APPENDIX H

Theater Missile Defense, National IBM Systems, and the Future of Deterrence

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Mch has changed over the decades in regard to the desirability of and the capability for defense against ballistic missiles. Now attention to ballistic missile defense (BMD) in the United States is directed toward theater missile defense (TMD), nominally for defense against short-and intermediate-range ballistic missiles (up to 3,000 km or so) armed with nuclear, explosive, chemical, or biological warheads.

Defense is proposed to extend to U.S. forces abroad, allied forces, and the capitals or cities of friendly or allied nations. In addition, it is proposed to use the same technology to have a light defense of U.S. territory itself against "accidental launch" by Russia, or against small attack by a so-called "rogue" state.

But much has remained the same.

CONTEXT

For three decades the United States has had no defense against the nuclear armed ballistic missile force of the Soviet Union, relying instead on deterrence by threat of nuclear retaliation. Repeatedly we made an effort to structure an effective defense, but the sole deployment decision (Safeguard) ultimately promised no effective defense even of our strategic offensive force, but rather provided a testbed to perfect the antiballistic missile (ABM) software.

Nevertheless, had it been technically feasible to deploy a highly effective and durable ABM, we would have chosen to do so. And had the Soviet Union been able to field an "effective" ABM, the United States would have responded by expanding its missile force to overwhelm the defense, enhancing the force with penetration aids to defeat the defense, or underflying or bypassing the defense with cruise missiles, bombers, or other nonballistic missiles. Of course, a truly dominant defense that could not be overcome, underflown, or otherwise bypassed would be another matter entirely.

The no-ABM case is simple to analyze—on both sides. Its perceived problems include the clear reliance on deterrence of attack by threat of retaliation rather than on protection in case of attack—hence vulnerability to accidental or unauthorized launch. However, deterrence by means of retaliation can be defeated only by defenses that counter all the means of destruction and penetration available to the other side. It is essential to understand that military systems have to deal with an intelligent adversary rather than a predefined threat; the perfect ABM may fail catastrophically, or it might be bypassed.

An antiballistic missile defense with the goal of denying the other side's deterrence by means of nuclear retaliation against the society itself—population and industry—has an extraordinarily difficult task. Fundamentally, this difficulty arises because the enormous destructive power of a nuclear weapon means that a half-megaton weapon could kill a half million people; a weapon plus delivery system costing $10 million to $100 million could destroy value on the order of $500 billion (assuming $1 million per life). Another metric compares how much it costs the offense to overcome the defense and, ultimately, the cost exchange ratio between offense and defense—not for holding the damage precisely constant, but retaining a similar magnitude of damage.

In general, defense can be very costly if the requirement is to maintain near-perfect protection against a responsive adversary. The offense, for instance, can choose the specific target; can exhaust the local defense with warheads, dummies, or decoys; or can use enough weapons to leak through the imperfections if not to overwhelm the defense; or can attack the defense specifically ("the eyes of the system," for instance, which are often more fragile or more visible than the targets themselves).

This essay is not itself a book on the future of deterrence and warfare, centered on missile defense; rather, it is a sketch of the current situation regarding tactical and strategic missile defense, with indications of the relationship to deterrence and warfare.

BACKGROUND

This essay is informed by the author's involvement with strategic offensive and defensive forces since 1952 and with every successive generation of proposal or deployment of ballistic missile defenses.

Indeed, the revolution in microelectronics, radio frequency technology, and signal processing has wrought a revolution in the reliability and effectiveness of radar detection of objects in space or in the atmosphere, and this has been augmented by major advances in optical detection capability both in the visible and the infrared (IR).

So it is commonplace in the United States or elsewhere to read about or to see videos and photographs of test intercepts taking place in the vacuum of space, or in the atmosphere.

In the 1950s or thereabouts, effective intercept could be conceived only with a nuclear-armed interceptor, and the one strategic ABM system briefly deployed in the United States (Safeguard) was equipped with low-yield nuclear warheads on its short-range interceptor. The exo-atmospheric interceptor was to be equipped with a multimegaton warhead not only to compensate for inaccuracy in intercept but also to be able to destroy spaced warheads and decoys.

But just as the detection capability has improved, so has the ability to conceal the target (stealth), to mimic the target (especially with the aid of antisimulation), and to jam the detection radars or the fuze of the interceptor itself. These techniques have been explored quite thoroughly by the United States for strategic missiles, and some of them for aircraft, but it is not clear how well perfected they are for short-range or tactical ballistic missiles.

In addition to the pure BMD systems, initially derived in any case from the army surface-to-air missile systems (SAMs), dual-purpose systems have been in favor especially for theater defense. Thus the Patriot that saw service in Israel and Saudi Arabia in 1991 was fielded primarily as a SAM system and not an ABM system.

Much has been written about the performance of the Patriot, beginning with the claim of essentially hundred percent "effectiveness" in countering the Scud missiles launched by Iraq. My own judgment, largely based on a close reading of the analyses of Dr. T.A. Postol and his critics, is that few, if any, warheads were destroyed or disabled by Patriot interceptors.

This would be of little import if the success of the Patriot against Scuds were not used as a baseline by many in arguing for the effectiveness of future TMD and BMD systems. To the extent that the baseline is important, these arguments fall on their face. But even if the Patriot did not work at all, this does not mean that future systems would be ineffective.

In addition to the Patriot, the Soviet (now Russian) SA-10, SA-12, and S300 systems could have some capability against ballistic missiles. How good a capability? And how good is good enough?

THE PROBLEM

The problem is not to "hit a bullet with a bullet," a problem that was solved long ago. That requires only detecting the incoming "bullet" at a sufficient standoff to be able to get an interceptor into its neighborhood before impact (or perhaps before reentry into the atmosphere), and guiding the interceptor so that it arrives with sufficient precision to a point on the trajectory of the incoming warhead (and at the correct time) to collide with or for the interceptor warhead to explode so as to destroy or disable the incoming warhead.

Intercept is easier if the interceptor can climb along the inverse trajectory, in which case precise control of its velocity is less important to the success of the intercept. Otherwise, for "crossing intercepts" the interceptor must be steered as a function of its velocity and drag to make the intercept at one point or another along the trajectory of the incoming missile.

A major problem for intercepts outside the atmosphere is that it costs very little for the offense to provide "penetration aids" or countermeasures, particularly simple against non-nuclear interceptors.

For instance, a large balloon surrounding the reentry vehicle or missile would deny the interceptor the ability to detect precisely the location of the vulnerable warhead within the balloon.[1] A smaller balloon around the warhead accompanied by other balloons at some distance (either tethered or free flying) would require the defense to destroy all of these with interceptors, or to have some preliminary balloon-destroying interceptor followed by an assessment and intercept of the real warhead, or to attempt to discriminate between the balloon containing the warhead and the balloons that are empty. These particular penetration aids are simple only when the light and heavy objects are all in "free fall" and they would be inapplicable to maneuvering portions of the trajectory or within the atmosphere.

The "counter countermeasure" of the defense could be this required enhanced discrimination capability, but that is an extremely fragile option. At the very least, electrical heaters on the balloons could mimic the residual heat from a warhead to confound infrared sensors, as a counter counter countermeasure to this response.

But a much more powerful penetration aid is to be found in the technique of "antisimulation" in which the warheads themselves are given a broad spectrum of observables, in order to make them easier to mimic by inexpensive decoys.

Of course one could imagine an adversary with sufficient blindness and specific limitations in technology to be able to buy or make ballistic missiles and their warheads, but with a peculiar inability to make these penetration aids.

I don't think so.

In view of the ease of countering intercept outside the atmosphere, most of the serious proposals for intercept deal with the incoming warhead during the reentry phase, when light balloons are stripped away by atmospheric drag, and the dynamic pressure makes it more difficult to mount penetration aids on the warhead itself.

But such endo-atmospheric intercept poses its own problems for the defense (especially for interceptors not armed with nuclear warheads) since the trajectory of the threat is affected by drag, and because the threat has now the option of substantial maneuvers, by interaction with the very dynamic pressure that causes the drag. If the missile is very accurate, the preservation of that accuracy while incorporating "substantial maneuvers" can be a serious problem, however.

Similarly, the extrapolated position of the interceptor is affected by its own drag, and the control is not so simple as it is in the exo-atmospheric intercept. Still, successful endo-atmospheric intercepts have been made in tests, either with fragment-kill warheads or hit-to-kill warheads. These latter make use of the fact that each gram of an interceptor at 6 km/s closing speed has some four times the energy of a gram of high explosive.

The Iraqi Scuds demonstrated this major problem associated with endoatmospheric intercept, in that the range extension of the Scud, done by the Iraqis

[1] Such a balloon, of itself, would not reduce the effectiveness of an interceptor armed with a nuclear warhead, but it would totally defeat an interceptor that was effective only in actual coalition with the offensive reentry vehicle.

themselves, involved a lengthening of the missile tank, which led to instability and breakup on reentry. Thus the incoming high-explosive warheads were maneuvering in a tight helix, while the Patriot had no specific software to help it make an intercept under those circumstances. Furthermore, it is clear that the fuzing option for the Patriot was far from optimum for the closing velocities that were involved.

The designer of the Soviet SA-10 system remarks that his system does have a more flexible fuzing option, as would any future system.

NEAR-TERM OPTIONS FOR U.S. THEATER MISSILE DEFENSE

The widely deployed 1960s-origin U.S. Army Hawk SAM system can have an option against TBM. In the 1960s it was proposed to upgrade the Hawk system for defense against Soviet SS-9 ICBMs that might be used in nuclear attacks on Minuteman silos. And they would have worked for that limited purpose. In fact, the Ballistic Missile Defense Office (BMDO—successor to the Strategic Defense Initiative Office [SDIO]) is expected to spend some $60 million to upgrade the ABM capability of the Marines Corps HAWK air defense system.

WHAT IS THE THREAT?

The military effectiveness of inaccurate high-explosive (HE) warheads against our military forces in the field is negligible. (As a case in point, the cost of perfect defense against this negligible threat is high—illustrating the strong dependence of cost of defense vs. demanded effectiveness.) Furthermore, the threat of precision HE-armed theater missiles to our forces in the field could be countered by intercepts at a kilometer distance rather than by interceptors that need to cover the entire area, at substantial expense and uncertain results. The threat of chemical or biological weapons to deployed U.S. forces is not much greater than that of HE-armed weapons, in view of the available defensive clothing and decontamination measures, and there is, for the present, no significant threat of nuclear-armed missiles. Against biological warfare (BW) and chemical warfare (CW), passive protection can be so effective that it would have a very substantial effect of deterrence by reducing the value of such weapons.

However, the threat of biological and chemical weapons against friendly cities is far from negligible, although delivery by ballistic missile is neither the greatest nor the most urgent threat, and passive protection can do much there as well. We cannot always count on people getting it as wrong as did Aum Shinrikyo in its (chemical) attack on the Tokyo subways.

As shown by the destruction produced by a 2-ton explosive blast in Oklahoma City, substantial human and property damage could be done to modern cities by even high-explosive armed Scuds or other missiles, although their impact would likely cause less damage on average than that carefully placed van bomb. Nevertheless, a 300-kg Scud warhead destroyed the Ministry of Education building in Riyadh on January 25, 1991.

Credibility and Responsibility

During the Desert Storm operation against Iraq in 1991, it was announced by President George Bush that the effectiveness of the Patriot missile in intercepting Scuds was almost 100 percent. It seems to me that not only President Bush but also the Defense Department and the U.S. Army must have believed this, and once the words are out of the mouth of the President, there is a substantial establishment devoted to establishing their truth or reality, as was the case following the announcement of the Strategic Defense Initiative by President Ronald Reagan on March 23, 1983.

Over the years since January 1991, I have discussed Patriot performance with several diplomats and military officers of friendly countries and have learned that they overwhelmingly believe that Patriot did not conduct successful intercepts, but that it was a "political response to a political weapon" and in this regard was "very successful."

And one can hardly disregard historical facts presented, for instance, by Alexander H. Flax.[2] By late summer 1944, only one in every seven V-1 "buzz bombs" launched by Germany against England survived to their targets, but the V-2 rocket attacks had begun. During July and August, Allied air forces expended one-fourth of their total tonnage on missile-related targets, and General Dwight D. Eisenhower recounted, "It seems likely that, if the German had succeeded in perfecting and using these new weapons six months earlier than he did, our invasion of Europe would have proved exceedingly difficult, perhaps impossible."

According to Eisenhower, with the chosen ground attack routes into Europe, "In this way we would, incidentally, quickly clear the area from which the V-1 and V-2 had been consistently bombarding Southern England."

So weapons that might be better ignored (because more effective military use could be made of the resources expended against those weapons) did divert major resources and did affect decisions of the military leaders substantially.

Perhaps the claim of a highly successful Patriot system kept Israel from responding militarily against Iraq, which would have complicated the military and political situation, to say the least. But in the U.S. democracy we would be deceiving not only our citizen-bosses but also our leaders themselves if we did not tell the truth in such matters.

Although Winston Churchill remarked that "in wartime, truth is so precious that she should always be attended by a bodyguard of lies," that bodyguard is stifling not only to democracy but also to the national security unless used only where strictly necessary. In the case of Patriot as an antimissile system, insufficient provision was made for gathering information on its effectiveness.

[2] Personal communication, April 14, 1995.

When an aircraft is intercepted by Patriot, it normally crashes into the ground, but since that is the purpose of the ballistic missile, it is not so easy to tell the difference between an intercepted missile and one that has not been touched.

THE BIG PROBLEM FOR CITY DEFENSE

A problem for ballistic missile delivery of chemical weapons (CW) or biological weapons (BW) comes from the inherent difficulty of disseminating CW or BW from a reentry vehicle from a missile with a range of 500 to 3,000 km. It is far simpler to improve the military effectiveness by early release of submunitions in the ascent phase. In this way, submunitions weighing only a few kilograms or so would be released by the hundreds, to have the dispersion desired in the target area. Although desirable to the offense from the point of view of military effectiveness, this would also be an effective counter to any nonnuclear defense except that operating before launch or during the ascent phase.

Indeed, the early release of submunitions totally counters the performance of nonnuclear TMD systems thus far proposed, except those that involve fastacceleration interceptor missiles launched from close to the ballistic missile launch site so as to be able to destroy the missile during powered flight. This could be achieved by ground-emplaced interceptors (GEIs), or by launching the interceptors from orbiting aircraft, or in principle by powerful lasers in low Earth orbit, or by a large number of Brilliant Pebble interceptors in orbit.

Effective launch-phase intercept is not a simple task, since it requires intercept often within 40 s after launch. Limited in initial acceleration by the necessity to moderate the heating and dynamic pressure it would encounter in the atmosphere, a GEI nevertheless could make an effective intercept if placed within 50 km of the launch site of a typical Scud, for instance.

An air-launched interceptor of 8 km/s could move 300 km during that time, but a stealthy air vehicle or assumed air superiority might be required. Russia might not agree in principle that launch-phase intercept for TMD is compatible with the 1972 U.S.-Soviet ABM treaty, but possibly could agree on a specific system that would be permitted by an amendment to that treaty and that might be available to both sides.

As for active defense by counterforce, a recent report[3] argues that the highest payoff comes from counterforce attack against garrisons, depots, and command and control facilities; the second highest payoff from attack on transportation infrastructure and industrial facilities; and the lowest payoff from attack on mobile missiles themselves and missile launchers. This report considers the boost-phase intercept alternative, but emphasizes that it should not be viewed as primary or the preferred solution but constitutes a "mid-term to long-term capability." Although boost-phase intercept is politically difficult, I

[3] Air Force Studies Board, Counterforce Options Against Tactical Missile Systems (U). National Academy Press, Washington, D.C., 1994 (Classified).

emphasize that no midcourse or terminal capability such as those now proposed for TMD or even for national ABM systems will handle the motivating threat of BW and CW from bomblets dispersed on ascent; so it is boost-phase or nothing.[4]

The United States proposed to interpret the ABM treaty as permitting any system that had not actually been tested against targets exceeding *5* km/s—an easing of constraints that I am sure would lead the U.S. Congress to abandon the strategic arms reductions, in view of the ABM capabilities that would then be permitted and projected for Russia. A BMD capability deployed in the United States to protect against "accidental launch" would need to handle incoming reentry vehicles (RVs) of a full 7 km/s reentry speed, but a system designed for those speeds and fully tested only against a target of 5 km/s would not be inhibited by lack of testing against the RVs of 7 km/s.

Testing does not "develop" the missile system; it just challenges and perhaps verifies the model that was used to design and develop the system. Thus, the radar tracking of 7 km/s objects is verified independently of any intercept, and the IR detection by the interceptor (or the radar detection by the interceptor) is a function of interceptor speed but not adversely affected by increased target speed. As for an all-up system "proof test," that would not be available even for incoming RVs of a full 7 km/s reentry speed, unless those RVs were supplied for test by the adversary![5]

Because Russia is more threatened by accidental launch and intermediate-range missiles launched from its neighbors than is the United States, a decision by the United States to proceed with such a system would result in a comparable system in Russia, which would then cause havoc with the assured penetration of strategic ballistic missiles launched from British, French, or Chinese forces, unless those forces were modified or greatly augmented. To the extent that an ABM system depending on exo-atmospheric intercept by nonnuclear armed interceptors is deployed, countermeasures are relatively simple, and it is for that reason that such a system is not even very useful against accidental or limited attack. A commitment to ABM would, however, force those operating strategic retaliatory forces to provide effective penetration aids against endo-atmospheric intercept; for the U.S. missile forces, such "penetration aids" have been additional missiles and warheads. Indeed, there is little doubt that Russia would deploy a system of nuclear armed interceptors which would add many warheads to the Russian nuclear armory.

In the context of a theater opponent countering U.S. "high-tech" conventional military capabilities, a recent article[6] states that the "explosion of a single high-altitude low-yield nuclear weapon could destroy $14 billion worth

[4] Or preboost phase, or deterrence of launch, or passive defense.

[5] They should be asked also to supply decoys and jammers that might automatically accompany any attack, even an accidental or unauthorized one.

of low-Earth-orbit satellites that would transit through the enhanced radiation belts produced by such a nuclear event." Of course, the signing of a universal comprehensive test ban treaty would tend to prevent and certainly make illegal such an act, and one must try to find a way to make it explicit that such damage would result in dire retribution for anyone who caused it, without making excessively clear to potential troublemakers the magnitude of the damage that could be caused this way. Such retribution would be all the more legitimate if the United States and the other nuclear states emphasized their commitment not to use nuclear weapons first, so that this postulated use of nuclear weapons would damage the entire international security system, as well as the specific target of the nuclear attack.

The Threat to the United States

That there are serious objective dangers to the United States is indisputable. In 1969 a panel of the President's Science Advisory Committee (PSAC) on chemical and biological warfare was asked specifically to review for President Nixon the utility of a ban on biological weapons. Indeed, President Nixon soon issued an executive order eliminating not only U.S. use of BW, but also possession, manufacture, and even R&D on biological weaponry. This was followed quickly by the negotiation with the Soviet Union of a treaty banning BW in the same way, leading to the international Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction, signed April 10, 1972, which entered into force March 26, *1975*. The Soviet Union has apparently not fully complied with the convention, and the full force of international resolve has not yet been turned to implementation of the convention and to its buttressing by means of effective societal verification.

Any use of BW by the Soviet Union against the United States was, presumably, in any case deterred by U.S. possession of nuclear weapons and their delivery capability, whether or not nuclear retaliation was specifically threatened in the case of BW attack. There is no reason to believe that such deterrence would not still work against Russia, or against most states contemplating use of BW or CW. By the same token, it is hard to see how one could deter by threat of retaliation the use of BW by terrorists. Indeed the very aspect of BW that makes it so ineffective against combat troops may paradoxically greatly increase its effectiveness against civilian populations.

This is the substantial duration (hours or days) between the ingestion of the agent and the outbreak of the illness, giving time for a modest crew to spread BW agent widely. Furthermore, although most of the BW agents contemplated by major power for use in warfare were infectious but not contagious,[7] terrorists could perfectly well use highly contagious natural agents. The main point is

[6] R.C. Webb et al., "The Commercial and Military Satellite Survivability Crisis," *Defense Electronics,* August 1995.
[7] That is, one or a few "bugs" could cause an infection in humans, but the disease would not spread with substantial probability from human to human.

that terrorists and nations (in the modern world of relatively open borders, international travel, and mixed societies) would hardly rely by choice on ballistic missiles for delivering BW as a terrorist weapon against population centers of the other side.

REGIONAL MISSILE DEFENSE IN RELATION TO THE ABM TREATY

The problem of regional missile defense, as discussed above, is not only one of effectiveness against the regional threat, but the impact of TMD on the ABM treaty deserves attention, given the magnitude of the regional threat compared with the essential nature of the ABM treaty in limiting strategic offensive arms.

There is qualitative impact as well as quantitative impact. The ABM treaty was crafted not only to prevent the existence of an effective nationwide defense against nuclear-armed strategic ballistic missile forces, but also to provide a substantial "buffer time" before such a defense could be deployed. A situation in which an ABM does not exist but in which it could be deployed the next month, would be worse, in reality, than the gradual deployment of such a defense. The very prospect of an ABM defense effective against the existing strategic offensive force would call forth penetration aids, multiple warheads, and expansion of the strategic force, until the ABM were overcome, if, indeed, it was cost effective to overcome it. But can an ABM be "overcome"?

The current generation of political leaders and strategic analysts seem to ignore the insight of the 1960s that led to the adoption of the ABM treaty and which is valid today, in essence. It recognizes that some 400 nuclear weapons reaching their targets would surely destroy the United States or the Soviet Union (and fewer would now be required to destroy Russia) as a functioning modern society. That number penetrating would constitute effective "assured destruction" and the prospect of receiving such a retaliatory strike would essentially nullify any desire to have a first strike or to dictate political surrender to the other side.

The large force of more than 10,000 strategic nuclear warheads on each side appears to have grown to that level not because that many were deemed essential for the assured destruction role, but because a large fraction of the strategic warheads might be destroyed before they could be launched in retaliation, and an additional factor entered to compensate for some ABM system that might be built before the force could be further expanded.

In addition, there was still a residue of the 1962 McNamara mission of "damage limitation" by which nuclear warheads beyond those required for assured destruction would be used to destroy the strategic offensive force of the other side. Furthermore, the calculus of destruction before launch and the penetration of ABM systems is subject to a very great "offense-defense asymmetry" of conservatism that in itself could account for the positive feedback and essentially divergent numbers of nuclear weapons, increasing almost without limit.

On the other hand, the agreement to strictly limit ABM, and to provide an effective buffer time during which the strategic offensive force could later be modified, laid the basis for the reduction of strategic warheads to the committed level of 3,000 to 3,500. Playing an important role, although not very often explicitly acknowledged, was the recognition also that the destruction of even vulnerable land-based "MIRVed" missiles before they could be launched in retaliation was not feasible, in view of the possibility of "launch under attack (LUA)" or "launch on warning."

So this calculus also drove the two sides to a capability of launch under attack, although the number of strategic offensive warheads did not decline to reflect fully the reality of LUA.

The problem of destruction before launch (DBL) was especially severe because the United States had voluntarily chosen to respond to the potential of a Soviet ABM system *(or* to grasp the fruit of technological advances in nuclear weapons and missiles) by deploying multiple warheads on our land-based missiles, thereby unilaterally introducing the potential for the Soviet Union to destroy three Minuteman-3 warheads with a single accurate Soviet nuclear warhead. The Soviets followed (in view of the fact that MIRVs were never put on the table in the initial SALT negotiations), thereby incurring on their side a tremendous vulnerability, especially in view of the greater reliance placed by the Soviet Union on intercontinental ballistic missile (ICBM) weapons in contrast to submarine-launched ballistic missiles (SLBM).

Under START, the multiplier of DBL due to the self-imposed vulnerability of MIRV will disappear with the elimination of land-based MIRVs on both sides, but on the other hand the number of warheads on either side will also be much reduced, and there will be greater sensitivity to the effect of an ABM system.

Some in the U.S. defense community still want to rescind the ABM treaty. They tend to believe in national security on a unilateral basis, as reflected in the 1980 presidential campaign literature of Governor Ronald Reagan, which stated that President Ronald Reagan would have a three-point program to build nuclear weapons to disarm the Soviet Union, and if the Soviets tried to respond, it would be so costly that they would destroy themselves economically. Russia is now in substantially more dire economic straits than was the Soviet Union, and the appeal of this program may be substantially larger to a small but influential minority in the United States.

Unfortunately, there is much misinformation, and even technical misinformation provided to the Russian legislature, that could lead to substantial missteps by the United States and by Russia.

For instance, a study[8] paid for by the BMDO and released publicly in February 1995 has been claimed to counter the analysis of Professor T.A. Postol of the Massachusetts Institute of Technology and his colleagues that argues that

[8] Lee, Laura T., et al. "The Abuse of Footprints for Theater Missile Defenses and the ABM Treaty" (U), SPARTA, Inc., McLean, Va., September 1994.

THAAD[9] has significant effectiveness against strategic ballistic missiles, *if* it is effective against missiles of 3,000-km range.

Unfortunately this BMDO-sponsored study has no "study" behind it—just the briefing charts, as explained to me by BMDO staff and the contractor. Furthermore, the results are *wrong,* although it is more difficult to determine that they are wrong if there is no written analysis that can be evaluated.

The key claim of the Sparta study is that for the missiles of range against which THAAD is to be deployed (up to 3,000 km), the ground-based radar in the terminal area can see the missile during its ascent phase, where the radar cross section is large because the missile is essentially broadside to the radar beam; the ICBM, however, is below the horizon in its boost phase and then presents a small enough nose-on angle to the radar so that it cannot be seen. The data shown for radar cross section vs. angle, however, and the sketch of the trajectory make it very clear that the 3,000-km missile is well below the horizon during any high cross-section phase of flight. Even shorter-range missiles need never present an aspect angle greater than 45 degrees, out to which, according to the cross-section data shown in the BMDO study, the cross section is very low.

So in this case one should not trust the material published by BMDO, on which BMDO policy, that of the Department of Defense (DOD), and presumably U.S. national security policy are based. Of course, one might point to errors in the analyses of some critics of DOD programs, but that seems to me quite irrelevant.

"Force on force" criteria for the acceptability of TMD advanced by an unnamed government official, and quoted in a *Washington Times* newspaper article of May 10, 1995, imply that "unless there is some kind of significant, meaningful, major, material capability against the other guy's strategic force, then that is a permissible TMD." This implies that only systems with capabilities against the entire strategic force are limited by the ABM treaty, so that one-on-one tests should not determine the criteria for regional or strategic systems.

Evaluation of the effectiveness of various systems must consider as a primary element "sensor integration"—even so simple as launch detection satellite cueing. For instance, SDIO Director Dr. Henry Cooper revealed that U.S. "Defense Support Program" satellites detected every Scud launched by Iraq during Desert Storm. And the U.S. Navy has recently discovered a substantial capability of a fleet of vessels against cruise missile or even theater ballistic missile attack, by taking seriously the integration of sensors on the various ships. Even in the early 1970s, the DOD testified about its concern with "SAM upgrade," one version of which was the networking of the Soviet SA-2 surface to-air missile sites, to provide a coherent ABM capability. It is not a simple job to establish the absence of such links.

[9] The Theater High Altitude Air Defense interceptor, of which the U.S. Army proposes to buy 1,442 missiles.

Such an interpretation would entirely destabilize the strategic scene, not least by forcing major actions in the near term by Britain, France, and China, and also forcing Russia to modify its strategic force. Russia would be able to mobilize the resources to restore the effectiveness of its strategic force only by portraying the United States as an enemy bent on disarming strike, and by far the easiest way for Russia to increase the effectiveness of its planned forces is immediately to stop the START process.

On December 28, 1995, President Clinton vetoed H.R. 1530, the National Defense Authorization Act for Fiscal Year 1996, on the grounds, first, that it

> requires deployment by 2003 of a costly missile defense system able to defend all 50 States from a long-range missile threat that our Intelligence Community does not foresee in the coming decade. . . By setting U.S. policy on a collision course with the ABM Treaty, the bill would jeopardize continued Russian implementation of the START I Treaty as well as Russian ratification of START II—two treaties that will significantly lower the threat to U.S. national security, reducing the number of U.S. and Russian strategic nuclear warheads by two-thirds from Cold War levels. The missile defense provisions would also jeopardize our current efforts to agree on an ABM/TMD (Theater Missile Defense) demarcation with the Russian Federation.

The December 4, 1995, edition of *The Washington Times* includes the text of the U.S.-Russian "Agreed Framework" covering theater and regional antimissile systems, which was agreed to on November 17, 1995. The article reporting on this document notes that the original is classified SECRET and presumably reflects the Administration position on modifying the ABM treaty to permit certain types of TMD.

Revival of the Strategic Defense Initiative?

In May 1995, a letter from the leaders of several defense contracting corporations stated that spaced-based chemical lasers were essentially ready for deployment as a test system with a 4-m-diameter mirror and that within a few years an entire system of 12 SBLs with 8-m-diameter mirrors could be deployed at a cost of $15 billion. There is substantial pressure behind such deployments, with these lasers claimed to have an effective range of 3,000 km, each one claimed to defend effectively against missiles launched in the 10 percent of the surface of the Earth within its field of view, so that a constellation of 12 SBLs would provide an effective defense against a small threat, and 25 SBLs would provide a very substantial defense.

The letter claims that the lasers could be deployed each with fuel for something like 200 effective "shots," and that the primary purpose would be to destroy missiles in their boost phase. Of course, these lasers would as readily destroy ICBMs as theater missiles in boost phase, and they would strike at the heart of the strategic reductions that we have in process.

However, just as was the result of the analysis in the early days of the SDI, however effective such lasers might be, they could be destroyed as they were being deployed, by simple antisatellite (ASAT) measures.

There would be no reason in the 1990s for Russia to use the co-orbital ASAT that the Soviet Union tested some 22 times and that was described, for instance, in our article in *Scientific American.* [10] Instead, Russia would surely use a directascent ASAT, equipped with either a small nuclear warhead or a pellet warhead to destroy the rather fragile SBL, without imposing the requirement of sufficient accuracy to destroy by kinetic energy collision of the ASAT homing head itself. SDI proponents formerly argued that the deployed constellation of SBL would be mutually protecting, but such systems are not operational as soon as they are put into orbit, and the exchange ratio between the cost of an SBL and the cost of a direct-ascent ASAT is surely such that no such weapons in space could survive.

Nevertheless, the launch of space-based lasers to provide an effective component of strategic or theater defense would lead to a strategic confrontation that would not be optional but mandatory.

A Truly Cooperative Defensive System?

During the SDI program, there was promise of a defensive system that would "benefit" both the United States and the Soviet Union. President Reagan seemed sincerely to advocate a system that would actually protect both the United States and Soviet Union, destroying equally Soviet or U.S. missiles if they were launched. However, U.S. Defense Department personnel made very clear that not only was this not their goal but also that they would not even "share technology" with the Soviet Union. In a September 1986 debate in Dallas, Texas, the DOD representative chose his words very carefully to say that we would "share the benefit of defensive technology."

I likened this to the slave owner who "shared the benefit" of slavery. The slave owner obtained the profits, and the slave was protected and fed and housed, to some extent, so long as his product was sufficiently valuable to the owner. If one side has acquired a good defense (especially when combined with its strategic offensive force), it will be a tranquil (and compliant) world until the other side catches up, makes an end run, or miscalculates. That same kind of shared benefit, and tranquility, obtains when only one side has a disarming force against the other; and both sides know it.

Brilliant Pebbles Resurgent?

The x-ray laser, cherished development of Edward Teller and Lowell Wood and their colleagues at the Lawrence Livermore National Laboratory, seems truly dead and will surely remain so, so long as there is a ban on nuclear testing.

Not so for their next enthusiasm, "Brilliant Pebbles."

[10] Garwin, Richard L., Kurt Gottfried, and Donald Hafner. 1986. "Antisatellite Weapons," Scientific American, Vol. 250, No. 6, June.

One does not actually need to have an explosive warhead to conduct an effective intercept in space. Any significant crossing angle (with a low-orbit satellite moving at 8 km/s) would lead to relative velocities of 5 to 15 km/s, and the kinetic energy of the interceptor in the frame of the more massive strategic offensive weapon would correspond to many times the explosive energy per gram of high explosive. Indeed, the two are equal at a relative velocity that will give a kinetic energy of some 4,000 J/g, or about 2.8 km/s. At 10 km/s relative speed, each gram of interceptor has 12 times the kinetic energy of a gram of high explosive.

So although it had long been considered to use pellet warheads or for that matter orbiting pellet clouds to destroy objects in space, the public relations associated with the advocacy of SDI called now for "smart rocks"—as if one would be using a simple rock, but "smart" enough to be guided to a collision with the target.

Some went one step farther, claiming to increase the intelligence by making the rocks "brilliant" and reducing the size by the miracle of modem consumer electronics so that these were no longer smart rocks but "Brilliant Pebbles." Instead of a few kilograms as was originally proposed, the mass in orbit grew to on the order of 100 kg, for which one can make quite a reasonable interceptor, in principle. Thus was born the proposal to orbit something like 5,000 Brilliant Pebbles (BPs), to destroy strategic weapons during their boost phase. Of course, the BPs would need to be assigned to the boosting weapon and conduct an intercept with the precision necessary to strike the missile during boost phase. The BP would need to be self-guided, and there are counters to this, on the part of the ICBM itself.

However, in 1991 I published a paper,[11] and distributed widely a more extensive version,[12] contrasting the requirements for a direct-ascent ASAT to destroy Brilliant Pebbles with the requirements for the Brilliant Pebbles themselves. In every way the ASAT job is simpler. The nation that wants to destroy a constellation of BPs can take its time in doing so, and it can do so with very small homing interceptors supported by ground-based radars or lasers with a view of the engagement taking place in low Earth orbit—a capability that the BP itself cannot call upon.

Furthermore, the ASAT itself need detect the BP satellite and provide guidance from a distance of only a few kilometers, or for that matter a few hundred meters, given the accuracy with which the ASAT can be guided to the predicted position of the BP with the aid of ground-based radar or lasers.

The ASAT guidance and homing system need survive only for a few minutes, whereas that of the BP needs to survive for years in space, and the same is true of the power supply for the ASAT, which could be batteries,

[11] Garwin, Richard L. 1991. "Defense Is Easier from the Ground," Op-Ed piece, Space News, March 11-17.
[12] Garwin, Richard L. 1991. "Are Brilliant Pebbles the Counter to Stretched Scuds?", February.

whereas the BP would need to have a solar supply. Instead of a refrigerator for its infrared sensor (if any), the ASAT could carry liquid nitrogen or even liquid helium for the few minutes of its flight.

Thus it is clear that the ASAT job of wiping out the BPs is very much easier than that of putting up the BPs in the first place.

Instead of Brilliant Pebbles, Brilliant Eyes?

Brilliant Pebbles, of course, would be a clear violation[13] of the ABM treaty. As a result, it was proposed to deploy a system of "Brilliant Eyes," fewer than are necessary for a BP constellation, and the nominal job of which would be to refine the trajectory observations of warheads in midcourse, so that terminal ABM systems could work more effectively. I have been unable to see why the sensor of a terminal ABM system could not be given the capability to make an intercept without the trajectory "refinement" available from BP (if such could be obtained), nor do I understand why an "optical probe" launched from the terminal area on detection of a ballistic missile launch would not be a better idea than a Brilliant Eye.

I note, however, that Edward Teller proposed in the SDIO era that Brilliant Eyes should have all of the capabilities of Brilliant Pebbles, including rocket engines and homing systems that could boost the interceptor and conduct an intercept, but they would be deployed without the fuel and so would be "legal" under the ABM treaty.

I don't know any other judgment that such a system would be legal under the ABM treaty, any more than the Krasnoyarsk radar was legal. After all, that radar could have been maintained unlinked from the rest of the strategic defense system, or its beam could be held low enough to constitute a space track or early warning rather than ABM system, but there was no way in which such limitations could be verified or enforced. The same is true of BMDO claims that Brilliant Eyes are acceptable if they lack a direct communications link to interceptors.

Similarly, since the ABM treaty has the goal of providing the time buffer before deployment, to build and launch and test Brilliant Eyes that have a capability of Brilliant Pebbles would presumably not be allowed either.

A truly cooperative defensive system could hardly be objectionable, but we are not ready to deploy such a system. It would need to be accompanied by a regime that would make illegal the launching of missiles from one nation against another, which might indeed then lead to the disappearance of ballistic missiles entirely. But an effective ABM system and a commitment to upgrade it and to keep it effective would need to be operated by the United Nations and would require an operating committee and a voting procedure, all of which basis would need to be laid before a system was developed and deployed. I am not

[13] Article V: "1. Each Party undertakes not to develop, test, or deploy ABM systems or components which are sea-based, space-based, or mobile land-based."

saying that this is simple or that it can be achieved with confidence, but only that this groundwork must be laid before defenses can be developed without destabilizing the world.

A space-deployed defensive system, protected by international law and by the might and power of the nations subscribing to international law, would be quite a different consideration from a unilaterally deployed system. So that is of interest for the long term, although serious consideration may result in the rejection of such a system as infeasible, impractical, or undesirable.

One near-term and noncontroversial contribution to stability can be obtained by silo-cover sensors deployed cooperatively. That is, the United States would provide a small package for each Soviet silo cover, with the function of continuing to transmit a signal that cannot be simulated, so long as the sensor remains attached to the silo cover and the silo cover has not moved. The actual transmission would be handled by a Russian-supplied relay box. Russia would supply similar sensors to the United States. Each sensor would have its own cryptographic key (or a "public-key" system could be used) so that it would continually encrypt the time and the serial number of the sensor, so long as it remained attached to an unmoved silo cover.[14] High Russian officials explain that (like the Soviet rocket forces before them) their normal posture is one of responding when the first few nuclear explosions occur on Russian territory. Their other real option is to launch on warning of attack, before any explosions have occurred. And they insist that "delayed retaliation" is not an option for them. Hence the reliable assurance that U.S. missiles have not been launched is very important to the prevention of a massive launch of Russian strategic forces.

CONCLUSIONS

In the meantime, the consequences of unilateral deployment of space weaponry are so severe that I believe that it is necessary to revive the U.S.Soviet talks on banning antisatellite weapons and extend them to the banning of all space weapons as well as ASAT test and use. The ban on space weaponry would not affect communication satellites, navigation, satellite imagery, launch detection systems, or other satellites that are not actual weapons. Such a treaty could be agreed to between the United States and Russia and then opened for revision and subscription by all of the nations of the world, in analogy to the Biological Weapons Convention.

In addition to the traditional "national technical means of verification" (a euphemism for "satellite reconnaissance") authorized in the ABM Treaty of 1972 and in later treaties, new treaties ought to make provisions for societal verification, by which the text of the treaty is published widely in the states party, domestic law is established that makes it illegal for individuals to perform

[14] A sensor embodying these characteristics is deployed in cooperative monitoring of nuclear material stockpiles and may be viewed at the Cooperative Monitoring Center, Sandia National Laboratories.

those activities that the state has agreed not to perform, and the permission and responsibility are given individuals to report to a verification commission a state's violation of the agreement.

For the real threat of use of CW and BW against friendly cities, the most effective approach is to pursue vigorously the entering into force of effective bans on BW and CW and to have it understood that any violation of such a treaty (especially the use of BW or CW) would lead to the most severe response by the community of nations. A response with nuclear weapons could not be precluded. Passive defense should be emphasized, particularly for ships and the military, and should be considered for civil populations under particular threat.

Active defense of ships against cruise missiles and ballistic missiles should take advantage of the fact that only a very small region needs to be defended, if intercept takes place no farther than 5 km from the ship. This is a very different system from those that are discussed, which try to obtain a theater-wide capability.

Against accidental launch of strategic systems (far less likely under conditions of nontargeting and reduced readiness than it was formerly) cooperative control measures are far superior to BMD, and cheaper, too. The silo-cover cooperative monitor should permit reduced alert levels under normal circumstances.

Against a blackmail or rogue nation strategic threat, destruction of the strategic missile before launch should be considered, but a light ABM even against one or a few missiles is not a realistic option, in view of the necessity to intercept above the atmosphere, where countermeasures against nonnuclear intercept are quite feasible. A commitment to an effective light nationwide defense would (and technically should) lead to the use of nuclear-armed interceptors, which would be very similar to the classical ABM systems.

Of course, it is our *actions* that will influence the world, not our desires. Hence it is important to have some kind of understanding of the impact of various candidate actions on the world. By "actions" I mean not only development and deployment of weapons, but also speeches, negotiations, deception, and so on.

Our actions can have direct effects, but also indirect effects when others are moved to take or not to take actions of their own. In some cases, indirect effects can be much larger than direct effects, and they may come earlier as well. My own judgment is that it is not in our national security interest to interpret the ABM treaty as limiting subsystem performance only if it has actually been demonstrated against strategic-class reentry in actual tests. The effects of such an interpretation on our own security have not been thought through.

Thus, the United States should go ahead with dual-capable (aircraft, cruise missiles, and theater ballistic missiles) systems such as the PAC-3 upgrade of the Patriot, with remote firing of such interceptors from displaced radars and should rely for system performance on "launch-point cueing."

In general, there should be increased emphasis on passive defense against CW and BW and on a *balanced* defense against all threats. But we should not confuse the wish for effective defense and the capability for effective defense, which confusion can jeopardize the uneasy security provided by deterrence against major potential threats.