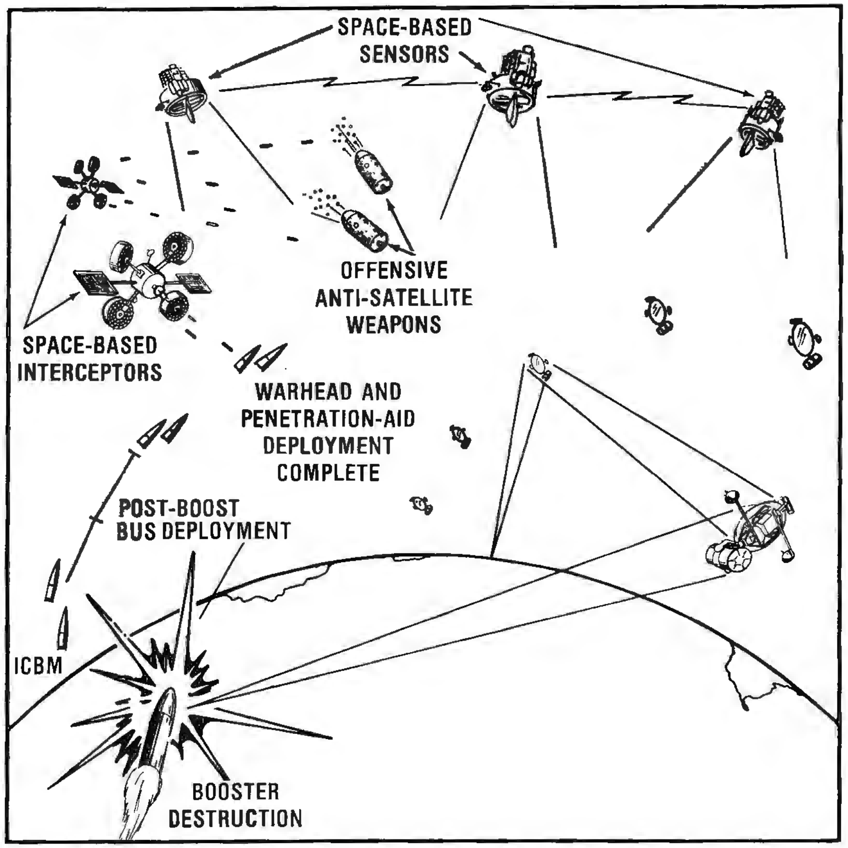


Figure 2. Strawman concept for ballistic missile defense during the boost phase. An essential requirement is a global, full-time surveillance capability to detect an attack and define its destination and intensity, determine targeted areas, and provide data to guide boost-phase intercept and post-boost vehicle tracking systems. Attacks may range from a few missiles to a massive, simultaneous launch. For every booster destroyed, the number of objects to be identified and sorted out by the remaining elements of a multitiered defense system will be reduced significantly. An early defensive response will minimize the numbers of deployed penetration aids. The transition (post-boost phase) from boost phase to midcourse allows additional time for intercept by boost-phase weapons and for discrimination between warheads and deception objects. Space-based sensors detect and define the attack. Space-based interceptors protect the sensors from offensive anti-satellite weapons and, as a secondary mission, attack the missiles. In this depiction nonnuclear, direct-impact projectiles are used against the offensive weapons.

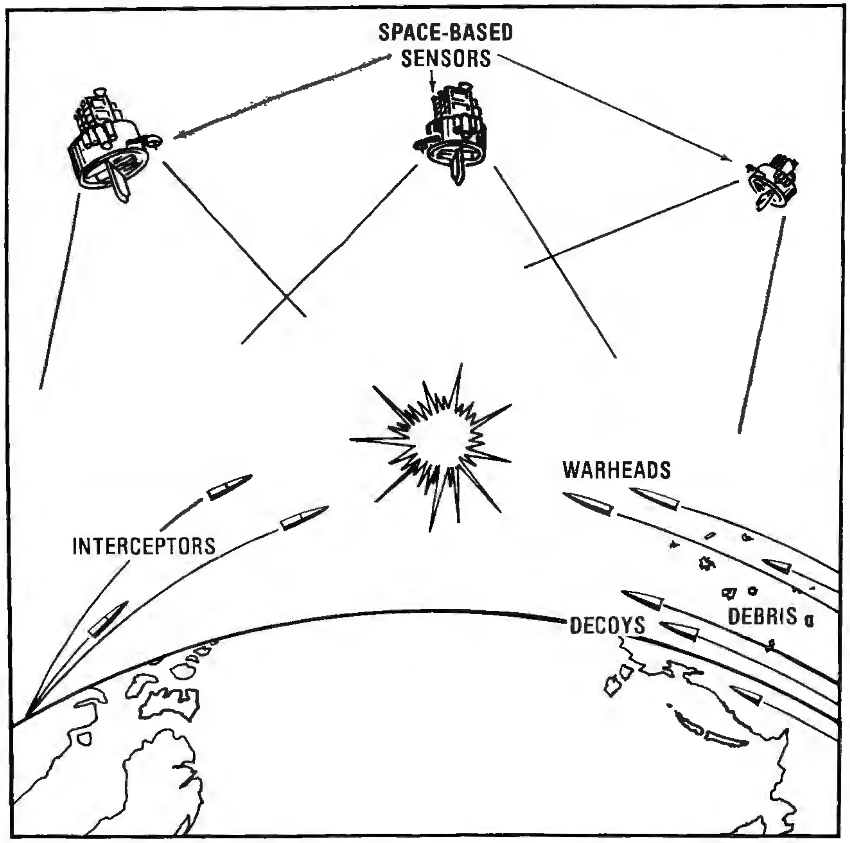


Figure 3. Strawman concept for ballistic missile defense during the mid-course phase. Intercept outside the atmosphere during the midcourse phase requires the defense to cope with decoys designed to attract interceptors and exhaust the defending force. Continuing discrimination of nonthreatening objects and continuing attrition of reentry vehicles will reduce the pressure on the terminal-phase system. Engagement times are longer here than in other phases. The figure shows space-based sensors that discriminate among the warheads, decoys, and debris and the interceptors that the defense has committed. The nonnuclear, direct-impact projectiles speed toward warheads that the sensors have identified.

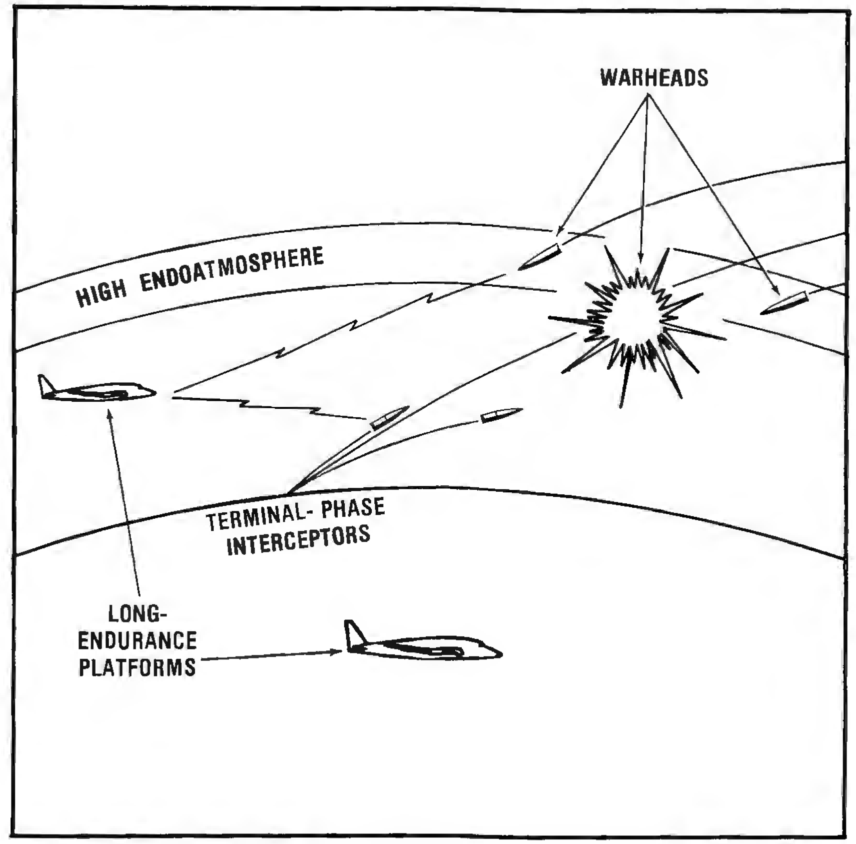


Figure 4. Strawman concept for ballistic missile defense during the terminal phase. This phase is the final line of defense. Threatening objects include warheads shot at but not destroyed, objects never detected, and decoys neither discriminated nor destroyed. These objects must be dealt with by terminal-phase interceptors. An airborne optical adjunct is shown here. Reentry vehicles are detected in late exoatmospheric flight with sensors on these long-endurance platforms. The interceptors—nonnuclear, direct-impact projectiles—are guided to the warheads that survived the engagements in previous phases.

ORGANIZATION

Caspar W. Weinberger
Secretary of Defense

Paul Thayer
Deputy Secretary of Defense
Chairman, Senior Interagency Group,
Defense Policy

Fred C. Ikle
Under Secretary of Defense for Policy
Chairman, Interagency Group,
Defense Policy

Maj. Gen. Donald L. Lamberson
Assistant for Directed Energy Weapons
Executive Secretary, Senior Interagency Group,
Defense Policy

Richard D. DeLauer
Under Secretary of Defense for Research
and Engineering
Chairman, Interagency Group,
Defensive Technologies

Brig. Gen. Robert R. Rankine
Assistant for Directed Energy Weapons
Executive Secretary, Senior Interagency Group,
Defense Policy

Franklin C. Miller
Director, Strategic Forces Policy
Study Director, Interagency Group,
Future Security Strategy Study

Fred S. Hoffman
Chairman, Future Security Strategy Study
Contractor Support Team

John L. Gardner
Director of Defensive Systems
Executive Secretary, Interagency Group,
Defensive Technologies

James C. Fletcher
Chairman, Defensive Technologies Study Team

DEFENSIVE TECHNOLOGIES STUDY TEAM MEMBERSHIP

Study Team Leadership

Dr. James C. Fletcher, Study Chairman	The University of Pittsburgh
Dr. Harold M. Agnew, Vice Chairman	General Atomic Technologies, Inc.
Major General John C. Toomay, Deputy Chairman	United States Air Force (Retired)
Dr. Alexander H. Flax, Deputy Chairman	Institute for Defense Analyses
Mr. John L. Gardner, Executive Secretary	Office of the Secretary of Defense
Major Simon P. Worden, Executive Military Assistant	Office of the Secretary of Defense

Conventional Weapons Panel

Dr. Julian Davidson, Panel Chairman	Science Applications, Inc.
Dr. Delmar Bergen	Los Alamos National Laboratory
Mr. T. Jeff Coleman	Coleman Research, Inc.
Dr. Clarke DeJonge	Science Applications, Inc.
Dr. Harry D. Fair	Defense Advanced Research Projects Agency
Dr. James Katechis	U.S. Army Ballistic Missile Defense System Command
Dr. Joseph R. Mayersak	USAF Armament Division
Lt Col Miles Clements, Military Assistant	Headquarters, Department of the Army
Lt Col Peter E. Gleszer, Military Assistant	Headquarters, Department of the Army

Systems Concepts Panel

Dr. Edward T. Gerry, Panel Chairman (Boost-Phase Systems)	W. J. Schafer Associates, Inc.
Dr. Wayne R. Winton, Panel Chairman (Midcourse Systems)	Sparta, Inc.
Mr. Charles R. Wieser, Panel Chairman (Terminal-Phase Systems)	Physical Dynamics, Inc.
Dr. J. E. Lowder	Sparta, Inc.
Dr. James R. Fisher	U.S. Army Ballistic Missile Defense Systems Command
Dr. Louis C. Marquet	Defense Advanced Research Projects Agency

Directed Energy Weapons Panel

Dr. Gerold Yonas, Panel Chairman	Sandia National Laboratories
Dr. J. Richard Airey	Science Applications, Inc.
Dr. Robert T. Andrews	Lawrence Livermore National Laboratory
Dr. Richard J. Briggs	Lawrence Livermore National Laboratory
Dr. Gregory H. Canavan	Los Alamos National Laboratory
Dr. Robert W. Selden	Los Alamos National Laboratory
Dr. Petras Avizonis	USAF Weapons Laboratory
Captain Richard J. Joseph	Defense Nuclear Agency
Dr. Joseph A. Mangano	Defense Advanced Research Projects Agency
Dr. Robert C. Sepucha	Defense Advanced Research Projects Agency
Captain Alan Evans, Military Assistant	USAF Systems Command

Systems Integration Panel

Lieutenant General Kenneth B. Cooper, Panel Chairman	United States Army (Retired) Systems Planning Corporation
Mr. Wallace D. Henderson	Braddock, Dunn and McDonald
Mr. Robert T. Poppe	General Research Corporation
Mr. John M. Bachkosky	Office of the Secretary of Defense

Surveillance, Acquisition, Tracking, and Kill Assessment Panel

Dr. John L. Allen, Panel Chairman	John Allen Associates, Inc.
Dr. George F. Aroyan	Hughes Aircraft Company
Dr. John A. Jamieson	John Jamieson, Inc.
Mr. William Z. Lemnios	Massachusetts Institute of Technology
Mr. Dennis P. Murray	Research and Development Associates
Mr. Robert G. Richards	Aerojet Electronics Systems
Mr. Fritz Steudel	Raytheon Corporation
Lt (jg) Patricia A. O'Rourke, Military Assistant	Office of the Chief of Naval Operations

Countermeasures and Tactics Panel

Dr. Alexander H. Flax, Panel Chairman	Institute for Defense Analyses
Dr. Robert B. Barker	Lawrence Livermore National Laboratory
Dr. Robert G. Clem	Sandia National Laboratories
Dr. Walter R. Sooy	Lawrence Livermore National Laboratory
Dr. James W. Somers	Defense Nuclear Agency

Battle Management, C^3, and Data Processing Panel

Dr. Brockway McMillan, Panel Chairman	Private Consultant
Dr. Duane A. Adams	Private Consultant
Dr. Harry I. Davis	Private Consultant
Mr. J. R. Logie	Private Consultant
Dr. Robert E. Nicholls	Massachusetts Institute of Technology/Lincoln Laboratory
Mr. Robert Yost	Science Applications, Inc.

Executive Scientific Review Group

Dr. Edward Frieman, Group Chairman	Science Applications, Inc.
Lt Col Michael Havey	Office of Science and Technology Policy
Dr. Solomon J. Buchsbaum	Bell Laboratories
Mr. Daniel Fink	Private Consultant
Mr. Bert Fowler	Mitre Corporation
Dr. Eugene Fubini	Private Consultant
Admiral Bobby R. Inman	United States Navy (Retired) Microelectronics and Computer Technology Corporation
Dr. Michael May	Lawrence Livermore National Laboratory
General E. C. Meyer	United States Army (Retired)
Professor William A. Nierenberg	Scripps Institute of Oceanography
Dr. David Packard	Hewlett Packard Company

GLOSSARY

active sensor A system that includes both a detector and a source of illumination. A camera with a flash attachment is an active sensor.

airborne optical adjunct A set of sensors designed to detect, track, and discriminate an incoming warhead. The sensors are typically optical or infrared devices flown in an aircraft stationed above clouds.

algorithm Rules for solving a problem using computer language.

architecture The physical structure of a computer system, which can include both hardware and software (programs).

birth-to-death tracking The ability to track a missile and its payload from launch until it is intercepted or reaches its target.

boost phase The portion of a missile flight during which the payload is accelerated by the large rocket motors. For a multiple-stage rocket, boost phase involves all motor stages.

booster The rocket that "boosts" the payload to accelerate it from the earth's surface into a ballistic trajectory, during which no additional force is applied to the payload.

bus deployment phase The portion of a missile flight during which multiple warheads are deployed on different paths to different targets (also referred to as the post-boost phase). The warheads on a single missile are carried on a platform, or "bus" (also referred to as a post-boost vehicle), which has small rocket motors to move the bus slightly from its original path.

chemical laser A laser in which chemical action is used to produce the pulses of coherent light.

coherent light	The state in which light waves are in phase over the time scale of interest. Light travels in discrete bundles of energy called photons. Each photon may be treated like an ocean wave. If all the waves are in phase, they are said to be coherent. When light is coherent, the effects of each photon build on top of the others. A laser produces coherent light and therefore can concentrate energy.
cold bodies	Objects at or near low ambient temperature, which radiate infrared radiation. All objects radiate electromagnetic energy, and if the object is hot enough, this energy is visible light.
constrained threat	A situation where opponents are limited in the number of warheads or types of missiles, for example, by arms control agreement.
continuous-wave laser	A laser in which the coherent light is generated continuously rather than at fixed time intervals.
decoy	A device that is constructed to look and behave like a nuclear-weapon-carrying warhead, but which is far less costly, much less massive, and can be deployed in large numbers to complicate defenses.
directed energy	Energy in the form of particle or laser beams that can be sent long distances at nearly the speed of light.
discriminate	The process of observing a set of attacking objects and determining which are the real warheads and which are decoys and other nonthreatening objects.
dynamic reconfiguration	A means whereby a battle-management system can change its condition during a battle to respond to changing circumstances, such as the destruction of some defensive components.
electromagnetic gun	A gun based on the idea of an open solenoid. The projectile is accelerated by electromagnetic forces rather than by an explosion, as in a conventional gun.
endoatmospheric	When all activities take place within the earth's atmosphere, generally considered as occurring at altitudes below 100 kilometers.

excimer laser	A chemical laser that uses noble gases.
exoatmospheric	When all activities take place outside the earth's atmosphere, generally considered as occurring at altitudes above 100 kilometers.
fragment clouds	Clusters of small objects placed in front of a target in space. This is a simple way to destroy the target.
free-electron laser	A laser in which electrons are converted to coherent light. The electrons are supplied by an accelerator and power for the laser by electrical energy.
hypervelocity gun	A gun that can accelerate projectiles to 5 kilometers per second or more, for example, an electromagnetic, or rail, gun.
imaging	The process of identifying an object by obtaining a high-quality image of it.
infrared sensor	A sensor to detect the infrared radiation from a cold body such as a missile reentry vehicle.
Interagency Groups	Two groups, one for Defensive Technologies and one for Defense Policy, set up to monitor the work of each study team.
intercept	The act of destroying a target.
kinetic energy	The energy from the momentum of an object.
laser	A device for generating coherent visible or infrared light.
laser designator	The use of a low-power laser to illuminate a target so that a weapon equipped with a special tracker can home in on the designated target.
laser imaging	A new technology where a laser beam can be used in a way similar to a radar beam to produce a high-quality image of an object.
laser tracker	The process of using a laser to illuminate a target so that specialized sensors can detect the reflected laser light and track the target.

leakage The percentage of warheads that get through a defensive system intact and operational.

midcourse phase The long period of a warhead's flight to its target after it has been dispensed from the post-boost vehicle until it reenters the atmosphere over its target.

multispectral sensing A method of using many different bands of the spectrum to sense a target, for example, visible and infrared light. If several bands are used, deceptive measures become much more difficult.

neutral-particle beam An energetic beam of neutral atoms (no net electric charge). A particle accelerator moves the particle to nearly the speed of light.

particle beam A stream of atoms or subatomic particles (electrons, protons, or neutrons) accelerated to nearly the speed of light.

passive sensor A sensor that only detects radiation naturally emitted (infrared radiation) or reflected (sunlight) from a target.

penetration aids Methods to defeat defenses by camouflage, deception, decoys, and countermeasures.

post-boost vehicle The portion of a rocket payload that carries the multiple warheads and has maneuvering capability to place each warhead on its final trajectory to a target (also referred to as a "bus").

radiant energy The energy from radiation such as electrons, protons, or alpha particles.

real-time protocols Computer programs capable of making decisions as rapidly as input information is received.

repetitively pulsed laser A laser that fires its beam in sequential short bursts, as opposed to a continuous beam or a single pulse.

responsive threat Offensive forces that have been modified to defeat a defensive system.

Senior Interagency Group Set up in response to the President's directive to study the ballistic missile defense problem. The group reported to the National Security Council and consisted of senior representatives from the Department of Defense, the Department of State, the Arms Control and Disarmament Agency, the Central Intelligence Agency, the National Aeronautics and Space Administration, the National Security Council, and the Office of Science and Technology Policy.

signal processing A computer system's capability to organize the raw data received from many different sources.

single-event upset Electronic components of a battle-management system performing abnormally because of radiation.

structured attack Timing the arrival of a sequence of warheads at their targets to create maximum destructive effects.

terminal phase The final phase of a ballistic missile trajectory, during which warheads and penetration aids reenter the atmosphere.

threat clouds Dense concentrations of both threatening and nonthreatening objects. The defense must distinguish between them.

Why 'Star Wars' is important for Israel SDI

By AVI HOFFMANN
Post Defence Reporter

Some of the new technologies that will evolve under the umbrella of the U.S. Strategic Defence Initiative "Star Wars" could be extremely important for Israel, a leading foreign military expert told *The Jerusalem Post* last week.

Dr. Robert O'Neill, director of the London-based International Institute for Strategic Studies, thinks Israel would be well advised to join President Reagan's SDI programme to ensure that its defence industries "move up with the leading edge of technology." In addition it is advisable to show support for the programme to maintain a good political relationship with the U.S., he says.

West European politicians and strategists are reversing their initial opposition to SDI, he said. It will become even more popular in Europe once people understand what it is about, O'Neill added.

A major part of the success of SDI, he said, will depend on improvements in computer technology, battle-management systems and detection systems, rather than the "space junk" that people imagine is the essence of SDI. "Star Wars" is only a small part of the whole programme, he said.

If Israel participates in SDI, the country will be in a better position to update aviation electronics and to keep combat command and control systems close to state of the art, O'Neill said. This will have special relevance against tactical ballistic missiles, he said. Syria already deploys SS-21 surface-to-surface missiles, he said, and these pose a threat to major strategic targets in Israel. SS-21 is very acc[illegible] and has a 120 km range.

At present, [illegible] id, the strategic balance is not swinging against Israel, which can be reasonably confident in handling Syria, the only realistic adversary facing Israel today.

O'Neill foresees a significant shift in tomorrow's

Participation in SDI will help Israel to update aviation electronics systems...

battlefield, with armour playing a less prominent part. The tank is becoming more vulnerable, and more expensive, and the generals will have to use armour on a more selective basis,' he said. Attack helicopters and other modern anti-tank weapons pose severe threats to armour, he said. In addition, defensive measures such as detection and sighting systems, obstacles, minefields and artillery are being constantly improved, he pointed out.

O'Neill's scenario envisages deep-penetration raids by limited columns of armour, supported by commando-type special forces, rather than large masses of armour rolling across borders. He described a massive pre-emptive attack by armour in the modern battlefield as "a very dodgy business."

Asked to characterize the next war Israel might be involved in, he said it would be short, because of the destructiveness of the weapons involved.

Israeli airpower is still a viable option, he said, but would have to be used more carefully than in the 1973 war because of the improved anti-aircraft capability of the enemy.

Long-range missiles had significantly affected the naval arena and Israel would have to think about bigger and more ships as well as enhanced surveillance efforts to counter the threat, said O'Neill.

SAN JOSE MERCURY NEWS 23 September 1984 Pg. 3-P

Soviets may plan a December surprise

Kissinger sees demilitarization of outer space as centerpiece of possible peace initiative.

By Henry A. Kissinger

WE may be witnessing the preliminaries of a Soviet peace offensive. First, we are presented with the clumsily handled resurrection of Andrei Sakharov and his wife to calm Western opinion. Then an American TV network is given a relatively free hand to report on the Soviet scene. Next, Konstantin Chernenko releases an interview in Pravda that softens some of the harsher Soviet rhetoric. And this is followed by the announcement that Andrei Gromyko would meet with President Reagan.

Whether these events are connected does not emerge clearly from the crab-like manner by which Soviet diplomacy advances. A steady stream of attacks on the United States continues. But at a minimum, the Soviets seem intent on showing a milder face to the world. A full-scale peace campaign may await the outcome of our elections. But there can be little doubt that its centerpiece, whenever it comes, will be the demilitarization of outer space.

The usual ploy

It is also safe to predict that the Soviets will seek to achieve their principal objective by insisting on their agenda. Thus Chernenko in characteristically elliptical fashion has put forward these propositions:

- That negotiations about defensive space weapons must precede talks dealing with offensive weapons.
- That the United States must commit itself at the outset to demilitarization of space.
- That the United States must agree to a moratorium on testing weapons in space.

It is not too early to begin thinking about two basic issues: Should the administration continue to insist that talks on offensive and defensive weapons be conducted simultaneously? And what should the U.S. position be? (Can the United States commit itself to the demilitarization of space at the outset of negotiations?)

As to the issue of linkage, a little history may be instructive. In 1967 President Johnson proposed to Prime Minister Alexei Kosygin that anti-ballistic missile defenses be banned; Kosygin flatly rejected it. President Nixon finally submitted a plan for an American ABM to Congress in 1969.

Former Secretary of State Henry A. Kissinger writes a column for the Los Angeles Times that appears periodically in the Mercury News.

After Congress went along with the president, the Soviets opened the very negotiations they had rejected two years earlier. Now they would talk about no other subject, least of all offensive weapons. As late as three weeks before the final breakthrough, the Soviets put forward what is now the Chernenko ploy: They offered the "concession" of talking about offensive weapons but only *after* negotiations about defensive weapons had been completed.

Linkage at last

Finally in May 1971, the Soviets grudgingly agreed to link the two. Today the outcome is likely to be the same if the administration holds its ground.

The Soviets have been vociferous about banning defensive weapons in outer space, where U.S. technology is superior. They have been ambivalent or silent about land-based defensive weapons in which they have conducted vigorous research and appear to be constructing radars that violate the spirit and almost surely the letter of the ABM treaty.

A treaty now limits both sides to one land-based ABM site. The United States has unilaterally dismantled its site. The Soviets have maintained theirs and spurred research on traditional technology. The United States is doing research aimed at a new system that would destroy incoming warheads in space but also would require some defensive stations on the ground that catch the missiles that get through. To deploy such a system would require a renegotiation or abrogation of the ABM treaty.

I have not yet made up my own mind on what position the United States should ultimately take on that issue. I was less than enthusiastic about President Reagan's "Star Wars" speech when I first read it.

As one of the architects of the existing ABM treaty, I instinctively resisted the proposition that it be modified. Too, a foolproof defense of civilian population — that seemed implied by that speech — is a mirage; even a 90 percent effective 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.

The nuclear age forces the statesman to navigate between the callousness that reduces mass slaughter to a mathematical equation, and the nihilism that abdicates to totalitarianism in the name of survival. Since the ABM treaty was signed it has become clear that to rely on a strategy of mutual annihilation based on unopposed offensive weapons

CONTINUED NEXT PAGE

SURPRISE...Continued

raises profound and political issues. Has a president the right to expose our people forever to the vagaries of an increasing number of volatile decision-makers? Such a course involves the near certainty of a growth in pacifism or the risk of a holocaust as a result of miscalculation or the gradual escalation of peripheral crises.

Even granting — as I do — that a perfect defense of our population is almost certainly unattainable, the existence of some defense means that the attacker must plan on saturating it. This massively complicates the attacker's calculations. Anything that magnifies doubt inspires hesitation and adds to deterrence.

The case grows stronger if one considers the defense of Intercontinental Ballistic Missile launchers. A defense of the civilian population would have to be nearly 100 percent effective, while a defense that protected even 50 percent of land-based missiles and air bases would add hugely to deterrence. The incentive for a first strike would be sharply, perhaps decisively, reduced if an aggressor knew that half of the opponent's ICBMs would survive any foreseeable attack.

Then there is the problem of third nuclear countries. Calculations and restraints that are highly plausible to advanced industrial societies are not necessarily equally persuasive to leaders of the Khadafy variety. Although a foolproof civilian defense against a superpower is difficult to conceive of, substantially complete defense against third nuclear countries could be possible well into the next century.

Perhaps the most compelling argument is the possible beneficial effect of some missile defense on arms control. Arms control theory is now at a dead end; the stalemate in negotiations reflects an impasse in thought. The reductions proposed by the Reagan administration would add little to stability; the freeze that is its alternative would perpetuate what needs correction.

A breakthrough requires reductions of the numbers of warheads on a scale inconceivable so long as the strategic balance depends entirely on offensive weapons.

Under present conditions the reductions that can be verified are relatively small. They are either dangerous because they simplify an attacker's calculations, or they are irrelevant because they leave large residual numbers of warheads.

If, however, the strategic warheads of both sides were reduced to a few hundred — a number astronomically below any so far envisaged — the side capable of hiding even a thousand warheads might be able to disarm its opponent by a surprise attack or blackmail him into submission when the clandestine weapons are revealed. But with a properly designed defense, much larger numbers would be needed for a strategically decisive evasion, and those numbers could be detected.

Three propositions

I consider these arguments compelling with respect to three propositions:

- We should not commit ourselves at this point to the demilitarization of space.
- We should proceed actively with research and development and forgo moratoriums.
- We should be prepared to negotiate over arms control of *all* defensive weapons.

Before committing ourselves to actual deployment, an answer to the following questions is needed:

- Is it possible to design a ballistic missile defense that is primarily useful for the defense of the retaliatory forces or against maverick third nuclear countries?
- If such a limited defense become part of an arms control agreement, how would the limitation be expressed and verified?
- Could we avoid loopholes for further expansion to a full-scale defense?
- Would such a defense be destabilizing by tempting a first strike and relying on the defense to absorb the counterblow? (In theory this should not be, if *both* sides have relatively limited defenses.)
- What in such a context would be the appropriate low level of offensive forces to bring about the breakthrough toward real arms control which has eluded us for a decade?
- Or would strategic defense at any level destroy all hopes for an equilibrium?

The real debate will be joined after the American election. Theoretically both superpowers should have an interest to prevent war by miscalculation and irresponsible third nuclear powers from blackmailing them with nuclear weapons. Neither side can gain from seeking unilateral advantage.

Thus a renewal of negotiations will be a test less of ingenuity than of political maturity. There seems general concern with the precariousness, both physical and psychological, of a balance based on large unopposed offensive systems. But 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. It remains to be seen whether domestically we can overcome debate by sloganeering and internationally whether the superpowers can move the quest for peace from polemics to a joint enterprise. ■

CORPORATE R&D...
CONTINUED

year, President Reagan wants Congress to pump $3.7 billion into the program.

Not surprisingly, the goings-on at the Star Wars office are closely watched from corporate boardrooms. Says Army Colonel Robert W. Parker, director of resource management at SDI's office: "One way or another, 80% percent of our money is going to the private sector." On any given day, representatives of dozens of companies and universities visit the headquarters. Abrahamson, who last headed the civilian Space Shuttle program, has given the private sector an unprecedented role in shaping a defense project. That way, he hopes to attract "the brightest minds."

PATCHWORK. Abrahamson's first task was to pull together the best of 20 years of past research on antimissile weaponry. The SDI project is largely patched together from existing research efforts by the Army, Navy, Air Force, Defense Advanced Research Projects Agency, and other agencies. These projects involve some 300 contractors, and funding their work will account for most SDI spending.

Under SDI's wing are such projects as the Army's effort to develop a ground-launched projectile that can knock out missiles in space. That system brought down a dummy warhead high over the Pacific last summer. The Air Force is overseeing the development of electromagnetic guns that could fire projectiles at incredible speeds in space. Other patches of the SDI quilt are the Navy's program to develop laser weapons and a particle-beam accelerator known as White Horse at the Energy Dept.'s Los Alamos National Laboratory.

Abrahamson's office, however, faces the daunting task of forging those diverse weapons and surveillance technologies into a space-based shield capable of destroying thousands of warheads in minutes. To spur the massive innovation needed to make Star Wars work, Abrahamson devised a competition nicknamed Horserace that is intended to help shape SDI's strategies and the mix of weapons needed. The scheme encourages companies to apply their best efforts to the task by rewarding those that are quickest to show important results. "This is a new role for government and industry," says one company executive. "It used to be that the government gave us a set of specifications."

TEAMS OF GIANTS. Horserace got out of the starting gate last July when 225 companies picked up formal requests from Abrahamson's office for proposals on how an entire Star Wars defense could be built. Ten teams, led by such aerospace stalwarts as Hughes Aircraft,

CONTINUED NEXT PAGE

NEW YORK TIMES 2 APRIL Pg. C-1

'Star Wars' Science Expected to Spawn Peaceful Inventions

Gains seen for medicine and industry.

By MALCOLM W. BROWNE

WHATEVER finally comes of President Reagan's proposed "Star Wars" defense against nuclear missiles, current research at the nation's weapons laboratories promises a bumper crop of spinoff discoveries and gadgets, many of which will spur progress in medicine, industry and basic science.

Scientists at such weapons laboratories as Lawrence Livermore in California, Los Alamos in New Mexico and Oak Ridge in Tennessee say their projects will benefit pursuits as arcane as the analysis of supernova explosions and as mundane as the processing of vegetables. Instruments, machines and ideas being developed in connection with weapons programs may help detect cancer in its early stages, screen people for genetic defects, custom-grind special contact lenses and win back the America's Cup.

Of the $100 million the Government is expected to spend on Strategic Defense Initiative research in the coming year, most will go for projects having little immediate bearing on peaceful applications. Critics of the Presidential initiative argue that the money would be better spent directly on civilian research.

Promises for Peaceful Use

Still, the development of military hardware has often enriched science and technology, and the trend is certain to continue. World War II, for example, speeded the development of jet aircraft, space flight, antibiotics and nuclear energy. Among the spinoffs of the nuclear bomb program was the creation of an artificial element called americium, the essential ingredient in smoke detectors now used to help prevent destructive fires in the home.

The beams of laser light and charged particles that may one day be used in warfare show particular promise as tools for peaceful research and medicine. A case in point is the deadly X-ray laser, which may soon begin revealing the mechanisms of life in hitherto inconceivable detail.

Military designers are interested in building an X-ray laser weapon, mainly because it could deliver vastly more destructive energy to a distant target in space than is possible using conventional lasers. But the creation of an X-ray laser has confronted formidable obstacles; producing a cascade of X-rays requires a great amount of energy. One obvious way of creating such energy is to pump the laser with a nuclear explosion, and the first bomb-powered X-ray laser was successfully exploded five years ago at the Nevada test site. But in recent months the Administration has emphasized a desire not to use nuclear devices in the proposed space weapons because of political and technical problems.

Era of New Super Microscopes

But aside from its weapons applications, the X-ray laser has excited biologists, chemists and physicists because of its possible use in a super microscope, an instrument that will perhaps be capable of taking holographic three-dimensional movies of the genetic code of a living cell. Nuclear explosions are inconvenient power sources for any kind of laboratory, however, so scientists in and out of Government service have sought less destructive techniques for generating X-ray laser beams.

Last October, researchers at Livermore reported success with their gigantic Novette laser, a machine that fills a building the size of an aircraft hangar. Green laser light approximately one trillion times more powerful than ordinary sunlight was focused on foils of the metals selenium and yttrium, causing the foils to explode and emit thin laser beams of intense X-ray light.

Many problems remain to be solved before X-ray lasers become common research tools. But according to Dennis L. Mathews, the physicist in

CONTINUED NEXT PAGE

SCIENCE...CONTINUED

charge of the Livermore project, the goal is in sight. The results will be dramatic, not only because of the penetrating power of X-rays, but because X-rays have much shorter wavelengths than visible light and can therefore pick out finer details than can be discerned using even the most powerful light microscope. An X-ray laser microscope would also have important advantages over an electron microscope, in that it could look directly at a live specimen without killing and preparing it in advance.

"I would guess that we're going to see the first X-ray hologram one or two years from now," Dr. Mathews said in an interview last week. "It may be rather crude — perhaps showing just the gross internal structure of a cell. But refinements will come rapidly, and eventually, I think, we'll be able to make holographic pictures even of living DNA molecules, the molecules that make up the genetic code."

The potential of weapons-related inventions for advancing medical research has become so impressive that private business organizations have begun to exploit them. At Los Alamos laboratory, for example, scientists devised an optical instrument using circularly polarized light. Realizing the commercial potential the instrument would have if it could be adapted to clinical research, a group of business people paid Los Alamos $4 million in venture capital to develop a marketable product. The result was an instrument that can make fast, cheap assays of viral components of blood.

Another important clinical instrument, a computer-controlled microscope that analyzes digital information from the images it gathers, emerged three years ago from Livermore. It has found use in screening blood samples for genetic abnormalities and the onset of cancer.

Death Rays Against Fruit Flies

The development of death-ray technology could also lead to safer fruits and vegetables on supermarket shelves and might even help safeguard the continent's forests from acid rain, scientists say. The tool that could do these things, a very powerful miniature particle accelerator called the High Brightness Test Stand (H.B.T.S.), already exists.

According to the machine's developer, Stephen Mathews, also physicist at Livermore, the H.B.T.S. was invented using a system called magnetically switched linear-induction acceleration to produce a very intense beam of high-energy electrons. This beam, in turn, powers a device called a free-electron laser — one of the candidates for development as a space weapon. But Dr. Mathews has conceived some unexpected uses for the accelerator, which is only about six feet long and which could be manufactured to sell for about $1.5 million.

The Livermore scientist proposes using the little accelerator to kill insects, including the infamous Mediterranean fruit fly, larvae and parasites that infest freshly harvested fruit and vegetables. His idea is to direct the electron beam from the accelerator at a metal target, thereby producing a very intense X-ray beam that could irradiate food products. Irradiation would replace the chemical fumigation used on many crops, thereby eliminating all chance that such poisonous fumigants as ethyl bromide might cling to the produce.

The Food and Drug Administration is considering allowing the irradiation of foods, but the only source of sufficiently intense radiation now available is the isotope cobalt-60, which radiates lethal gamma rays. Cobalt-60 can be used safely, Dr. Mathews says, but America's supply of the substance, which must be made in nuclear reactors, is so small and expensive that it would hardly suffice to treat California's almond crop, much less the nation's fruit and vegetable crops. Particle accelerators could do the job, however, perhaps even moving by truck from one harvest to another. Further in the future, Dr. Mathews sees the device being used to irradiate fresh fish and other perishable foods, thereby greatly extending their shelf lives.

CONTINUED NEXT PAGE

CORPORATE R&D... CONTINUED

Martin Marietta, TRW, and Rockwell International, were awarded initial contracts. By 1986 the strategic defense staff plans to select two companies to build a ground-based simulation of the system. Star Wars officials say those contracts will be "big," but they won't estimate how big.

SDI will need much more than existing technology if it is ever to fly. To get all the necessary advances, it will pump 3% to 4% of its projected budget over the next five years into pushing innovations in technologies ranging from advanced computers to optics. And officials are convinced they can stimulate universities and industry to accomplish in two or three years what most scientists maintain will take a decade or two. "You can have overnight revolutions, overnight breakthroughs," insists James A. Ionson, the 34-year-old astrophysicist who heads SDI's Innovative Science & Technology Office (IST).

This year, IST will shell out $28 million to begin developing a new bag of high-tech tricks for Star Wars, and he has asked Congress for $137 million for next year. In February, Ionson set up his first high-tech consortium: five universities that will develop nonnuclear systems to power space-based battle stations. The university researchers will try to find ways to generate megawatt bursts of power to run SDI's weapons. They are considering batteries as well as such far-out schemes as generating electricity by running rocket exhaust through a magnetic field.

ESOTERIC CONCEPTS. In late March or early April, IST will roll out more consortiums—including small businesses—that will probe ways of telling real warheads from decoys and develop the high-speed computers necessary to aim and fire orbiting and ground-based weapons. This summer, Ionson plans to launch another group to look at the possibility of putting fission—or even fusion—reactors in space. Next year he plans to delve into advanced concepts in particle beams.

Almost no cutting-edge technology will go without a shot of new research funds. The computer project, for example, will attempt to develop superfast optical computers that use light instead of electrons. Ionson is even considering so-called biochips, an esoteric computer concept that envisions using circuits made of organic molecules instead of silicon chips. Such computers could pack tremendous amounts of information into an almost infinitesimal amount of space. "It would mean an absolute revolution in the computing industry," says Ionson.

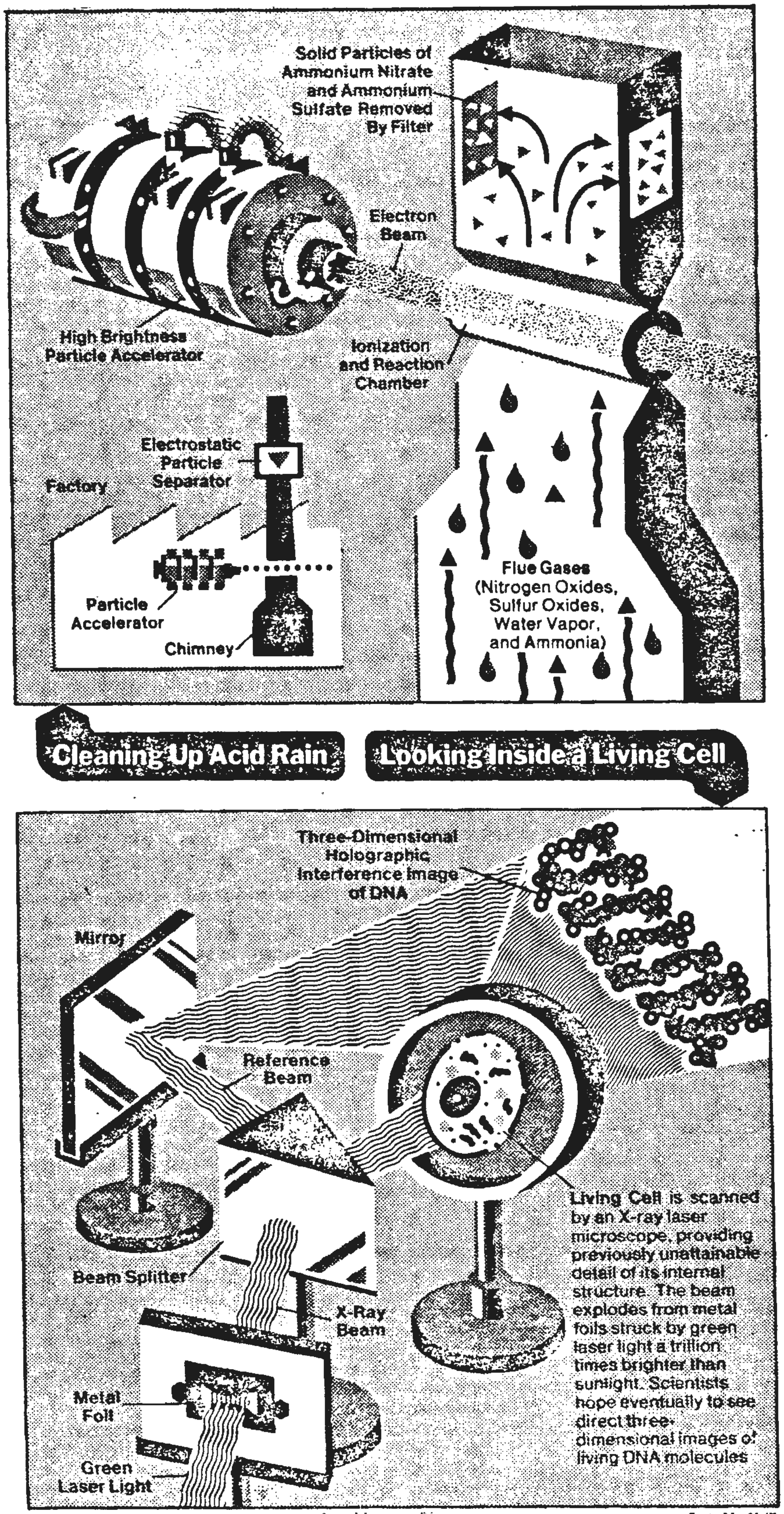
Star Wars, however, is still in its infancy. The problems that must be overcome before an effective defense against nuclear weapons can be constructed remain immense. Thus, many of the major defense contractors are taking a wait-and-see attitude for now. Experienced corporations such as Boeing Co., which has a $20 billion backlog of civilian and military orders, know the program isn't essential to their immediate future. Some scientists argue that the personnel for a massive Star Wars R&D effort is lacking in some fields, such as optics.

Whether or not Star Wars comes to fruition, Abrahamson and Ionson are convinced that it will produce a wealth of new technology. "Star Wars will create an industrial revolution," insists Ionson, who points out that gamma-ray lasers designed to cripple missiles could also provide the first three-dimensional images of the nuclei of atoms. "You could actually examine cells, genes, strands of DNA. The possible medical uses are absolutely spectacular."

That enthusiasm is catching on. "We're wide open on what we'll focus on," says Charles S. Bridge, chief scientist at Litton Industries Inc. And, without question, the Star Wars office now holds the strings of a massive technological effort that could dwarf the Apollo lunar exploration program and move technology light-years forward.

By Dave Griffiths and Evert Clark in Washington and Alan Hall in New York

SCIENCE...CONTINUED



Scott MacNeill

Use Against Acid Rain

Livermore's baby particle accelerator is also undergoing tests as a device for removing gases from industrial chimneys, which are believed to be a major cause of acid rain. Unlike solid particles of soot, these gases cannot be filtered from smoke or removed by conventional electrostatic antipollution devices. But the particle accelerator would hurl a powerful beam of electrons through the chimney gas, thereby ripping apart gas molecules of sulfur and nitrogen oxides. Farther up the chimney, ammonia gas and water vapor would be pumped in, and as the molecular components recombined they would form solid particles of ammonium nitrate and ammonium sulfate, which could be filtered out easily.

Dr. Mathews said that Laboratory tests have shown 90 percent to 100 pecent of the acid-forming flue gases can be removed by the electron-beam technique. While a power plant would have to use 5 percent of its output of electricity to run the accelerator, he added, the elimination of smokestack pollution would halt or slow the current ravage of forests and lakes in the United States and Canada by acid rain.

Weapons laboratories use powerful lasers not only as destructive beams but also as industrial tools, and some of these tools have considerable promise. A large plant at Livermore, for example, uses laser beams to separate uranium-235 — fuel for nuclear bombs and reactors — from the mixture of isotopes extracted from uranium ore. The laser process is much more efficient than the process it replaced, in which the uranium isotopes were converted into gas, which was separated into its constituents by repeatedly passing it through membranes.

Scientists say the laser separation process could be adapted for use with other metals. One of the isotopes of mercury, for example, could be separated in commercial quantities, and this isotope could be used to make fluorescent lights much more efficient than those now in use.

Many Uses for Astronomy

Among the pure sciences most likely to benefit from the offshoots of weapons research is astronomy.

Many proposed laser weapons would require very large, perfectly shaped and polished focusing mirrors, which could be used in space to aim the beams. The precision required of these mirrors goes far beyond the techniques of ordinary optical mirror-making, and required the development by Livermore of a huge diamond lathe controlled entirely by computer. With the computer controlling its position and pressure, the diamond tool in the machine gouges out microscopic grooves in the part or mirror surface until it perfectly matches the specifications.

CONTINUED NEXT PAGE

NATURE VOL. 314 25 APRIL Pg. 660

Star wars

Israel attracted by spin-off

Rehovot

ISRAEL is almost certain to accept the invitation it has received from the United States to participate in the Strategic Defense Initiative ("star wars") research programme.

If the government does so, it will enjoy the support of most of the scientific community, which hopes that the project will provide research funds that are no longer available from other sources and also create positions for young scientists who might otherwise leave the country.

Professor Josef Singer, president of the Haifa Technion and an aeronautical engineer who has himself done defence research, supports Israeli participation but warns his colleagues that they should not expect the United States "to spend billions of dollars and to engage thousands of scientists and engineers".

Singer points out that the US armed forces have already spent millions of dollars over the past 30 years in support of research projects at institutes in Israel. "And", he says, "while Israel stands to gain more in resources and know-how, it also has a contribution to make. Otherwise, it would not have been invited to

CONTINUED NEXT PAGE

Star wars

France rallies European forces

THE French government is determined to shake Europe awake, and to encourage all the nations of Europe to take a great leap forward in science and technology, by creating a new European research organization with considerable powers and funds, dubbed "Eureka". Or it may be that the French government is scared stiff of participation in the US Strategic Defense Initiative (SDI, or star wars) because it feels this might suck France dry of some of its best weapons technolgies, and wishes to form a common European industrial and research front. Eureka would be that front.

Which is the truer picture of French intentions? Probably both are true, which has made it a little difficult for Western European foreign ministers to respond to an urgent letter, proposing the flexible and rapid creation of Eureka, addressed to them last week by their French opposite number, M. Roland Dumas.

In the letter, Dumas says that Eureka (which in a rare French linguistic concession he gives the English name "European Research Coordination Agency") would set up major programmes half-funded by Eureka and half by industry in optronics, new materials, high-powered lasers, artificial intelligence, high-speed and ultra-miniaturized microelectronics and space. Any European state should be able to join in any programme, Dumas suggests, leading to a "variable geometry" Europe for research. But what research? Dumas' shopping list is remarkably similar to one that might be drawn up by SDI, rather than the new technologies in general (where is biotechnology, for example?), but the letter does not mention SDI by name.

Nevertheless, French interest in creating what the Prime Minister, M. Laurent Fabius, calls "a European area for research" is well known, and long pre-dates interest in SDI. France has doubled its government civil research spending since President Mitterrand came to power in 1981, but now realizes that France cannot go it alone against the United States and Japan. Thus Pierre Papon, director-general of the principal French research council, the Centre National de la Recherche Scientifique (CNRS), which has 10,000 researchers, made a detailed tour of Europe last year seeking bilateral research agreements, and the present research minister, ex-president of the French space agency the Centre National d'Etudes Spatiales (CNES), has also shown himself a dedicated European.

But these individuals and others in the French science political scene may be getting impatient at the pace of European integration in science and technology. ESPRIT, the European programme of research in information technology, flagship of the European Economic Community (EEC) programme in integrated "pre-competitive" research, has been extremely slow to spend real cash, and for the moment can claim only that it has brought a few European companies to the same table. The only really working institutions of any size seem to be the European Organization for Nuclear Research, CERN, which has only a moderate economic impact, the European Space Agency (ESA) of which Curien has been chairman, JET (the European fusion experiment, with impact only far in the future) and the European Airbus.

France wants much more, and earlier this month Jacques Delors, the new French president of the European Commission (the EEC bureaucracy), tried to provide it. In a written presentation, he asked European ministers at a summit meeting to double EEC research spending from its present three per cent of the Brussels budget to six per cent, and he linked the increase with the need for Europe to respond to SDI. Ministers — who at present in the 10-nation EEC must agree any proposal unanimously — threw out both ideas. Many states were, it seems, prepared to increase the research budget, but by nothing like the factor of two, and the SDI link was described by

CONTINUED NEXT PAGE

SCIENCE...CONTINUED

Mirrors of such precision may significantly enhance the quality of future astronomical telescopes. Moreover, the diamond lathe could make them in any size and of any kind of irregular shape, so as to permit novel telescope designs. At the other extreme in size, the lathe could be used to grind perfect contact lenses for eyes with unusual impairments.

Weapons laboratories are developing special multilayered mirrors capable of focusing and bending X-rays, which pass right through ordinary mirrors. These X-ray optics will find applications in the emerging field of X-ray astronomy.

The batteries of supercomputers operated by the weapons laboratories, when not employed in designing weapons, are being used to develop mathematical models helpful to astronomers, weather forecasters, shipbuilders and others. The mathematical modeling of events that take place inside a hydrogen bomb explosion, for instance, is applicable to the explosion of a supernova star.

Livermore has also shed light on the nature of the cores of such giant gassy planets as Jupiter and Saturn. By subjecting hydrogen to the intense pressures produced in an explosion, scientists have reproduced conditions in planetary cores, where hydrogen becomes a metallic solid.

Eager to Share Discoveries

Computer modeling of the turbulent flow of gases, important factors in a nuclear explosion, may have some bearing on global weather patterns and forecasting. Another type of computer modeling under development at Livermore and elsewhere is expected to help in the design of boat and ship hulls, and one current project aims at improving yacht design for the next America's Cup regatta.

By and large, American weapons laboratories are eager to share the discoveries and technology they turn up, provided they can do so without violating national secrets. The difficulty, spokesmen for the laboratories say, is that commercial manufacturers often insist on exclusive rights to whatever processes or inventions they get from the laboratories, and this is sometimes impossible.

"Maybe the most important thing we do for private industry," said Suzanne Monaco, director of Livermore's technology transfer department, "is to show people what can be done. We have a kind of can-do attitude toward every problem we approach, and it rubs off on the outsiders we try to help."

SDI
The Technical Alternatives

by JIM MARTIN

In a recent issue, *Time Magazine* said of SDI, "Advocates conjure up visions of death rays flashing across thousands of miles of space to zap Soviet missiles as they rise. Critics counter with derisive pictures of the most sophisticated weaponry foiled by something as simple as grains of beach sand scattered in orbit."

To the people at *Time*, the essential question was whether the system could work, but even *Time's* staff missed the one truth that has characterized all the "technical" discussion which followed President Reagan's 1983 plea that we use our technological expertise to foster defensive rather than offensive systems. Almost no one has actually examined the technology to determine the concepts' feasibility (the plural *is* intended, since we deal here with multiplicity of technical concepts). Isolated pieces of technology are drawn into the argument as individual proponents and opponents of SDI find them relevent in proof of positions they have typically formed on bases other than technical analysis.

There is no SDI technology today, only a planned and partially budgeted R&D effort aimed at the determination of whether the concept of a layered defense system is technologically feasible. There is no system configuration today, only a list of potential alternatives whose worth must be proven or disproven in the course of research. There is no proven level of effectiveness, no numerical analysis of missiles destroyed and missiles escaping the various layers of the system, only a hope that the research will demonstrate a capture potential high enough to deter any aggressor from the use of his nuclear arsenal in time of crisis.

Why then an article which purports to discuss the very technology it claims to be nonexistent? The very fact that the technology is so widely misunderstood and so frequently misassessed is the most driving argument for an analysis, not of the system to be deployed in the future, but rather of the basic technology options, their strengths and weaknesses, their current level of advancement and the areas in which we must further advance if SDI is ever to become a reality. Any article which claims to discuss the system itself rather than the technology menu from which its various elements will be selected is decidely premature.

The one aspect of SDI technology which is admitted by both sides of the controversy is that the challenge is enormous. But it is unrealistic to argue, on the one hand, that all of the technology exists today and that the only real question is the speed with which we can deploy it, or, on the other, that we have reached the limits of American technical ingenuity and that we should therefore not consider any system for which the elements are not already on the well-stuffed shelves of the Quartermaster Corps. We must assess what is and what can be developed from what is, for the answers ultimately will be found in an amalgram of the two.

THE BASIC QUESTIONS

Perhaps the point at which we should begin is the basic question of density and operating power. Even the most generalized conceptualization of an SDI system should make it apparent that the sensor and data processing demands will be unprecedented. In many cases, the degree of required power and precision can be defined by extrapolating from existing systems. The first question must be whether we can construct systems of greater density than anything fielded today, and with 10- to 20-fold increases in performance.

Ultimately, we are really discussing quantum leaps in both hardware and software sophistication. Perhaps that sounds less glamorous than the overblown scenarios of huge satellite laser systems shooting their lethal beams down from orbit toward a horde of rising missiles, but it is a much more realistic point at which to begin the assessment than the George Lucas-esque imagery so often scattered through the media (who adequately demonstrate *their* viewpoint by their consistent refusal to call the program by its correct name).

We are moving in the right directions in both hardware and software to at least make the concept of a reasonably (not necessarily totally) secure defensive system a distinct possibility. In hardware, the progress of the VHSIC program is a clear sign of our future ability to radically increase hardware densities. VHSIC and similar developments in the commercial sector have enabled us to fabricate ICs containing more than a quarter of a million transistors per chip. To put this in perspective, there are few pieces of equipment in the field today containing devices of more than 25,000 transistors.

But VHSIC is merely scratching the surface of silicon density. Most experts concur that the reduction in the near future to feature sizes of .1 to .5 microns will allow the design of 2 million transistor devices on .4 × .4-inch dice. These represent a 100-fold increase in device density over what we find in systems today. SDI advocates and SDI critics toss out estimates that range from 10-fold to 40-fold for the increase in logic density successful SDI systems will require. VHSIC and related developments can take us well beyond that level. Admittedly, we must still design and fabricate chips with the right logic functions, but that is a challenge we have met frequently in the past. Improvements in CAD make this perhaps less of a challenge than was the design of the first microprocessor.

But VHSIC is only part of the improvement available to us. New developments in chip-on-substrate and chip-on-board assembly techniques (particularly low-capacitance tape-automated bonding techniques) can currently allow us to reduce assembly densities as rapidly as we improve chip densities. The rapid transition into high-speed, low-power CMOS provides us with a technology that will allow us to pack systems densely with little or no concern for the heat components generate. CMOS will also allow us to orbit complex systems with relatively small power consumption or to deploy complex ground systems capable of running for long periods on battery back-up. The one area that obviously requires further effort if we are to have

CONTINUED NEXT PAGE

ALTERNATIVES...Continued

"SDI-level" integrated circuits is that of radiation hardening. This is the area in which the phase I VHSIC effort failed to come close its stated goal.

Secondly, we have the question of "software power." In this area, we are also in better shape than the critics seem to believe. To a large extent, the critical attacks upon SDI's technology base are more a result of the slow process by which we deploy new systems than they are of an actual assessment of the technology available to us. The technology in the field is typically a generation behind the technology used currently in systems research. Nowhere is this more evident than in the software area. Existing systems employ a confusing array of non-interchangeable and often low-performance software. The software available for new systems, thanks largely to the implementaion of Ada, is more powerful, more flexible, and significantly more easily transported from system to system.

Initial analysis has indicated that SDI will probably require some use of knowledge-based systems (a more accurate choice of terminology than the more commonly preferred "Artificial Intelligence"). To an extent that may not be determined for years, the rapid computation required for effective strategic defense may well necessitate the use of knowledge-based computer technology.

The complexity of the total system will make interoperability crucial, and the amount of data and signal processing involved will make parallelism essential. But these are tools and techniques which, if not fully deployed in existing systems, are well enough investigated and understood that we could utilize them in a strategic defense system. The technology base does exist. DSP Systems, for example, recently announced a parallel processor system capable of 7 billion operations per second, which could conceivably allow a hundred fold increase in the per-element processing speed of a phased array radar. Could that find applications in SDI? The same system is capable of real-time video processing. What could that, coupled with leading edge optics technology, provide us in satellite surveillance systems? We have and continue to create incredible technology. The questions that we must address are the specifics of technology implementation.

To do so, we must first examine the specific tasks that any strategic defense system must include, and these are surveillance and threat detection, target acquisition and tracking, and target destruction. Despite press comments regarding weapons in orbit, all of these tasks could conceivably be handled with ground-based, sea-based or airborne systems as well as by satellites. For some, however, there would be a significant loss of reaction time (perhaps as much as 40 percent of the estimated missile flight time), so orbital basing of some portions of an SDI system would have advantages.

There are also subsets to those tasks. Facing a strong defensive system, ICBM designers would certainly attempt to incorporate features in their designs that would increase the probability of the vehicle's successfully reaching its target. Although it is safe to assume that none of missiles in the presently huge Soviet arsenal employ such techniques, SDI must, by its very nature, look toward the future, anticipating future techniques in strategic offense. The three most obvious means that could be employed to increase the probability of an ICBM's success are electronic countermeasures (ECM), the use of decoys or dummy missiles, and "stealth" (primarily radar reflective techniques). Some mention has been made in the past year of "fast burn" launch vehicles, but reduction of the time during which infrared detection could be used from 5 minutes to 2 is not a serious concern, given current capabilities in this area. The subsets may, to some extent, prove a greater challenge than the basic system.

It is also important to understand that SDI should not be viewed as a system whose sole objective is the detection and destruction of ground-launched ICBMs. Many SDI critics use as one of their counter arguments a claim that SDI will provide no protection against startegic bombers, sea-launched ballistic missiles (SLBMs) or cruise missiles. This is a near classic example of sophomoric logic, since it can easily be demonstrated that a comprehensive system would be able to detect and engage all threats, regardless of launch point or flight altitude.

SURVEILLANCE AND DETECTION

Let us examine first the challenge of surveillance and threat warning. This is the one portion of the system which is most likely to be space based, since only an orbital system could detect ground-level activity in the Soviet Union. But, as Ashton Carter has noted, satellite sytems are vulnerable. An orbitting detection system should have some type of less vulnerable back-up. There are several alterantives available. Ship-borne systems would be worth considering, although the expense of maintaining a number of ships for missile detection might make this economically prohibitive unless those ships could accomplish other missions at the same time. Airborne detection (along the lines of AWACS) would certainly be worth considering, as would ground based systems. It should be noted that placement of the back-up systems will be a factor in determining the detection technology employed, since a ground-based system in North America, for example, would not be able to detect a missile based in central Asia from the heat generated at launch. The boost engines would have already been jettisoned by the time the missile cleared the detection system's horizon.

But our primary concern is not the back-up system, but rather the system that would be installed in orbit. The most logical approach to surveillance and detection would be a series of satellites with optical, laser and infrared capabilities. Each capability would not need to exist in each satellite. Most of the SDI discussion to date has centered on the heat detecting capabilities of an infrared sensor system, and the incredible heat generated by a rocket motor during launch and boost is the most accessible means for detecting that launch. The scenario involved, however, is one in which minutes are critical. Determining that a launch *may be about to occur* may be more valuable than the actual detection, minutes or hours later, of the launch. It is for this reason that optical systems would also be employed.

It is unlikely that a Soviet decision to launch would be an immediate decision. The decision would be made hours or even days before. It is also likely that the Soviets would begin troop mobilization prior to their attack.

CONTINUED NEXT PAGE

ALTERNATIVES...Continued

Optical surveillance systems would detect heightened activity around Soviet ABM sites, airfields, and other facilities. Increased troop movements on their borders would also be probable. All of this information could be used to alert us to a *possibility* of imminent attack. Part of the reason that the Soviets have argued so strongly against SDI is their awareness that these optical systems not only exist today, but that they are at least one generation more advanced technically than their Russian counterparts.

The infrared technology needed to detect the actual launch of missiles (which could probably be detected optically as well, although that would require a higher level of operator attention and involvement) also exists today. We have employed it in heat-seeking missiles for some time. Where we need to improve our capability in order to make SDI a reality is in the area of infrared triangulation, the techniques that will allow us to determine course and trajectory from the information provided by infrared detection during boost. It is likely that space-based radar or low-intensity liders (systems capable of measuring distance and velocity by laser) might have to be employed for this purpose.

With a combination of optics and high sensitivity infrared, we could also resolve the problem of bombers and cruise missiles. Although they do not generate the heat of a missile launch stage, bombers and cruise missiles generate detectable heat. We are capable today of building satellites that could detect any source of heat moving at greater than a certain speed and then locking an optical system on that heat-source in order to determine what it is. We could add several satellites of this nature to our SDI network to virtually eliminate the bomber/cruise missile threat.

One argument voiced by the critics is that these satellite systems could be destroyed as the first step in any Soviet attack, but those critics fail to realize two points. First, the sudden "disappearance" of an entire series of satellites would be as clear an indication of an imminent attack as the detection of launched missiles. Secondly, we are not so foolish as to fail to employ back-up systems which would be activated upon the warning the destruction of the satellite would provide. I mentioned earlier the use of non-space-based back-ups, but space back-up systems are equally realistic.

Tracking a satellite is a challenge. The deeper the orbit the greater the challenge. With the Shuttle, we are able to make it harder for the orbit to be determined from data taken during launch. It is even conceivable that the STS could "drop" a satellite in space, using a momentary retrofire to move it away from the shuttle. Radio signals could later trigger a boost vehicle "while no one is watching" to silently move the satellite to its planned orbit. All of these options make practical the concept of "silent" satellites, satellites which do not transmit until they have data to report. Since the easiest means of satellite detection is radio signals, finding these satellites in a geosynchronous orbit would be like trying to find a one micron solder ball somewhere in the Pacific Ocean using a radar system in Peru.

Now the point could be raised that we would need to confirm that these "silent sentinels" continue to function properly. That could be done with laser transmissions on a controlled periodic basis to "housekeeping" satellites capable of relaying the data to earth. No current technology can detect a short laser burst between two objects in orbit. If the housekeeping satellite were attacked, we would probably no longer need period health checks, for the sentinels would be required to perform their primary function shortly after.

Perhaps the biggest problem we would face in the deployment of silent sentinels, and I believe it was John McLucas who pointed this out, is that Third World nations are beginning to request geosynchronous satellite slots for their planned systems. It would be hard to deny a request for a position that is supposedly vacant without somehow identifying what we have hidden there.

We also have means of protecting satellites in identified orbits. We can harden them. We can give them autonomous repositioning capability. We could equip them with several small kinetic weapons with which to defend themselves. The options are many.

The biggest challenge is not the deployment and protection of the satellites. It is the development of a new generation of sensors and the processing systems to support them. But we have basic capabilities that can be advanced to the levels SDI would require. No magic is required for detection and surveillance.

TARGET ACQUISITION AND TRACKING

Let us then examine the second area: target acquisition and tracking. Once we have determined that missiles have been launched, we must track them as targets. Although this could be accomplished by the detection and surveillance systems, the possibility of jamming interference must be acknowledged. A nuclear screen could be placed between the anti-missile weapon and its source of information (say between a kinetic missile and a satellite), causing a disruption of communication. The weapon itself must, therefore, have its own target detection and tracking system, capable of working despite both nuclear and electromagnetic interference. If the weapon is not of the "destruct upon engagement" variety (such as a kinetic missile), then the tracking system must be capable of determining whether the target has been successfully destroyed, so that a second attempt may be made if needed.

The challenge here will depend upon the type of defensive weapon employed. But we should perhaps not examine so much what will be as what exists today from which technology could be adapted. One tracking system from which concepts could be drawn is Phalanx, a system currently deployed on a number of Navy vessels. Phalanx is a radar-controlled, rapid-fire gun capable of engaging targets from water level to near vertical across a predetermined arc

CONTINUED NEXT PAGE

ALTERNATIVES...Continued

(the primary limitation of that arc being the ship's superstructure). Phalanx itself would probably not be a good SDI weapon because its range is limited, but the guidance and detection system could form an excellent basis for a "final layer" defense. Phalanx operates by detecting the course of the incoming target and the course of the outgoing rounds, and then shifting the gun until the two converge. It is this kind of high speed tracking that SDI will require.

Several years back, ERIM (the Environmental Research Institute of Michigan) developed a closed-aperture phased array radar system capable of analyzing three-dimensional radar images with a level of accuracy that allowed it to differentiate between two tanks, identical except for a slight modification to the barrel of one. The problem was that the system was enormous, because of the number of integrated circuits required. In a few years, VHSIC chips will allow us to build that system in a 6-inch cube. This too should be a candidate detection system.

And there are many more detection systems which provide some of the basics required by SDI for advanced research and initial development. And we are capable of the processing power needed to support them. We are not talking about a revolution in technology to make SDI achievable, but rather an evolution. The only question that we cannot answer today is how much of an evolution will be needed.

THE WEAPONS POSSIBILITIES

Perhaps the most interesting area for discussion is that of the weapons themselves. There are basically three alternatives: beam weapons, kinetic weapons, and nuclear weapons (which, as Dr. Teller has pointed out, does not *de facto* mean megaton or even kiloton warheads). It is conceivable that all three might be employed, each within a different layer of the defensive network.

Perhaps the easiest to discuss is the second, kinetic weapons, and this is also the one that is best proven. By now, everyone is familiar with the Homing Overlay Experiment (HOE) performed a year ago. HOE was a kinetic impact missile with a deployable metal shroud. Using its mesh umbrella, an HOE fired from Kwajalein engaged a dummy Minuteman which had been fired from Vandenberg AFB 4,000 miles away. HOE met its target over the Pacific, destroying it as the two approached at a combined velocity of more than 14,000 mph. That translates into an accuracy of 10 feet despite a combined approach rate of more than 20,000 feet per second. The degree of course adjustment of which an ICBM is capable is negligible, and it is doubtful that any Soviet ICBMs contain the level of threat detection capability that would allow them to detect such a missile, let alone evade it. Kinetic impact ABM missiles are not theory, they are reality.

The main question that has been raised about the kinetics is where they would fit into the total system. Some analysts have indicated they might be employed against missiles in the boost phase, but this is doubtful. To do so would require one of two approaches, either space-based kinetic weapons or missiles launched from submarines close to the Soviet coast. Neither is practical. Satellite based kinetic missiles would require (given the number of anticipated targets) the boosting of a tremendous total payload, and the satellites involved would have to be in a relatively low orbit to be effective. This would have two effects. First, a low orbit, since it is not geostationary would place the majority of all missiles outside a useful range at any point in time. Secondly, the low orbit would also make them extremely vulnerable to ASAT activity.

As far as sea-launched missiles are concerned, since they would be fired later than the ICBMs against which they were targetted, they could not engage those targets until they were past their boost phase. Beam weapons, as we shall see later, make more sense during the boost phase.

Kinetic weapons, launched either from sea or land (or possibly even from airborne platforms, although this would appear unnecessary) would be most useful during the mid-course phase of the target's flight. This is obviously the phase in which HOE was used against its Minuteman target. One advantage a kinetic weapon might (with proper construction) provide during this phase is that it might still be operational after engaging a balloon or other light-weight decoy. If so, it could then continue to seek a "real" target from the many available incoming targets. Obviously, making the missile and its deployable shield strong enough would add weight, but within levels that would probably prove acceptable. A second challenge in the design of this type of defensive weapon would be the inclusion of some sort of "claiming" system that would allow missiles to communicate to prevent two from engaging the same target. This would require the kind of sophisticated electronic systems that VHSIC and post-VHSIC chip densities will enable.

Kinetic weapons would be less practical (although still feasible) for the final (re-entry) layer of the defensive network. We shall see why when we discuss nuclear weapons.

The weapons that seem to get the most attention in the press are beam weapons. Images of Darth Vader and the Imperial Hordes. I suspect that most of the beam weapons will prove less practical than many think. Particle beams appear to offer the most lethal capability for destroying a target, but, barring some incredible breakthrough in accelerator technology, they are simply too large and cumbersome to be practical. Were we able to move a quarter-mile long, 500-ton linear accelerator into space (and repeat that operation hundreds of times), it is doubtful that we could develop the ability to aim such a behemoth as quickly as the strategic scenario would require. Even then, we would still have the problem of the warping of beams due to the earth's magnetic field. There are more realistic avenues to pursue.

Chemical and excimer lasers offer more promise, but not a lot more.

CONTINUED NEXT PAGE

ALTERNATIVES...Continued

Because of the power required for either, space-based lasers would be extremely bulky. They are "fast" enough (operating at the speed of light) that they could be placed in geosynchronous orbit, which would make them less vulnerable than kinetic missile staellites, but that would still not eliminate the weight problem.

Also of concern is the fact that chemical and excimer lasers would have to be focused on one spot on a missile's hull for anywhere from one to eight seconds, depending upon the type and intensity of the beam. This would make them easily counterable through the simple mechanism of rotating an ICBM during flight.

Each would also require (regardless of whether they were ground-based or orbital) aiming mirrors of anywhere from 25 to 100 feet in diameter. These mirrors would have to be capable of rapid movement from target to target. One alternative to mirrors clearly worth considering is staring mosaic sensor arrays, a dynamic area about which little has been heard in the last few years.

Perhaps their very impracticality is the reason lasers are so widely discussed. If they really offered potential, they would be classified. A lot has been said about the edge the Soviets have in the area of lasers, having outspent us by better than 3-to-1 during the last decade, but the impracticality of chemical and excimer lasers may be such that theirs might be a futile investment.

But there is one form of laser that does offer significant potential, the pumped X-ray laser, which takes its power from a small nuclear blast that is converted to directed energy before it destroys itself. Little is publicly known regarding X-ray lasers. It is well established that they can be reasonably compact and lightweight, that they do not require any measurable time on target to effectively destroy that target, and that they require must less precise aiming.

They could be ground based for use in terminal defense, but their light weight makes them ideal for boost phase use and for mid-course use. Against targets in the boost phase, pumped X-ray lasers mounted on missiles could be fired from submarines off the Siberian coast or in the North Atlantic. Some might feel that flight across Europe might be a less likely trajectory for Soviet missiles, but we must consider all alternatives. We should also consider the extent to which we could extend our shield to NATO allies. They could also be launched from ground sites in Europe or Alaska. Launchers could possibly be located on a permanent basis in deep water near the Soviet shoreline or under the polar ice cap. (It is worth noting that the Soviets apparently have the capability of launching missiles through the polar ice.) Missile launched lasers would be equally effective during the mid-course phase. Because they are lightweight, X-ray lasers for use against missiles in the downward portion of their exoatmospheric trajectory could be mobile-based, in perhaps large trucks or railroad cars. Ground-based they would be effective during re-entry.

But there is another alternative for re-entry, and that is, as we mentioned before, nuclear weapons. The suggestion of nuclear weapons for defense will generate some strong reactions, but some questions must be raised. The primary one is whether we wish to base our entire defensive effort on the assumption that an aggressor will attack us only with nuclear warheads. It is no secret that the Soviets have invested enormous sums in the development of biological or "germ" weapons. It would be unrealistic for us to assume that they would never use them. Our final echelon of defense will prove highly ineffective if its destruction of an incoming missile only aids in the dispersion of that missile's biological contents. A nuclear defense would eliminate this threat. A small nuclear blast could effectively destroy any germs its target contained.

The blast would not have to be large. Dr. Teller has indicated a 100-ton equivalency would be adequate. Other experts have concurred that at a reasonable altitude (in excess of several miles) such a blast would present little problem even for those directly beneath it. Even if their estimate were in error, it should be obvious that such a blast would create far less damage than an incoming multi-megaton ICBM that was allowed to explode.

Other alternatives at this point are possibly less safe. Kinetic missiles would not prevent salvage fusing from allowing the ICBM to accomplish its objective despite its destruction. Insufficient data exists relative to pumped X-ray lasers, but they are likely to be effective against biological weaponry. What must be established is their effectivity relative to salvage fusing.

CONCLUSION

One other point must be made regarding the potential technology for SDI. Most of it falls in areas in which we have a significant lead over the Soviet bloc. They are good at building ICBMs, which require relatively unsophisticated electronics and cheap available labor. SDI, on the other hand, requires sophisticated technology and highly skilled labor. It requires highly advanced sub-micron integrated circuitry, innovative computer and signal processor architectures, precision sensors, advanced guidance systems, and an extreme level of technological ingenuity. We are ahead of the Eastern bloc in all these areas, but in none as dramatically as the last.

Our engineering creativity may be our greatest asset. We have the manpower and the computer skills that allow us to address the SDI concepts from the perspective of technology that exists today and technology that can be evolved from it. Ultimately, if we are able to say that SDI is a workable concept, it will be because we will have applied ourselves to the determination of technical fact, rather than allowing ourselves to be dissuaded by premature and misdirected rhetoric. □

DEFENSE SCIENCE 2003+ April/May 1985 Pg. 13

PRESIDENT REAGAN
On The Strategic Defense Initiative

Since the advent of nuclear weapons, every President has sought to minimize the risk of nuclear destruction by maintaining effective forces to deter aggression and by pursuing complementary arms control agreements. This approach has worked. We and our allies have succeeded in preventing nuclear war while protecting Western security for nearly four decades.

Originally, we relied on balanced defensive and offensive forces to deter. But over the last twenty years, the United States has nearly abandoned efforts to develop and deploy defenses against nuclear weapons, relying instead almost exclusively on the threat of nuclear retaliation. We accepted the notion that if both we and the Soviet Union were able to retaliate with devastating power even after absorbing a first strike, that stable deterrence would endure. That rather novel concept seemed at the time to be sensible for two reasons. First, the Soviets stated that they believed that both sides should have roughly equal forces and neither side should seek to alter the balance to gain unilateral advantage. Second, there did not seem to be any alternative. The state of the art in defensive systems did not permit an effective defensive system.

Today both of these basic assumptions are being called into question. The pace of the Soviet offensive and defensive buildup has upset the balance in the areas of greatest importance during crises. Furthermore, new technologies are now at hand which may make possible a truly effective non-nuclear defense.

For these reasons and because of the awesome destructive potential of nuclear weapons, we must seek another means of deterring war. It is both militarily and morally necessary. Certainly, there should be a better way to strengthen peace and stability, a way to move away from a future that relies so heavily on the prospect of rapid and massive nuclear retaliation and toward greater reliance on defensive systems which threaten no one.

On March 23, 1983, I announced my decision to take an important first step toward this goal by directing the establishment of a comprehensive and intensive research program, the Strategic Defense Initiative, aimed at eventually eliminating the threat posed by nuclear armed ballistic missiles.

The Strategic Defense Initiative (SDI) is a program of vigorous research focused on advanced defensive technologies with the aim of finding ways to provide a better basis for deterring aggression, strengthening stability, and increasing the security of the United States and our allies. The SDI research program will provide to a future President and a future Congress the technical knowledge required to support a decision on whether to develop and later deploy advanced defensive systems.

At the same time, the United States is committed to the negotiation of equal and verifiable agreements which bring real reductions in the power of the nuclear arsenals of both sides. To this end, my Administration has proposed to the Soviet Union a comprehensive set of arms control proposals. We are working tirelessly for the success of these efforts, but we can and must go further in trying to strengthen the peace.

Our research under the Strategic Defense Initiative complements our arms reduction efforts and helps to pave the way for creating a more stable and secure world. The research that we are undertaking is consistent with all of our treaty obligations, including the 1972 Anti-Ballistic Missile Treaty.

In the near term, the SDI research program also responds to the ongoing and extensive Soviet anti-ballistic missile (ABM) effort, which includes actual deployments. It provides a powerful deterrent to any Soviet decision to expand its ballistic missile defense capability beyond that permitted by the ABM Treaty. And, in the long-term, we have confidence that SDI will be a crucial means by which both the United States and the Soviet Union can safely agree to very deep reductions, and eventually, even the elimination of ballistic missiles and the nuclear weapons they carry.

CONTINUED NEXT PAGE

PRESIDENT...Continued

Our vital interests and those of our allies are inextricably linked. Their safety and ours are one. They, too, rely upon our nuclear forces to deter attack against them. Therefore, as we pursue the promise offered by the Strategic Defense Initiative, we will continue to work closely with our friends and allies. We will ensure that, in the event of a future decision to develop and deploy defensive systems—a decision in which consultation with our allies will play an important part—allied, as well as U.S. security against aggression would be enhanced.

Through the SDI research program, I have called upon the great scientific talents of our country to turn to the cause of strengthening world peace by rendering ballistic missiles impotent and obsolete. In short, I propose to channel our technological prowess toward building a more secure and stable world. And I want to emphasize that in carrying out this research program, the United States seeks neither military superiority nor political advantage. Our only purpose is to search for ways to reduce the danger of nuclear war.

As you review the following pages, I would ask you to remember that the quality of our future is at stake and to reflect on what we are trying to achieve—the strengthening of our ability to preserve the peace while shifting away from our current dependence upon the threat of nuclear retaliation. I would also ask you to consider the SDI research program in light of both the Soviet Union's extensive, ongoing efforts in this area and our own government's constitutional responsibility to provide for the common defense. I hope that you will conclude by lending your own strong and continuing support of this research effort—an effort which could prove to be critical to our nation's future.

Ronald Reagan

SD1

SPECIAL REPORTS

NEW YORK TIMES 15 Dec 1985 Pg.1 (17)

A THREE-PART SERIES

TODAY: PART I
WEDNESDAY: PART II
THURSDAY: PART III

'Star Wars' Advances: The Plan vs. the Reality

By LESLIE H. GELB
Special to The New York Times

WASHINGTON, Dec. 14 — More than two and a half years after President Reagan broached the idea of a space-based defense, many Administration experts and critics alike remain uncertain about the consequences of such a defense for nuclear strategy and arms control. Yet almost all in the Government are going along with the program and, as a result, it has moved forward significantly in the past six months.

Weapons in Space

How Program and Debate Are Moving Ahead

First of three articles.

Indeed, the prevailing view now is that it will become harder and harder to turn back — even though Administration officials and legislators acknowledge that there is deep confusion about the purposes and consequences of "Star Wars," as the proposed system is popularly known.

Despite the gathering momentum, key Administration officials say the program has not reached the point of no return. They say they are waiting for the opportunity to get the President to authorize measures that will take it even further before he leaves office in 1989, so his successor will be more or less compelled to forge ahead.

The first clear-cut result of the program seems to be that the world of the Antiballistic Missile Treaty of 1972, a world essentially without defenses against missile attack, will never be the same.

The conditions of that world, with the United States and the Soviet Union each limited to one missile defense site, are being eroded by the new technology and treaty loopholes. Both sides are exploiting treaty ambiguities, although each says it believes the other is more guilty of this.

The result is the development of anti-tactical ballistic missiles, antisatellite weapons and large radars. All of these improve antiballistic missile capabilities, the very thing the treaty was framed to severely limit.

Strains in Administration

The summit meeting between Mr. Reagan and Mikhail S. Gorbachev, the Soviet leader, made no progress in this respect. And, for all the apparent agreement at the top of the Reagan Administration, there are serious internal strains over how to proceed.

Several key officials acknowledge that Administration goals are still suspended somewhere between Mr. Reagan's dream of total defense of the American people from missile attack and the more proximate prospects for improving deterrence or protecting missile retaliatory forces.

Officials also acknowledge that a struggle is beginning over how to measure the ultimate cost-effectiveness of space-based defenses.

In particular, they point to a fight brewing between Defense Secretary Caspar W. Weinberger and his key aides on one side and Paul H. Nitze, the State Department's senior arms-control adviser, on the other. In recent Congressional testimony, Mr. Weinberger leveled a broadside against Mr. Nitze's insistence that defenses ultimately be judged in terms of their cost and effectiveness against offenses.

The President and most of his top aides are also trying to make certain that no future arms-control agreement will close off the Strategic Defense Initiative, the formal name for the "Star Wars" program.

Given Mr. Reagan's opposition to compromise on the Strategic Defense Initiative, officials who work for him engage in a kind of muted shadow-boxing. Most refuse to contemplate negotiating restraints on "Star Wars" with Moscow, some in the hope that this will kill off prospects for an arms control process that they believe harms American interests. Some State Department officials want to use "Star Wars" as a bargaining chip for cuts in Soviet offensive forces.

But it is clear from conversations in Washington and Moscow that neither these officials nor Soviet officials have figured out how to limit research and close treaty loopholes, if that were mutually desired. Those tasks are understood by most to be exceedingly complicated.

The parties within the Administration and Congress to these various disputes — over the goals of defending people or weapons, standards for judging prospects and arms control — have reached a kind of equilibrium. Neither side prevails. The result is that the established policy and the programs chug right along, more slowly than if there were unity, but forward nonetheless. And even some Soviet officials wonder aloud whether the march toward defenses can be stopped.

The single most compelling reason for this is the force of Mr. Reagan's commitment and vision of transforming nuclear strategy from deterrence based on the threat of retaliation to peace based on effective defense. Administration skeptics say they dare not question this vision. Legislators raise plenty of questions, but say they think it necessary for reasons of prudence and politics to approve funds to keep the intiative going.

There is also the cloudiness of the critics' position. The critics say they favor only research, and the Administration responds that it is doing only research. The critics say defenses are unaffordable, unworkable and bad, but that case is hard to make conclusively before more research is done.

And there is the allure of exotic technologies. So much that seemed impossible in the past is now a reality. Businesses and research institutions are being drawn into the space-research orbit by lucrative contracts. European allies who express alarm about arms control and the undermining of alliance strategy are tantalized by the research money and technology.

But there are also countervailing pressures. In particular, Congress and the Administration will be wrestling with increased efforts to cut military spending generally.

Nonetheless, the consensus is that a continuing and probably extensive research effort is virtually inevitable. This is particularly true as long as the Soviet Union also seems bent on some sort of space- or land-based missile defense, though the precise nature of what that is remains unclear.

Representative Les Aspin, Democrat of Wisconsin, chairman of the House

STAR WARS...Pg.2-SR

STAR WARS...from Pg.1-SR

Armed Services Committee, says the commitment to S.D.I. has grown substantially, even though its feasibility and good sense have been no better demonstrated today than they were when the President first spoke of the idea."

"There's the feeling that there's no really big decision to make now because it's just a research program," he said. "So all we're really doing is taking the proposed S.D.I. budget and trimming it back strictly on grounds that Mr. Reagan is asking for big increases each year and that it isn't wise to have such large increases at the initial stages of a advanced technological program.

"Given all the factors, we have no real other choice than to do this, which means keeping the program going but at a slower pace."

In the process, Mr. Aspin said, "the real danger is that we will end up destroying the idea of deterrence without achieving the perfect world of defense."

In March 1983, when Mr. Reagan began his program, he attacked the traditional theory of deterrence by retaliation as immoral and unreliable. His goal was grand, to make nuclear weapons "impotent and obsolete."

Several Administration officials now acknowledge that this went too far too fast. Even if Mr. Reagan's vision comes to pass, it might be 20 years or more away. In the meantime, the United States would have to rely on offensive forces and deterrence through retaliation. So, officials say, they began to tone down their public statements somewhat, to "enhancing deterrence." Along the way, the goals were left in some confusion.

On May 30, according to the officials, Mr. Reagan issued National Security Decision Directive 172. It states bluntly, "U.S. policy supports the basic principles that our existing method of deterrence and NATO's strategy of flexible response remain fully valid, and must be fully supported as long as there is no more effective alternative for preventing war."

Based on this, the Administration published a special report in June. At one point, in accord with the directive, it proclaimed that "successful S.D.I. research and development of defense options would not lead to abandonment of deterrence but rather to an enhancement of deterrence and an evolution in the weapons of deterrence through the contribution of defensive systems."

But the original goal also found its way into the report: "The purpose of the defensive options we seek is clear — to find a means to destroy attacking ballistic missiles before they can reach any of their potential targets."

The emphasis, the report says, is on "eliminating the general threat posed by ballistic missiles."

The report added that the "goal of our research is not, and cannot be, simply to protect our retaliatory forces from attack."

What to Defend: Missiles or People?

Tucked away inside this larger debate is a more immediate question, namely whether initial "Star Wars" deployments should be used to defend missile silos and other military targets or whether they should defend people.

Administration officials are at pains to deny that they have any intent of turning Mr. Reagan's vision away from defending people toward defending weapons. Many of them say they feel this would knock the bottom out of public support for the effort. But some legislators, like Mr. Aspin and Senator Albert Gore Jr., Democrat of Tennessee, maintain that protecting military targets is the real goal.

Talking of the first stages of deployment, Fred C. Iklé, Under Secretary of Defense for Policy, said, "The first impact of ballistic missile defense of the new technology rather than the traditional defense will be to make it more difficult for the aggressor to destroy all missile silos and command and control centers."

The publicly expressed concerns and the logic of Administration policy have tended to go more in the direction of defending military targets from the beginning. When President Reagan spoke of "the window of vulnerability" in his first years in office, that is what he meant — that American missiles and command centers were vulnerable and needed to be defended. This problem has never been solved, although two years ago a Reagan commission on strategic forces said that the problem never existed in the first place.

Nevertheless, many top Administration officials call this their No. 1 strategic worry, and say missile defense is the only answer.

They reason that the best way to solve this problem is to get Moscow to get rid of its large land-based missiles, but the Russians will not go along.

A second possible solution is to deploy mobile missiles, which would be less vulnerable. But the Administration has proposed banning these because Moscow would have an advantage, being able to deploy them anywhere in the Soviet Union.

A third possible solution is greater reliance on submarine-launched missiles. But there is no telling how long submarines can remain invulnerable.

That leaves Washington, according to this reasoning, with its fourth and last option: defending its missile sites.

A senior Administration arms control adviser said in an interview that "without S.D.I. we have real problems sustaining deterrence."

Still, he went on to reject the fourth option, which is sometimes called hard-site or point or terminal defense, as impractical.

"Once you're into this, there is no way to keep the defenses limited to silo defense and prevent them from spreading to population defense," he said. "We cannot inspect, verify and control such a restricted system, especially if it were to be space-based rather than ground-based."

In the absence of further offensive agreements, this adviser and others argued that laying the basis for population defense could ultimately force each side into offensive buildups.

Like others, this official rejected outright the idea of limiting such a system to ground-based defenses. He said he thought Moscow, which has had more experience with these defenses, would have an unacceptable advantage. This official and others said Soviet officials have been quietly expressing interest in such a deal. Interviews with Soviet officials did not substantiate this.

Buying the Most For the Money

Even as the debate over protecting people or weapons continues, a new and equally portentous one is brewing over judging progress on research. Mr. Reagan's May directive says, "Within the S.D.I. research program, we will judge defenses to be desirable only if they are survivable and cost-effective at the margin."

Whether the system will be able to survive an attack is a question that will not be answered for some time. In the meantime, "Star Wars" progress was to be determined by whether research would show that it would be cheaper at the margin — that is, after all the basics are paid for — to add a unit of defense or an offensive warhead. The notion here is that if adding offenses would be less expensive, defenses would make no sense.

Mr. Nitze, the State Department's senior arms-control adviser, first used this criterion a year ago as a key test of the system's prospective cost-effectiveness.

But on Oct. 31 before the Senate Foreign Relations Committee, Defense Secretary Weinberger was asked about this idea. He responded: "Well, I have to say, Senator, that I really do not know what cost-effective at the margins means. It is one of those nice phrases that rolls around easily off the tongue and people nod rather approvingly because it sounds rather profound.

"I have the greatest admiration for Ambassador Nitze, but I do not know specifically what he has in mind with that. If he means is it less expensive to build strategic defenses than continually to engage in trying to add offensive systems, I would say the syllogism proves itself. It is clearly less expensive because the defense can in effect ultimately, if it is as effective as we hope it is, make it quite apparent that further offensive systems are not useful."

Mr. Weinberger added: "I cannot conceive of strategic defense being more costly than the constant need to modernize and strengthen as each side makes a move to which the other side has to make a response."

Asked if he would change his mind if

STAR WARS...Pg.3-SR

NEWARK STAR-LEDGER 12 Dec 1985 (17) Pg.14

Navy asks U.S. court to bar Jersey line from shipping cargo to Iceland

WASHINGTON (AP)—The Navy asked a federal appeals court yesterday to stop a tiny New Jersey shipping firm from continuing to carry military goods to Iceland, citing a diplomatic dispute that Secretary of State George Schultz claimed threatened relations with the strategically located island nation.

Government lawyers asked the District of Columbia Circuit of U.S. Court of Appeals to overturn a lower judge and reinstate the Navy's decision to ban Rainbow Navigation Inc. from carrying military cargo to a NATO base at Keflavik, Iceland.

Navy Secretary John Lehman Jr. suspended the Red Bank, N.J., carrier's exclusive right to the route in September, citing a never-before-used provision of the 1904 Cargo Preference Act that gives U.S. merchant ships the first crack at carrying U.S. military supplies. The provision exempts U.S. ships that charge "excessive or otherwise unreasonable" rates.

Rainbow operates a single, 300-foot freighter, which sails exclusively to Iceland and, before the Navy's intervention, carried about 85 percent of the military goods shipped to the base at Keflavik. The cargo represents up to 20 percent of all ocean trade between the U.S. and Iceland.

Alleging Rainbow's rates were too high, the Navy secretary opened the trade to three Icelandic lines.

But Rainbow lawyer Frank Costello told the appeals judges that Lehman based his decision not on rates, but after consultation with Schultz and Defense Secretary Caspar Weinberger.

Schultz and Weinberger, the lawyer alleged, were pressured by Icelandic officials who want their ships to handle 100 percent of the U.S. trade.

If Iceland doesn't get its way, Costello charged, officials have threatened to close the critical Keflavik base. The threat was denied by two Icelandic diplomats after the hearing.

But neither Icelandic nor U.S. officials dispute Lehman's action came after Icelandic officials complained about Rainbow's intrusion in the island's economy. Schultz, in an affidavit filed in the case, said Rainbow was "a major irritant in U.S.-Icelandic relations."

Schultz told U.S. District Judge Harold Greene, who overturned Lehman's order, that allowing Rainbow to carry the majority of U.S. military goods to Keflavik was angering Icelandic officials.

The Keflavik base is crucial to NATO's defense of North Atlantic sea lines and to the United State's ability to reinforce and resupply troops in Europe, Schultz said. In addition, the base, manned by 3,500 U.S. troops, offers a critical surveillance point for Soviet ships and aircraft, according to officials at the Icelandic embassy here.

"The United States' relationship with Iceland is extremely important to our country," said Schultz, warning the dispute could result in "retaliatory action by the government of Iceland."

Greene rejected the arguments by Schultz and the Navy, ruling Rainbow's cargo rights could be suspended only for excessive rates.

But Navy lawyer Peter R. Maier asked the appeals judges to overturn Greene, arguing the Navy weighed both economic and foreign policy grounds in acting against Rainbow.

Costello said Rainbow's rates were lower than or comparable to other shippers on small lines.

STAR WARS...from Pg.3-SR

now talking about developing its own weapons against medium-range missiles.

"The great loophole in the ABM Treaty," Mr. Smith said, "is not whether it permits the development of new exotic technologies, but whether, under the guise of antisatellite weapons and antitactical ballistic missile systems and radars, antiballistic missile defenses will emerge anyway. As I understand, the Administration intends to do just this."

Administration officials deny that this is their purpose, but acknowledge that they plan to move ahead in these areas. Moscow has already done so.

Amid all the complexities and counterarguments, one point is clear: in the absence of new agreements to close gray areas in old treaties and to ban or limit the development of new technologies, antiballistic missile capabilities will increase significantly on both sides in the coming decade.

NEXT: The rift among "Star Wars" researchers.

A 'Star Wars' Update

On March 23, 1983, President Reagan called on American scientists to find ways to erect a missile defense shield in space to render nuclear weapons "impotent and obsolete."

In the months that followed, his proposal, formally called the Strategic Defense Initiative and popularly called "Star Wars," began to be envisioned as one of the biggest research projects of all time, a five-year, $26 billion undertaking bigger than the Manhattan Project for the atomic bomb or the Apollo program to put men on the moon.

The space "shield" would not really be a shield but rather a complex network of systems, including laser beams, particle beams, electromagnetic "slingshot" rail guns and sensing, tracking and aiming devices, all requiring extraordinary coordination at many different levels and stages. Many questions about the program arose.

Last March, The New York Times published a six-part series of articles exploring these questions. It reported, among other things, that a move toward a new era of strategic thinking and nuclear competition had begun; that the roots of the American effort went deep into past decades; that an experimental laser station already existed in California's mountains; that Soviet research, too, was forging ahead; that defensive space arms could also be used offensively with devastating effect, and that many answers still seemed elusive about the plan's ultimate wisdom and feasibility.

Since that time, there have been several key developments, including a summit meeting between the superpowers in Geneva at which "Star Wars" was a principal topic of discussion and dispute.

This three-part series follows those events and reports important new developments as the "Star Wars" plan and the national debate over it move ahead

STAR WARS...from Pg.2-SR

a "Star Wars" system were found to be more costly, he said, "No sir, I would not, because I would think the additional cost in protecting people's lives, in protecting this nation, would be far worth anything that it would cost."

Richard N. Perle, Assistant Secretary of Defense for International Security Policy, sought to explain this further in an interview by saying that Mr. Weinberger "just did not want cost-effectiveness to be the sole criterion, and that he wanted to make people see the difficulties in interpretation of cost-effectiveness."

Mr. Gore said: "Any decision to discard this criterion would strip the program and the concept of its last shred of intellectual legitimacy. It would only stimulate a race to deploy offensive countermeasures. This was the realization that led us to the ABM Treaty in the first place. If they do this, they're saying, 'Damn logic, damn reasoned debate, full speed ahead!' "

Strategy Switch: Offense to Defense

As these problems are resolved, the Administration will also have to tackle the question that has given official planners the most trouble: namely, how to make the transition from a world dominated by offensive nuclear forces to one dominated by defenses.

For four decades, deterrence has rested on the idea that no matter which side struck first and no matter how vigorous the blow, the other could and would retaliate with a devastating blow. Thus, both would know there could be no meaningful victory, and neither would strike first.

The Administration contends that deterrence based on the threat of mutual annihilation is immoral. Further, it insists that technologies in the making will allow Moscow to make first strikes that could be successful.

The transition period, in which the Administration envisages a combination of offenses and defenses, could last 10, 20 or 30 years. And in the opinion of many, like Mr. Aspin, this period "would be far more dangerous and unstable than anything we've lived through so far."

The nightmare some imagine is that, for the first time, nuclear war might be made thinkable, and military planners would be able to calculate nuclear victory as follows: a first strike that knocks out more than 90 percent of the victim's offensive nuclear forces, plus defenses good enough to blunt most of what remained for a retaliatory blow.

Mr. Iklé and Mr. Perle say defenses will make nuclear war less thinkable, not more so. "From the moment deployment of defenses begins," Mr. Perle said, "you've complicated Soviet calculations needed for a first strike. Because of the defenses, Moscow could not count on being able to destroy enough of the retaliatory forces to make a first strike worthwhile."

But from a wide range of military and civilian planners in the Administration it appears that, as one of them put it, "We have not begun to think about, let alone explain to others, exactly what combinations of offenses and defenses would end up making the balance more or less stable."

Besides, the general view among these experts is that the transition from offenses to defenses could not be made safely without Russian cooperation.

Getting Moscow To Go Along

The Administration's public position on getting Soviet cooperation is upbeat. Mr. Iklé said agreement "won't come soon," but added, "In the long term, it is far more plausible that the Soviets will agree with us on the new strategic order that eliminates mass destruction of the Soviet Union if nuclear war were to break out."

To bring Moscow along, Mr. Reagan has offered to share "Star Wars" technology, although in private conversations, few in the Administration say this would be plausible.

Mr. Reagan has also ordered that all "Star Wars" programs be conducted in accordance with a "strict interpretation" of the Antiballistic Missile Treaty. Even critics of the program concede that this stricture has been followed — with the arguable exception of one or two planned tests. The "Star Wars" testing program has been limited to subcomponents, as distinguished from antiballistic missile components or systems themselves.

This stricture has been followed despite the Administration's assertion that the treaty actually allows development and testing of components and full systems of the new technologies.

Many arms experts dispute this interpretation, among them Gerard C. Smith, the chief negotiator of the treaty.

In any event, Mr. Reagan tried to convince Mr. Gorbachev of the virtues of space-based defenses at their meeting in Geneva last month. By all accounts, he got nowhere. Moscow's position remains that it will agree to cuts in strategic nuclear forces only if Washington agrees to restrict "Star Wars" to laboratory research.

As far as Mr. Smith is concerned, these positions will continue to block a treaty. A sizable number of Administration officials agree with him. "The alternatives are clear: arms control or a shot at developing defenses," Mr. Smith said. "As long as the President sticks to his position, we will have no arms treaty."

Even if Moscow were to show interest in negotiating a transition from offense to defense, it is far from clear that the Administration is in a position to lay out how to do so.

As Mr. Iklé said: "It's hard to talk to the Soviets about something we ourselves haven't thought through completely. We could discuss the transition only in the broadest terms."

The betting inside and outside the Administration is that Moscow's most likely response to "Star Wars" development will continue to be threats of more missile deployments. That view was bolstered inadvertently in a letter Mr. Weinberger sent to Mr. Reagan just before the summit meeting.

In it, Mr. Weinberger wrote that if Moscow were to deploy defenses, "even a probable territorial defense," such a development "would require us to increase the number of our offensive forces." This stands in direct contrast to the Administration's public position, a basic principle of its negotiating stance, that defenses should make it easier to reduce offensive forces.

The Future Of Arms Control

With the arms talks stalemated, one-sided decisions by both nations and the march of technology are moving to erode the old order of the Antiballistic Missile Treaty, the world in which the superpowers agreed to maintain peace through the threat of mutual annihilation rather than through defenses.

That was a major conclusion of a recent report by the Office of Technology Assessment, a research arm of the Congress. "The inherent limitations of language and the rapid pace of technology," the report said, "make it impossible to develop clear, unambiguous and objective standards by which to meassure all possible research programs" covered by the treaty.

One of many examples the report cites is one element of the space-based defense system called the "airborne optical adjunct." The Pentagon plans to test this element to determine the feasibility of using optical sensors from an aircraft. Calling the element an adjunct or a subcomponent, the report says, "depends less on objective determinations of capability than on how one defines those terms."

The report also notes Moscow's deployment of a radar at Abalakovo, in Siberia. Administration officials say the installation is a ballistic-missile early warning radar and say it violates the treaty stipulation that such radars can be situated only on the peripheries of the two nations.

The treaty permits space-tracking radars to be placed anywhere, and does not define the two kinds of radars. Moscow insists the Abalakovo radar is for space tracking and is thus not a treaty violation. There is no disputing the fact that the deployment of such radars in numbers in both countries would clearly defeat the purpose of the treaty.

Also, because the treaty only limits defenses against strategic, or long-range, missiles, Moscow has moved sharply to develop ballistic missile systems for use against medium-range missiles, sometimes known as antitactical systems. The Administration is

STAR WARS...Pg.4-SR

501

SPECIAL REPORTS

NEW YORK TIMES 17 December 1985 Pg.1 (19)

'Star Wars' in Strategy: The Russian Response

LAST OF A THREE PART SERIES

By CHARLES MOHR
Special to The New York Times

WASHINGTON, Dec. 16 — The debate over the "Star Wars" missile defense program is increasingly shifting to arguments about its real military value, as opposed to its mere technical feasibility.

Weapons in Space

How Program and Debate Are Moving Ahead

Last of three articles.

Would a space- and land-based shield against missiles offer meaningful protection to the United States? Or, even if it were to become scientifically plausible, would it, instead, weaken America's military power?

Most experts agree that present and prospective Soviet actions will bear heavily on the answers.

But whatever those answers are they will be crucial to what Lieut. Gen. James A. Abrahamson, director of the Strategic Defense Initiative Organization — the official name for the American missile-defense research program — says will ultimately "be the most complex and complicated decision ever faced by an American government."

And John E. Pike, a space analyst for the Federation of American Scientists who is generally critical of the program, agrees. He adds, however, "It is roughly comparable to the Hayes Administration's trying to decide if it wanted to buy an air force."

In most cases, the exact nature of the Soviet response to "Star Wars" and when the response will materialize is still uncertain and under dispute.

In a recent interview, General Abrahamson said the "only responsible" course, at least as the future looks now, is for the Kremlin to seek countermeasures that might baffle, or at least degrade, an American defense. "They are certainly going to try," he said.

In Moscow today, a Soviet military specialist today outlined possible countersteps to turn United States space defense systems into "useless junk." The Pentagon had no immediate reply to the writer's contention that Soviet countersteps, including dummy missiles and coated rockets, could cost "1 or 2 percent" of the cost of a "Star Wars" system.

A consequence of American expectations of the Soviet response, according to the general's key deputies, is that an analysis is now being done to see how a "Star Wars" defense could be most seriously threatened or damaged by Soviet countermeasures and tactics.

An example is a new study of space weapon platforms to see if their maneuverability can give more protection than hardening the weapons with protective armor. Another study seeks to find how a "shoot back" system meant to protect itself from attack might work in combat.

There is widespread agreement that the Soviet Union has been conducting large-scale research on some advanced missile defense technologies since the 1960's, and that the effort is determined and expensive.

But most experts in Soviet affairs and strategic issues continue to say the greatest short-term danger is not Soviet emulation of the American "Star Wars" program.

Rather, they say, a greater threat is that the Soviet Union would elect to significantly increase the numbers and striking power of its offensive missile force, develop a wide array of countermeasures, and possibly create nationwide, more traditional, land-based antiballistic missile, or ABM, systems, prohibited by the 1972 ABM treaty.

At the summit meeting in Geneva in November, Mikhail S. Gorbachev, the Soviet leader, warned that the Soviet Union would develop countermeasures if "Star Wars" work continues and the system is deployed, saying the Soviet countermeasures "will be effective, though less expensive, and quicker to produce."

Indeed, there has never been any ambiguity about Soviet officials' repeated threats of a missile buildup.

In an interview this fall, Marshal Sergei F. Akhromeyev, chief of the Soviet General Staff, said of the "Star Wars" testing: "If this process goes on we will have nothing to do but to take up retaliatory measures in the field of both offensive and defensive weapons."

Almost as soon as President Reagan proposed the "Star Wars" concept, declaring in March 1983 speech that his long-range intention was to make nuclear weapons "impotent and obsolete," the Administration recognized that a Soviet buildup of offensive arms in reaction would be a major problem.

Senior officials have stressed that the Administration's hope for a "highly effective" defense rests in considerable part on a mutually agreed reduction in offensive weapons — a diminution of the nuclear threat with which future defenses would have to deal.

Juggling Offense And Defense

This does not necessarily contradict General Abrahamson's theory of "responsible countermeasures." Both could exist at the same time; one nation could reduce its offensive weapons, built up its defensive ones, and at the same time develop means of countering its enemy's defenses.

General Abrahamson said such high development of defense "must be done in the context of dramatically lowering offensive weapons; this is something that must be negotiated." He added that "even partial defense is stabilizing" for Soviet-American relations.

The Administration theory is that defense is inherently good and that, even if a near-perfect defense is never feasible, any level of defense will "enhance deterrence" of nuclear war.

John L. Gardner, the defensive systems director under General Abrahamson, explained this point of view. His argument is that even a far-from-perfect ballistic missile defense will be valuable because it will "decrease the confidence of Soviet attack planners that they can achieve their attack goals," thus drastically decreasing the possibililty of a nuclear exchange.

For Mr. Gardner and for almost all other Administration strategic thinkers it is an article of faith that the Russians, planning their attack, would focus on targeting American strategic nuclear forces; command, control and communications centers; the national leadership, and other military targets.

Another problem lies in trying to ascertain at what point exactly the Russians will respond to American defen-

RESPONSE...Pg.2-SR

BALTIMORE NEWS AMERICAN 16 December 1985 (19) Pg. 9

Israel's spying should be of far less concern than the enemy's

By Marvin Leibstone

WASHINGTON

Israel has spied on the United States — and the United States has spied on Israel.

But are we listing misdemeanors or felonies?

If we refer to actual damage to U.S.-Israeli relations resulting from last month's revelation that Jonathan Pollard, an American, gave U.S. secrets to Israel, and recent accusations that Israel has tapped into U.S. embassies and spied on individual Americans, then Jerusalem's spymasters are guilty only of misdemeanors.

That is why U.S. and Israeli intelligence bosses have decided to keep cool. But it would seem that any relationship requiring spying must be teetering on the rocks.

Who is to blame in the Pollard case? Israel for recruiting and running him? The United States for making it difficult for Israel to obtain information it might have deserved outright?

A BIT OF history: In the mid-1970s, Israel wanted to know the whereabouts of thousands of M-16 rifles left in Vietnam by South Vietnamese and U.S. forces. It worried that these weapons could end up in the Middle East and asked for information from Washington. For whatever reason, the United States was slow to help.

During the same period, Washington, concerned about nuclear proliferation, asked Jerusalem repeatedly for confirmation that Israel could produce nuclear weapons. Israel's answers were vague.

The upshot? Israel sent intelligence agents into the field to find out about the M-16 rifles. According to a U.S. military official, agents snooped among Israelis to determine Jerusalem's nuclear capability.

It would be easy and therefore tempting to suggest that these countries do not trust one another entirely, and thus now and then send out a spy or two. But spying is more complex than that.

THE CURRENT Israeli embarrassment points to a significant fact about spying. Espionage is not only a method by which information is obtained. It is a commodity that brings in a high price and can be as effective a bargaining chip as an arsenal of weapons — even among friends.

When Israel captured Soviet tanks, weapons and communications equipment from Egyptians and Syrians during the 1973 Yom Kippur war, it realized that it had an "intelligence gold mine." The United States and other NATO countries would want to know everything about such items.

While Israel did not put price tags on each item, it reminded Washington that one good turn deserves another. Subsequent to information on Soviet equipment reaching Washington, U.S. loans and grants were made to Israel that exceeded previous amounts.

From 1973 until 1975, Israel provided information to the United States about potential uprisings in the Middle East and Soviet involvement. In turn, the United States gave information to Jerusalem about Arab terrorists operating outside the Middle East.

THE POINT HERE is that friends can be each other's clients. Whether two parties are trading in bananas, cooking oil or nuclear secrets, the items one side wants but which are not for sale can only be acquired through theft.

This does not justify Israeli spying in the United States, or U.S. agents operating in Jerusalem. It suggests that Israel and the United States spying on each other weighs much more heavily as "immoral research" than as treachery.

Some experts say that U.S.-Israeli relations deteriorated during post-Watergate investigations of the CIA. Israel watched one item of information after another leak to the press. Jerusalem lost confidence in America's ability to hold a secret.

By 1975, Israel's intelligence officials were passing less than half the information sent earlier to U.S. counterparts. From the efforts of a high-ranking U.S. military official and his Israeli counterpart, with a U.S. civilian acting as go-between, American officials learned that Israel was providing new military equipment to Christian forces in southern Lebanon.

THE CIVILIAN acted as a middleman between Jerusalem and Washington because Israel did not trust State Department or CIA bureaucracy with information it wanted sent only to America's highest military and civilian officials. But this led to a tit-for-tat mentality. The doors at several mid-level U.S. intelligence tiers were closed to Israeli contacts. The coolness lasted until 1978, when Israel realized Camp David would be a reality.

Not that closed doors were an excuse to use Pollard to get information in the United States. There is another reason why the Pollards, Walkers, Wu-tai Chins and Peltons of the world succeed as spies, at least for a while: You could call it "government opportunism."

It is a mistake to think that intelligence agencies operate with comprehensive plans. More often than not those plans are shallow. That is because placing a human asset close to an information target is difficult.

WHEN IT COMES to obtaining information, a spy agency, in addition to getting past security guards, has to consider electronic surveillance and counter-spies. Moreover, it is difficult finding a human being capable of getting the job done. Spies need to know other languages and customs, live a false identity and execute "tradecraft" to perfection. This requires a super IQ and enormous courage.

Easy access to the truth is rare in the spy business, every CIA director admits. So when a Pollard comes around, willing to deliver for cash, intelligence agencies are confronted with a striking opportunity. Most go for it.

One wonders if the CIA would turn away an Israeli scientist willing to sell nuclear secrets for, say, an amount equal to Pollard's recompense.

WILL ALL THIS eventually destroy U.S. and Israeli intelligence relations? Absolutely not, even if there are more revelations about Israeli snooping.

The two countries need each other's eyes and ears, just as much as Israel needs U.S. money and weapons and the United States requires a powerful Israeli military presence in the Middle East.

Besides, the United States has dumped the Pollard case in a larger pile of espionage problems.

Washington's main intelligence concern today is not counterspying against Israel but with those who might do us harm. The United States needs to clean up its act regarding penetrations by the Soviet Union, China, Cuba and other nations more potentially malevolent than Israel.

• *Marvin Leibstone writes for these pages on national and foreign affairs.*

RESPONSE...from Pg.1-SR

sive systems. They have promised to answer American deployment of a "Star Wars" defense, and have also demanded an end to all research on strategic missile defense technologies.

The United States argues that pure laboratory research cannot be prohibited because it is impossible to verify such an agreement.

In fact, late this year the Soviets unofficially acknowledged this. Vadim V. Zagladin, first deputy chief of the International Department of the Communist Party Central Committee, said the key was "how to draw the line between basic and applied research," with the latter to be prohibited.

Intelligence specialists in the Administration contend that Soviet research programs in advanced missile defense technologies in some cases surpass United States programs in size and in possible progress.

A joint State Department-Defense Department report this fall on Soviet strategic defense programs, says that the Russians "could have" prototypes of ground-based lasers to knock out ballistic missiles as early as the end of the 1980's. But the report added the more conservative note that an actual, operational Soviet defense shield "probably could not be deployed until the late 1990's, or after the year 2000."

Yet there seems to be some variance in official American assessments of the relative progress and status of the Soviet and United States research.

Defense Department officials say the Russians are making a lot of progress, sometimes citing some form of laser research. The 1985 version of an annual Pentagon report made public in March said the Soviets do not lead in a single area of defense military technology.

The Rand Corporation, a research institution that gives analytical advice to the Air Force, has done a number of studies of Soviet research programs. One study, published in May, concerned free-electron lasers, which General Abrahamson has recently identified as perhaps the most promising laser for antimissile defense. These lasers work by jiggling billions of electrons, free of their atomic nuclei, in powerful magnetic fields to emit concentrated light beams.

The May Rand report said the Russian effort was at least equal to the American one in this field, in terms of manpower and the "depth and breadth" of research in free-electron lasers. But the report said that American scientists had done twice as many experiments, which is the key to verifying a concept, and that they had obtained "significantly" better results.

In contrast, there is little doubt that, if the first Soviet response to Star Wars is, indeed, to get more missiles to saturate or overwhelm an American space shield, the Russians can do so, as they have working production lines.

Several experts have observed that from 1980 to 1984 the Soviet Union built more than 800 new intercontinental ballistic missiles, while the United States has not produced any intercontinental ballistic missiles for years.

Stephen M. Meyer of the Massachusetts Institute of Technology, who is an authority on Soviet military policy and a consultant to the Pentagon, says the Russians probably have about 1,000 missile boosters or rockets stored but not deployed.

As the debate over likely Soviet responses has evolved, it has thrown increasing doubt on such concepts as President Reagan's declarations that "Star Wars" technology could be shared with the Soviet Union.

Because of the asymmetrical nature of the basing of Soviet and United States strategic forces, several American analysts say exactly equal levels of defense would put the United States at a disadvantage. Echoing this view, General Abrahamson said this month that "it is imperative that we have a much more effective defense than they have."

If the elaborate space-shield system is to be put into effect, all agree that it system must be able to survive an attack, the quality American strategists call survivability. The experts are also trying to make the system "hard," or resistant to attack.

The Specter Of Soviet Attack

Col. George Hess, the "Star Wars" director for survivability, weapon lethality, space logistics and several other aspects of the program, said that "survivability of the system is probably the most critical element to the success of S.D.I."

In an interview, Colonel Hess said one analysis, carried out over the course of more than a year, has indicated that "we can improve the hardness of a deployed U.S. system with reasonable levels of expenditures." But, he added, "This doesn't say we can make them hard enough."

Critics say the system must have what is called enduring survivability, or the ability to withstand not only a large, quick "spasm attack" but also an attack of attrition.

Attention by outsiders and insiders has increasingly turned to the vexing problem of whether components, even if their creation is scientifically possible, can be integrated into an "operationally feasible" system, in which many components can be tied together in a whole that will not fail in a crisis.

Since spring computer experts have been debating whether reliable computer programs can ever be written that will insure that the "Star Wars" defense is trustworthy.

Although public attention has been drawn more to exotic elements like death-ray directed energy weapons, the problem of space logistics, or "the cost of access to space," is also important.

This is particularly true if the final system requires a constellation of thousands of satellites and many relay and fighting mirrors for lasers — the type of system that was called ideal in a study by the Strategic Defense Initiative Organization that was made public late this fall. After the first year of research on this problem, those conducting the study envisaged a complex, seven-layer system of weapon platforms. Other arrays of four, five and six tiers of weapons were also considered, as well as a system in which most components would be on earth, rather than in space.

Colonel Hess said that if the cost of lifting a pound of material can be lowered from the present price of up to $3,000 a pound to "$300 a pound or less, it becomes within the bounds of the reasonable."

He added that, with all such questions, "the burden of proof is clearly on S.D.I."

Those involved in the strategic debate are also beginning to concentrate on some other long-range effects of strategic defense. Skeptics say that wooing, or coercing, the Soviet Union into adopting missile defenses may kill the policy called "extended deterrence," the threat that the United States might first use nuclear weapons if the Soviet Union made a conventional attack on Western Europe. While some critics suggest that extended deterrence might disappear if the Soviet Union had defenses, "Star Wars" proponents think the policy is more credible if the United States has protection against missile attack.

It is also increasingly clear to most analysts that the now-vestigial American air defense will need to be recreated, because "Star Wars" will not be designed to meet threats from weapons like atmospheric bombers and low-flying cruise missiles. And, it is now being said that the antimissile defense would be much more effective with a serious civil defense program.

Another turn the Star Wars debate has taken has been renewed concern with what constitutes a perfect shield against missiles, a near-perfect one or, indeed, a leaky one.

In 1984 Ashton Carter, a Harvard University strategic and scientific expert, said in a report to Congress that a near-perfect defense was not possible. At that time, a year after President Reagan announced the "Star Wars" idea, the conclusion was controversial.

"Nobody thinks it is controversial today," one analyst said.

Instead of stressing the goal of a defense that is nearly perfect by the standard of how many Soviet nuclear warheads it could shoot down, Administration figures now stress that if "Star Wars" could only deny the Russians the ability to destroy the key military targets, which the Administration perceives to be the Russians' only goal, it would be "good enough."

George A. Keyworth 2d, the White House science adviser, has long been an adherent of President Reagan's "vi-

RESPONSE...Pg.3-SR

RESPONSE...from Pg.2-SR

sion" of a near-perfect defense of the American civilian population. But he said recently that, if a Soviet planner "can no longer be confident" in his war plans because of an American defense, then nuclear weapons "have been made obsolete since they have lost their military potential."

Congress Report Is Disquieting

Perhaps one of the most thought-provoking reports of the year on "Star Wars" was made public in September by the Office of Technology Assessment, an arm of Congress rather than the Administration. It raised some new questions about the rationale for "Star Wars." Though in many ways the report was severely critical of the proposal, one Administration "Star Wards" official called the study "excellent" and said "the level of the national debate is improving."

The Office of Technology Assessment team, drawing in part on analyses by the Rand Corporation, former Government officials and scholars, reached some disquieting conclusions.

Here are some of the conclusions of the report:

¶If both the Soviet Union and the United States have similar but limited defenses, the United States might protect more nuclear warheads in a Soviet first strike. But if the United States retaliated, fewer of its warheads would actually reach Soviet targets and explode there than under the current circumstances, because of the Soviet defense system. The net cost of nuclear war to Soviet leaders would thus be reduced, and war would become more thinkable.

¶In almost any scenario the existence of defenses makes striking first a more attractive option. If the Soviets were to strike first, for example, even a limited Soviet defense would have to deal only with a "ragged response" from a diluted United States retaliatory arsenal. Again, it was suggested that this would provide a theoretical incentive for nuclear conflict.

¶One of the most dangerous possibilities of all is a situation in which the defenses of each nation are to a significant extent vulnerable to pre-emptive attack by the other side. The argument here, too, is that this situation makes a first strike attractive.

¶The technological uncertainties of missile defense may lead to strategic uncertainty: with defense there will be more possible outcomes, but fewer certain ones, for a nuclear war.

The Planners Play War Games

The Office of Technology Assessment report aside, General Abrahamson's organization was already involved in strategic thinking. A satisfactory strategy, the general said, will be a vital element in the decision, which could come in six years, on whether to undertake full-scale engineering development, production and eventual deployment of an antimissile defense.

Strategic contingencies and possible Soviet responses are seen by the Defense Department analysts as indispensable tools in designing and integrating a workable defense.

General Abrahamson and his assistants, such as Mr. Gardner, say that they and their staffs have been involved in complex nuclear war games and nuclear exchange calculations.

Put simply, they argue that their strategic analysis tends to prove that at each level of defense, from modest to good, including mutal defense by the Soviet Union, that "deterrent posture is improved."

The Strategic Defense Initiative analysts, and those elsewhere in the Pentagon, say their studies are more sophisticated that those of non-Administration analysts and are based on more complete, secret data on Soviet and American military capabilities.

But one non-Governmental Soviet affairs specialist, who was recently invited with several colleagues to participate in a secret war involving "Star Wars" defenses, said: "We found we were playing against defense contractor personnel and others who know nothing about Soviet doctrine. It took our whole team, the Red Team, less than 20 minutes to agree that our first counter to 'Star Wars' would be to increase offensive missile numbers. Their team, the Blue Team, said, 'No, that is not how the Soviets think.' Every step we took suprised them."

As with other analysts, the Office of Technology Assessment researchers found confusion in the Government about the goals of "Star Wars," saying that "the pursuit of defenses able to protect the U.S. population and that of its allies in the face of a determined Soviet effort to overcome them does not appear to be a goal of the S.D.I. program."

Such a conclusion might seem controversial to those who have not closely followed the "Star Wars" debate, because President Reagan and other nontechnicans have often implied that active defense of people by a "shield" is a major goal.

The Office of Technology Assessment analysts buttressed their statement with a wide array of remarks by senior Government officials that seem to confirm their conclusion — that the more immediate aim of the plan is to protect missile silos, not people.

The difficulty of defending civilians is illustrated in a scenario that has been postulated several times by non-Administration analysts.

According to this scenario, a "99 percent effective" missile defense would not protect 99 percent of the American population; it would only shoot down 99 percent of Soviet missile re-entry vehicles or warheads. If such a defense existed, the Soviet Union could simply target 100 warheads on each of the 90 most populous cities in the United States; with such a defense, the Russians could be confident of destroying almost all of their targets.

The Office of Technology Assessment estimated that between 10 million and 25 million deaths could result from such a "leakage rate." The report said deaths could be kept to one million or fewer only with defense that was 99.9 percent effective or better.

Another consequence of the debate over the value of "Star Wars" is the new attention to what is called "rational" Soviet military doctrine.

The Administration position rests in part, for example, on an assumption that it would be lunacy for the Russians to choose cities rather than purely military sites as their targets. That assumption is based essentially on the theory that attacking cities would bring horrible retaliation.

Critics argue, however, that this assumption may not be valid. "It is conceivable that you could have a defense so good that the Soviets would have to aim 100, or 200, warheads at each of our largest cities," said Thomas H. Karas, a space policy analyst and the director of the Office of Technology Assessment team that prepared the report.

In any case, when decisions about the effectiveness and actual working structure of a missile defense depend heavily on what is called rational Soviet military policy, the nature of the "Star Wars" debate changes.

"You find that you are no longer arguing about strategic defenses, but that you are arguing about concepts of nuclear war fighting," said Peter Sharfman, manager of the international security program in the Office of Technology Assessment. "It is a proper argument, but goes way beyond the technical analysis of what defense can or cannot do."

Mr. Karas said: "An interesting question is: Did we feel secure in the early 1960's when the Soviets had a small number of inaccurate warheads that could only be used against cities? And that is essentially what S.D.I. is offering the prospect of returning to."