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## **“BRILLIANT PEBBLES”: THE REVOLUTIONARY IDEA FOR STRATEGIC DEFENSE**

*Imagine thousands of tiny satellites orbiting the earth. Each is actually a little rocket, no more than 40 inches long, and capable of tracking objects in space on a minute's warning. Imagine an enemy launching hundreds of nuclear ballistic missiles at the United States. The attack is detected, the tiny space rockets are activated, and they race toward the enemy missiles. At the edge of space, just above the earth's atmosphere, these missiles encounter a hail of fire as they crash into hundreds of the small rockets. Many enemy missiles are destroyed, along with their nuclear warheads, as if blasted by a gigantic, spaceborne shotgun.*

This is not the stuff of science fiction. The Strategic Defense Initiative Organization (SDIO), the Pentagon office responsible for developing strategic defenses, is conducting research on just such a system, a revolutionary concept dubbed “Brilliant Pebbles.” It would deploy thousands of missile interceptors in low-earth orbit, circling like satellites some 400 miles above the earth's surface.

**Central Ingredient.** These interceptor rockets are called “pebbles” because they are tiny and destroy their prey by smashing into them. Larger interceptors have been called “space rocks” by experts. They are called “brilliant” because they are “more intelligent” than the existing so-called “smart” rockets which can reach their targets largely on their own – hence the term “smart” – with little guidance from a centralized command and control system. The Brilliant Pebbles are “more intelligent” because they are more accurate and need less outside assistance than do other strategic defense missiles. The technologies and concept of Brilliant Pebbles were developed by Lowell Wood and a team of scientists at the Lawrence Livermore National Laboratory in California.

Brilliant Pebbles can become a central ingredient of SDI. Said Defense Secretary Richard Cheney before the House Armed Services Committee last April 25: "A restructured [SDI] program would continue toward deployment of a system that will meet the requirements of Phase I by focusing on evaluating the potential of the most rapidly advancing technologies such as Brilliant Pebbles."<sup>1</sup> Phase I is the Pentagon's plan for the first stage of SDI deployment. Since Cheney's testimony, SDIO has established a series of tests for the Brilliant Pebbles system to determine the capabilities of its technologies. Those tests are scheduled to take about three years, beginning this year.

**Highly Effective.** Technological advances make Brilliant Pebbles possible. These include the development of extremely small and lightweight micro-electronic components for computers, new wide-field-of-view cameras for improved missile guidance, powerful rocket motors, and laser communications systems. The designers of Brilliant Pebbles have exploited these technological advances to produce what promises to be a highly effective weapon against ballistic missiles. The test program is designed to validate the capabilities of the technologies and the system as a whole.

As a result of the technological advances, Brilliant Pebbles is the most promising development to emerge since the SDI program was launched in 1983. It offers the possibility of deploying an effective space-based defense against ballistic missiles by the middle of this decade because the technologies to be used in the system are already available. Strategic defense is needed because Soviet offensive missile programs continue to grow, notwithstanding *glasnost* and *perestroika*. What may be more important, even if the Soviet threat disappears, Third World countries like Iraq, Libya, and Syria have or are developing ballistic missiles that could be armed with nuclear, chemical or biological warheads and that could strike U.S. allies and eventually even the territory of the U.S. itself.

**Relying on Current Technology.** With its estimated \$25 billion price tag, Brilliant Pebbles could cut as much as \$44 billion out of the currently estimated \$69 billion price tag of a deployed SDI system. The Brilliant Pebbles system would be so cheap because its interceptors rely on current technology and do not depend very much on an expensive centralized command and control system.

As an important added benefit, Brilliant Pebbles is also more survivable against enemy attack than other SDI near-term deployment proposals. Unlike other systems, such as the Space-Based Interceptor (SBI) currently under development by SDIO, Brilliant Pebbles will employ thousands of very small interceptors. This huge number ensures that vast amounts of them would survive assaults by Soviet anti-satellite weapons. The reason: the more defense interceptors there are, the harder it is for the Soviets to destroy them

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1 Richard B. Cheney, "Statement Before the House Armed Services Committee," April 25, 1989, p. 8.

all in an attack. By contract, the space-based interceptor will be clustered on just 200 or fewer satellite platforms. The cheaper unit cost of the Brilliant Pebbles interceptor – currently estimated to be several hundred thousand dollars apiece compared to \$9 million for a SBI interceptor (SBI is estimated to cost \$18 billion for no more than 2,000 interceptors) – makes deployment in such large numbers possible.

Because the Brilliant Pebbles system is decentralized and each interceptor can operate largely on its own, the destruction or failure of several interceptors will not detract significantly from the capability of the system as a whole. This way an attack by Soviet anti-satellite weapons could not knock out the entire system by destroying only part of it. In essence, the Brilliant Pebbles system would work like modern Christmas tree lights; the string of lights stays on even if one or two lights burn out, instead of going out entirely as was the case in the old-fashioned tree lights that operated on a serial electric current.

Brilliant Pebbles is an important breakthrough that deserves the support of the Pentagon and Congress. To ensure that the SDI program derives as much benefit as possible from the Brilliant Pebbles technology, the Bush Administration should:

◆ ◆ **Make full funding of the Brilliant Pebbles test program a top priority for SDI.**

It will be impossible to determine whether Brilliant Pebbles truly is a major breakthrough in missile defense systems without testing it. Experts estimate the Brilliant Pebbles test program to cost \$250 million. While the federal budget pressures on the SDI program are enormous, Brilliant Pebbles offers such promise for deploying cheap and effective defenses against missiles soon that its testing program should be protected against budget cuts.

◆ ◆ **Carefully supervise the Brilliant Pebbles test program so that it is not disrupted or delayed by the Pentagon bureaucracy.**

Too often, promising research on a defense technology is delayed by bureaucratic red tape or opposition from the military services. For example, defense contractors working on SDI systems proposed an architecture similar to Brilliant Pebbles in 1986 but the SBI architecture was chosen by the Air Force, which was supervising the contract. SDIO should either supervise the Brilliant Pebbles test program directly or keep a very close watch on other Pentagon agencies, such as the Air Force, that may be assigned to manage elements of the test program.

◆ ◆ **Combine the Brilliant Pebbles program with the Space-Based Interceptor (SBI) program.**

SBI is the space-based weapon the Pentagon currently plans to deploy in the first phase, or Phase I as SDIO calls it, of a U.S. strategic defense system. The Phase I plan would cluster SBI interceptors on fewer than 200 satellite platforms dubbed “garages.” Brilliant Pebbles, however, would be more effective than SBI, destroying more enemy missiles more cheaply. Further,

many of the technologies employed by SBI are similar to those used by Brilliant Pebbles. As such, the two programs should be combined to avoid wasteful duplication, save money, and strengthen the Brilliant Pebbles program itself.

◆ ◆ **Plan to incorporate Brilliant Pebbles into the existing Phase I SDI deployment plan.**

If the Brilliant Pebbles technology proves itself, it should be incorporated into the SDI's Phase I deployment plan. Pentagon planners want to deploy Phase I this decade. Brilliant Pebbles is not currently in the Phase I plan because it was developed after 1987, when Phase I was approved. Thus, including Brilliant Pebbles in near-term deployment plans for SDI will require the revision of Phase I's so-called "architecture," or the structural design of the SDI system.

## **THE STRUCTURAL DESIGN OF BRILLIANT PEBBLES**

Brilliant Pebbles interceptors are 40 inches long and weigh less than 100 pounds when fully fueled. They would weigh about 10 pounds without fuel. When launched into space, they would orbit the earth at the relatively low altitude of 400 miles and would track and crash into enemy missiles at very high speeds.

The name Brilliant Pebbles comes from the interceptor's small size and sophisticated guidance system. Similar weapons capable of self-guidance have been referred to as "smart rocks." A Brilliant Pebble is a smaller, more accurate "smart rock." These interceptors would be deployed in space by the thousands, ensuring that hundreds of individual interceptors would orbit directly above enemy missile fields at any given time. From there, they could intercept launched enemy missiles as the missiles climb out of the earth's atmosphere.

**Becoming Routine.** The light weight of the interceptor makes it easier and less costly to put the system into space. At the current rate of \$3,000 per pound to put a payload into low-earth orbit, each "pebble" could be launched into orbit for under \$300,000. Since the U.S. would launch thousands of interceptors into orbit, the unit launch cost is likely to be much lower. This would be the case because deploying the interceptors will become a routine matter, allowing for maximum efficiency and reducing the launch cost per "pebble" to well under \$200,000. By contrast, at the rate of \$3,000 per pound, it would cost an average of \$30 million to launch an SBI satellite "garage" into orbit.<sup>2</sup>

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<sup>2</sup> For a discussion of launch costs associated with the SBI system see, John Gardner, *et al.*, *Missile Defense in the 1990s* (Washington, D.C.: The George C. Marshall Institute), p. 9.

One of the criteria established by the Bush Administration for the deployment of missile defenses is that they survive attack by Soviet anti-satellite weapons. The Brilliant Pebbles system is designed to satisfy this survivability criterion. Because Brilliant Pebbles interceptors are deployed separately, rather than clustered together on a large satellite platform, and because each interceptor operates on its own with little guidance from a centralized command and control system, they are highly survivable against attack. The destruction of even a hundred interceptors would not cause the entire defensive system to collapse because each is autonomous and does not depend on the survivability of other interceptors to function properly. Thus, for the Soviets or others to disable the system they would have to target and destroy all of the thousands of the small rockets deployed in space.

**Cost-Effective.** Another criterion established by the Bush Administration is that a strategic defense system be "cost effective at the margin," a concept first introduced by Reagan arms control advisor Paul Nitze in 1985. This means that it must cost the U.S. less to deploy SDI than it would cost an enemy to overwhelm SDI with large numbers of offensive missiles.

Brilliant Pebbles is likely to meet this requirement because of its relatively low cost. The interceptors are estimated to cost several hundred thousand dollars apiece and to last for ten years in space. Former SDIO Director James A. Abrahamson estimated in 1988 that one version of a complete SDI system employing Brilliant Pebbles would cost only \$25 billion. It could be deployed over a period of three to five years. This is compared to the estimate of \$69 billion for the current Phase I SDI system over five to seven years. It compares favorably as well to U.S. offensive missile programs, such as the single-warhead *Midgetman*, which will cost \$40 billion.

At such low costs, it is near certain that the Soviets would have to spend more on offensive systems to defeat or overwhelm Brilliant Pebbles by building more missiles. Assuming that the Soviet SS-18 missile costs about as much as the U.S. MX deployed in a silo, the deployment costs of Moscow's 308 missile SS-18 force likely exceeded \$60 billion.<sup>3</sup> And the SS-18 force is only one-fifth of all Soviet land-based missiles. Thus, the cost of the SS-18 force is far more than the \$25 billion for a U.S. strategic defense system based on Brilliant Pebbles that would defend against the entire Soviet land-based missile force.

## DEPLOYMENT OPTIONS FOR BRILLIANT PEBBLES

There are several options for deploying Brilliant Pebbles in a SDI system. Before he left office in 1989, former SDIO chief Abrahamson proposed what he believed were the best two. They are:

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<sup>3</sup> Estimating the cost of individual weapons systems produced by the Soviet Union is difficult without access to classified information. As such, the figures given here should be considered rough estimates.

**1) Simplified Brilliant Pebbles deployment.** Several thousand Brilliant Pebbles interceptors would be deployed in conjunction with a missile attack warning satellite system, plus command, control and communications facilities in space and on the ground. This deployment would meet the military requirements established by the Joint Chiefs of Staff for SDI in 1987: reported to be the successful interception of 50 percent of SS-18 missile warheads and 30 percent of all Soviet warheads in a large-scale attack on the U.S. According to Abrahamson, this deployment plan would cost \$25 billion over some five years.

**2) Multi-layered missile defense system.** This plan would add ground-based missile interceptors plus space-based and ground-based sensors to Abrahamson's "simplified Brilliant Pebbles architecture." The additional ground-based interceptors would include several thousand Exoatmospheric Reentry vehicle Interceptor Subsystem (ERIS) missiles, which would destroy incoming warheads outside the atmosphere by smashing into them, and 1,000 High Endoatmospheric Defense Interceptor (HEDI) missiles, which would do the same inside the atmosphere. The additional space-based sensors would consist of the Space Surveillance and Tracking System (SSTS), which is a satellite deployed in orbit some 6,000 miles high to discriminate between real missile warheads and decoys during the mid-course portion of a missile's flight. The additional ground-based sensors would include sensors and radars, also designed to discriminate between real warheads and decoys. According to Abrahamson, these additional weapons and sensors would cost between \$25 billion and \$30 billion to deploy. Thus, the entire multi-layered deployment plan, including the "simplified Brilliant Pebbles" system, would cost \$50 billion to \$55 billion over seven years.

## **THE COMPONENTS OF BRILLIANT PEBBLES**

Most Brilliant Pebbles would intercept and destroy enemy ballistic missiles in the so-called "boost" and "post-boost" phases of flight, which occur for up to five minutes after launch. With additional sensor capabilities, the interceptors even may be able to destroy missile warheads during the "mid-course" stage of flight, between 5 and 25 minutes after launch, when the warheads are moving over great distances and at high speeds through space. Mid-course intercept, however, is not a requirement for Brilliant Pebbles at this time.

**Wide-field-of-view Imaging System.** Each Brilliant Pebble interceptor contains an on-board imaging system, which provides electronic "pictures" of missiles in flight based on the heat and light they emit. This allows each interceptor to monitor objects in space and detect the presence of ballistic missiles. The sensor's wide field of view allows the system to monitor vast areas of space. The sensor can detect energy emissions from a wide range in the electro-magnetic spectrum, including the visual and the ultraviolet ranges. It can, therefore, track an enemy missile "visually," much as the human eye could, by picking up the light emitted by the missile. Or it can sense the heat of a missile's exhaust plume.

It is this sensor that allows each "pebble" interceptor to operate autonomously. Because it is able to detect and track enemy missiles on its own, it does not require that outside information, collected by other sensor systems, be fed to it.

This wide-field-of-view imaging system also enables the Brilliant Pebble to track stars and get a fix on its precise location in space. Using navigational principles not all that different from those used by the ancient mariners, the interceptor's exact position is determined by a process called "pattern matching" stars, in which the imaging system compares computer memory pictures of star patterns with those photographed by the wide-field-of-view camera as the interceptor flies through space. The sensor monitors the stars and feeds the information to the interceptor's on-board computer, which then calculates the interceptor's location based on its position in relation to the stars.

**Miniature Supercomputers.** Each Brilliant Pebble carries a supercomputer to process the information obtained from the sensor system. Though only the size of a deck of cards, this computer boasts the processing capability of a Cray-1 model supercomputer, among the world's most powerful. The Brilliant Pebbles computer is designed to run off high-energy, D-sized batteries. It can make rapid calculations of the stars' positions for purposes of navigation; it can process data on the whereabouts of enemy missiles; and it can help the guidance system steer the interceptor toward its target.

Its computer frees each Brilliant Pebble from dependence on sophisticated battle management computers on earth or in large satellites orbiting the earth. Although the Brilliant Pebbles computer requires little outside assistance to operate properly, it nonetheless will need "permission" from human commanders to attack enemy ballistic missiles. Since Brilliant Pebbles is not an automatic system, there will be no accidental launches by interceptors on U.S. or even Soviet missiles that are merely being tested or used for other peaceful purposes.

**High-performance Rocket Motors.** Brilliant Pebbles interceptors rely on powerful rocket motors to propel the missile, and steer it into the path of an enemy missile. The interceptor is designed to speed at some four miles per second in space in the closing moments of the chase, just before impact. Small rockets on the sides of the interceptors called "lateral thrusters" can fire bursts as brief as hundreds of milliseconds, enabling Brilliant Pebbles to maneuver with a high degree of precision. The interceptor must maneuver itself directly into the path of a ballistic missile, which will be moving at speeds up to 24 times the speed of sound. What makes Brilliant Pebbles particularly safe is that they carry no explosive warhead. They destroy enemy missiles by the sheer force of the collision with them. The impact at very high speeds, notwithstanding the fact that the interceptor weighs only a small fraction of the ballistic missile, is sufficient to annihilate its target.

**Monopropellant Fuel System.** Unlike some other rockets that store oxygen separately and mix it with fuel at the time of combustion, Brilliant Pebbles has an oxidizer already mixed with the fuel. It is called a "monopropellant

fuel system," meaning that there is a single, self-contained fuel system needing no separate oxidizer. This monopropellant system is highly efficient. It gives the Brilliant Pebbles interceptor not only its range, but a space life span of ten years.

**Redundant Communications Systems.** Brilliant Pebbles interceptors will not be "released" to seek and destroy target missiles until they are ordered to do so by a human commander. The system will be controlled by humans, not by computers.

The Brilliant Pebbles architecture will employ two independent communications systems to relay orders from human commanders on earth. One system will do so through a surveillance satellite in geosynchronous orbit. In this type of orbit a satellite does not go around the earth but maintains the same position relative to the earth's surface. The second system will relay the orders back and forth between Brilliant Pebble interceptors after the orders have been received from the commander on the ground. Having two communications channels will ensure reliability and protection against disruption by the enemy because one channel is always there to back up the other.

**Space "Life Jacket."** Protecting each Brilliant Pebble from the flying debris, dust and extreme temperatures of space will be what designers call a "life jacket." It will consist of a solar energy collector panel and rechargeable battery to provide electrical power for the interceptor and of an outer cover to protect against extreme temperatures. This "life jacket" also will protect the interceptor from damage caused by such space debris, as small pieces of old satellites. The life jacket would be shed by the interceptor after it is ordered into battle, right before it is fired at the incoming ballistic missile.

Taken together, these components comprise a highly effective space-based strategic defense system. As described by Lawrence Livermore Laboratory's scientist and Brilliant Pebbles designer Lowell Wood, a Brilliant Pebble has its own eyes (the on-board sensors), ears and mouth (the communications systems), brain (the computer) and legs (the rockets and fuel system). Most important, it will destroy enemy ballistic missiles when they are most vulnerable, which is in the first stages of their flight.<sup>4</sup> It is then that they are most subject to the stresses of trying to leave the earth's atmosphere, and are still carrying their many warheads, which can only be released later in the flight.

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<sup>4</sup> Lowell Wood described Brilliant Pebbles in these terms in a speech sponsored by the Center for Peace and Freedom in Washington, D.C., on June 30, 1989.



## THE BRILLIANT PEBBLES TEST PROGRAM

SDIO Director Lt. General George L. Monahan announced last May 12, that Brilliant Pebbles would undergo a three-year test program to demonstrate and validate its technologies.<sup>5</sup> The program will start this year and end in 1992. The total test program cost: \$250 million. The Pentagon spent \$46 million on Brilliant Pebbles in 1989, and it is estimated that another \$130 million will be spent in 1990.<sup>6</sup>

The test program will include twelve flight tests. Test versions of Brilliant Pebbles already have flown on SDIO's ARGUS NC-135 observation aircraft; this demonstrated the ability of the Brilliant Pebbles sensor system to track targets. The review of the Brilliant Pebbles concept is being conducted by both SDIO and outside experts. Among these is the so-called JASON Study Group of prominent scientists commissioned by SDIO last spring to study the overall system.

**Early Flight Tests.** According to SDIO Director Monahan, the first eight flight tests will not launch interceptors into orbit. They will be fired into space and drop immediately back to earth. An early flight test, for example, could launch a test "pebble" above the earth to search for a target that simulates an enemy rocket. A later flight test, by contrast, would place an unarmed interceptor into orbit containing its full complement of communications systems to determine the ability of ground commanders to control the interceptor.

Assuming that Brilliant Pebbles successfully completes the full cycle of tests by 1992, Monahan said that full-scale development of the system could begin in 1993, with production starting three years later. Thus, Brilliant Pebbles could be deployed before the close of the century. Monahan's predecessor, General Abrahamson, however, has stated that initial deployment could start within a little over four years.

**Technical Promise.** Preliminary indications are that the Brilliant Pebbles technology will work. The JASON Study Group determined last fall that the program showed enough technical promise to continue testing. The exact conclusions of JASON's findings are classified, but they confirmed the workability of the basic technologies of Brilliant Pebbles.

A major question is whether the Brilliant Pebbles test program it will have adequate funding. Congress voted to cut some \$1 billion from last year's \$4.9 billion request for SDI. SDIO is currently revising its budget allocations to account for these cuts. Preliminary indications are that SDIO will not cut the

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5 For a description of portions of this press conference, see Thom Shanker, "Star Wars' Tests Set for 1990," *The Chicago Tribune*, June 22, 1989, p. 1.

6 Patricia A. Gilmartin, "SDI Officials Plan to Boost Brilliant Pebbles Funding," *Aviation Week and Space Technology*, November 27, 1989, p. 21.

Brilliant Pebbles test program. SDIO officials are saying privately that the program will receive some \$130 million in fiscal 1990. This would come from a pool of funds amounting to \$200 million for space-based interceptors.

## **THE NEED FOR A STABLE PROGRAM**

As the Bush Administration plans to proceed with the Brilliant Pebbles test program, it should appreciate that no SDI program holds the prospects of doing so much at so little cost. Brilliant Pebbles could revolutionize strategic defenses. This will never be known, however, unless the program and testing proceed on schedule. Brilliant Pebbles could be a spaceborne defense system as effective as any so far envisioned by SDI planners, but at a cost far below the \$69 billion for the current Phase I system of SDI. To ensure that Brilliant Pebbles fulfills its promise, the Bush Administration should:

**1) Protect the Brilliant Pebbles research and testing program against budget cuts.**

Given Brilliant Pebbles' extraordinary promise, only scientific impediments should be allowed to delay its progress. This will require that the program be fully funded. It seems that SDIO understands this and is prepared to protect the Brilliant Pebbles program against budget cuts. Brilliant Pebbles needs some \$130 million in fiscal 1990.

**2) Avoid bureaucratic roadblocks.**

It is not unusual for promising military research and development programs to be delayed (even derailed) by bureaucratic red tape or squabbling. Frequently, such infighting is a result of "turf battles" between and among Pentagon bureaucracies and contractors attempting to protect special interests. Example: When the Air Force was supervising so-called architecture studies for the space-based elements of a future SDI deployment in 1986, it chose the SBI satellite architecture over one that resembled Brilliant Pebbles. Reportedly, part of the problem was that several Air Force program offices were supervising the studies. This led to disarray as the various offices issued conflicting instructions to the contractors conducting the studies. Also the Air Force wanted to make sure that sensor and tracking systems associated with the SDI program would receive special consideration. Apparently, they hoped to ensure that the sensor programs would survive even if the overall SDI program were abandoned. Thus, they preferred that the space-based weapons be housed in satellites with elaborate sensors on board, ones that could assist in discriminating between missile warheads and decoys. These sensors could always be used for early warning and tracking missions associated with the offensive missile force. Finally, the Air Force was concerned that thousands of individual interceptors could not be adequately controlled. Battle management problems were a concern at that time, particularly in Congress. The Brilliant Pebbles system, however, envisions communications systems that can control the individual interceptors.

Such institutional preferences should not be allowed to disrupt or delay Brilliant Pebbles. To avoid this, SDIO should block attempts by the Air Force or any other military service to delay Brilliant Pebbles because they have a special interest in protecting other missions such as early warning for the offensive nuclear force.

**3) Combine the Brilliant Pebbles and SBI programs.**

Brilliant Pebbles will perform the same mission as the SBI. When the Defense Acquisition Board, a group of senior Pentagon officials advising the Secretary of Defense on weapons purchases, approved SDIO's Phase I plan in July 1987, the SBI system was designated as the weapon for the space-based layer of the SDI system. At the time, Brilliant Pebbles had not progressed far enough to be considered for Phase I. Now it has. Brilliant Pebbles appears to be a more capable system than SBI. But Brilliant Pebbles could gain from research already completed on SBI. The technologies under investigation by the two projects are similar. They both employ hit-to-kill technology and are designed to destroy enemy missiles in the early stages of their flight trajectories.

Given the similarity of the two systems, SDIO should explore the possibility of combining them in some way. It well may be that some SBI technologies could make the Brilliant Pebbles system more capable, possibly in rocket and communications systems. Thus while the satellite components and computing systems of the SBI program could be terminated, the rocket and communications systems could be transferred to a reconstructed Brilliant Pebbles program. Similarly, the contractors working on SBI, Rockwell International Corporation and Martin Marietta Corporation, may be able to contribute to the Brilliant Pebbles system in a way that neither SDIO nor the Lawrence Livermore Laboratory may be able to do. They could provide, for example, the industrial capability for ultimately producing the system. Combining the programs could mean a total program cost for Brilliant Pebbles of \$200 million for fiscal 1990.

Given the tight budgets for SDI, it would be imprudent to fund the two programs fully since they are duplicating research on the same kind of technologies and are intended to perform the same kind of mission in the SDI plan.

**4) Plan to incorporate Brilliant Pebbles into the Phase I SDI deployment plan.**

If the test program demonstrates the validity of the Brilliant Pebbles concept, SDIO will have to consider modifying the existing Phase I architecture. Brilliant Pebbles is not included in existing Phase I plans. Revising the Phase I architecture need not be a major undertaking. It simply could substitute Brilliant Pebbles for SBI. Nothing else need be changed in the architecture. So proceeding would maintain continuity in the program because the basic features of the Phase I plan and its capabilities would be retained. By the same token, SDIO could decide to reduce the cost of an initial SDI deployment by proposing the sort of simplified Brilliant Pebbles

architecture proposed by Abrahamson in 1989. If this were done, several of the expensive ground-based missile systems currently or tentatively planned for Phase I, including ERIS and HEDI interceptors and the Space Surveillance and Tracking System (SSTS) sensor, could be dropped.

## CONCLUSION

The development of Brilliant Pebbles likely will prove to be an historic milestone in America's effort to develop and deploy an effective defense against ballistic missiles. The record of impressive progress in the program merits continuing efforts to realize the potential of Brilliant Pebbles. Institutional preferences among the military services should not be allowed to interfere or delay progress in developing and ultimately deploying this promising system. If the progress being made on Brilliant Pebbles continues, it is clear that the U.S. will be able to begin deploying an effective defense against ballistic missiles in the next five to seven years.

**High Stakes:** To realize this potential, several steps should be taken.

- 1) The Brilliant Pebbles test program should be protected against budget cuts.
- 2) The SDIO should retain control of the test program, protecting it from the parochial interests of the military services.
- 3) Brilliant Pebbles should be combined with the SBI program to avoid duplication, save money, and improve the prospects of success for Brilliant Pebbles.
- 4) The near-term or Phase I deployment plan for SDI should be modified to include the Brilliant Pebbles system.

If these steps are taken, the U.S. is certain to get as much out of the Brilliant Pebbles program as possible. If not, then one of the most promising new ideas to emerge from SDI could be lost. Given the enormous pressure put on the SDI program by its critics, the Administration can ill afford to squander the extraordinary opportunity for furthering SDI presented by Brilliant Pebbles. The stakes are very high. The failure to take full advantage of this opportunity could doom the prospects for deploying missile defenses before the end of the century.

Baker Spring  
Policy Analyst