istituto affari internazionali
88, viale mazzini • 00195 roma
tel. (06) 315892-354456 • telefax (06) 319806

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TECHNOLOGICAL AND STRATEGIC ASPECTS OF BALLISTIC MISSILE DEFENSE

by Ettore Greco

Summary

INTRODUCTION

Although almost seven years have passed since the Reagan Administration announced its plan to construct a shield against enemy missiles, the ultimate outcome of the Strategic Defense Initiative (SDI) is still uncertain. Nevertheless, this persistent uncertainty does not represent, in and of itself, a definitive failure of the plan. Indeed, the Reagan Administration officials as well as the former President himself have always emphasized that the SDI program would require "years, probably decades, of efforts on many fronts" (1) and would not be free from failures and setbacks. Indeed, the unshakable faith in the ultimate success of the SDI program has not made even its most ardent advocates blind to the difficulties of implementing it.

However, Ronald Reagan's promise to ensure an efficient defensive system against the threat of nuclear destruction has proved to be a demanding legacy for the new administration which took office in January 1988. Given the long-term approach to SDI and the delays already encountered, the Bush Administration will probably not have the last word on it. Even so, the decisions that will be made about SDI in the near future will undoubtedly have a significant effect on its fate.

The program has already been slowed down considerably. From the very beginning, Congress has consistently cut the Administration's budget requests for it. The reluctance of Congress to support the program to the extent considered necessary by its proponents, as well as the increasingly worrying US budget difficulties, forced the previous Administration to work out a substantial revision of the program in 1988. The design of the defensive system to be deployed in the first phase -- particularly that of space-based anti-missile rockets, the most expensive element -- was simplified (2), providing instead for increased numbers of the less expensive ground-based interceptors. According to the officials of the previous Administration, such a compensatory move would not alter the basic characteristics of the system or the performance requirements set for the first phase.

Thus, there were two aspects to the last version of the SDI program worked out by the Reagan Administration: on one hand, an admission that the United States was facing increasingly severe economic and technological obstacles with respect to the very sophisticated defense system that former President Reagan considered desirable and feasible; on the other hand, an attempt to preserve the key goals of the program, including the long-term ones, in spite of such difficulties.

The Bush Administration is currently engaged in the laborious task of reviewing the program. The President made no secret of his concern about the effects of the growing costs of the program on the budget. Apart from the negative impact on social expenditure, several military investment plans are threatened by the large sums of money needed to pursue the SDI program. Thus, the Administration has decided to cut the funds devoted to SDI for the next four years (1990-1994) by 7 billion dollars. Furthermore, the Democratic majority in Congress, stronger since the last election, is opposing SDI more vigorously than it had in the past. Finally, President Bush appears to be more willing than Reagan was to accept constraints -- at least in the short term -- on testing and development of ballistic missile defense systems, thus meeting one of the most important Soviet demands in strategic arms talks.

Although the new Administration is less committed to pursuing the program than was its predecessor, it has not made a formal decision to abandon it entirely. As an intermediate solution, it may give up some parts of the SDI program that the Reagan Administration had considered essential and concentrate its efforts on others. This, in fact, seems to be the inclination of the Bush Administration to date.

What follows is an assessment of strategic and technological aspects of the plan to deploy a US BMD system.

THE ORIGINAL VISION

In his speech of 23 March 1983 announcing the Strategic Defense Initiative, President Reagan evoked the image of a defense system capable of making nuclear weapons "impotent and obsolete", (3) that is, a perfect or near-perfect defense. Some have wondered whether the President's words should be taken at face value, but the fact remains that in all his following statements on the SDI program, he has systematically stressed its high profile. During the entire period of his Administration, Reagan never hinted at the possibility of reviewing the rationale of the program by de-emphasizing its significance for US security. For example, in a speech on 29 March 1985, two years after the launching of the program, he declared, "We're not discussing a concept just to enhance deterrence; not just an addition to our offensive forces, but research to determine the feasibility of a comprehensive non-nuclear defensive system -- a shield that could prevent nuclear weapons from reaching their targets" (4).

Indeed, the original goal of the SDI program was not only to ensure the defense of US retaliatory capabilities but also to provide a shield against the sword of Damocles of nuclear holocaust hanging over the cities and civilian population of the United States.

The desire to eliminate the threat of nuclear destruction is natural and, to some degree, inevitable. The human mind can hardly resign itself to the prospect of remaining under such a threat indefinitely and cannot help seeking to escape it. Unfortunately, in an offense-dominated strategic environment like the one we live in -- based on mutual assured destruction (MAD) -- there is little possibility of fulfilling this wish . What appears unacceptable about MAD to most of its critics is the impossibility of avoiding vulnerability. That recognition tends to make the role of nuclear weapons primarily a psycological one: though they can do little or nothing to enemy weapons, they must be able to exert an effective psychological influence on the enemy to prevent it from using its own weapons. This necessarily requires that the enemy's thought and behaviour be, to some degree, reasonable and hence predictable.

Some US leaders and analysts are dissatisfied that the security of their country depends on the decisions taken by the Soviet Union (5). Therefore, it is not surprising that there are decision-makers and strategic experts who are seeking an alternative to the traditional strategy of nuclear deterrence (6) To those who, in addition to being dissatisfied with the current strategy, are very suspicious of the Soviets, the only possible solution appears to be a military build-up (7) The SDI program holds the very attractive promise of escaping the balance of terror by restoring confidence in the capability of US weapons to avoid nuclear destruction. Consequently, it has been presented as the appropriate means for a completely new strategic approach based on a shift from punitive deterrence to deterrence by denial.

Indeed, there is also a clear intellectual dimension to the challenge launched by the SDI proponents. They have taken delight in defying "conventional wisdom" with the "heresy" of strategic defense, a neglected word in the "nuclear lexicon" (8) Their main accusation against MAD theory is that it was formulated in an era of American military predominance and is thus dangerous or at least inappropriate in an era of strategic parity. The target of their polemics has been the entire "conceptual arsenal of the 1960s" (9) They have called for the adoption of a new way of thinking, declaring their faith in the human capacity to address the problems of the nuclear era successfully (10)

Less radically, some SDI proponents have preferred to stress the need to integrate the traditional offense-oriented approach with a defence-oriented one to enhance deterrence. In their opinion, the inclusion of defense in future military strategy can avoid a complete dependence of deterrence on nuclear retaliation.

In both cases, however, the advocacy of SDI questions two major assumptions of MAD theory regarding the forseeable future: (i) neither side will acquire the capacity to alter the balance by gaining a unilateral advantage; (ii) technological progress will not provide a sufficiently reliable alternative to the current supremacy of offensive weapons.

The first point will be discussed below. As for the second point, it must be noted that the SDI program is based on the prediction that in the decades to come, key technological advances will affect mainly defensive arms, prompting a progressive change in the cost-exchange ratio between offense and defense in favour of the latter. The idea underlying such a prediction is that, given the great progress made in the field of offensive weapons in the past, future progress will very likely be in defensive weapons. A sort of new theory of historical recurrence has thus been invented.(11) Several historical parallels have been recalled to show how often scientists and other experts who had declared past technological dreams to be impossible were later contradicted by the facts.(12)

The infatuation with technology has prevented SDI advocates from recognizing that technology, at any stage of its development, suffers from defects and weaknesses. As has been seen, the process of achieving a perfect or near-perfect defense has not been regarded as easy and linear, though heavy bets have been placed on the possibility of attaining that goal. Such an ingenuously optimistic and enthusiastic concept of the nature of technology and its developments -- a sort of technological millenarism -- found its extreme expression in Reagan's idea that the technological secret of defense, once developed, should be shared with the Soviets -- as though technological progress, inherently competitive can be stopped at a hypothetical stage in which the security of both sides is assured. Some have stressed that this very naive confidence in the possibilities of technology represented a major shift from the traditional pragmatic approach of the United States that was based on a careful cost-benefit analysis of each military program (13).

Behind that vision, there is really a deep disillusionment with arms control, accompanied by the hope that its failure can be offset to some degree by technological progress in the field of defensive systems. In particular, the discouraging Soviet behaviour under the ABM treaty has been cited to support doubts about the reliability of the Soviet Union as a negotiating partner and,

consequently, justify Western aims for a sort of self-sufficiency through SDI (14). Indeed, SDI proponents seem to feel that the program has the important attribute of making attainable both crucial goals traditionally ascribed to arms control: a decrease in the risk that a war could occur and a reduction in damage should war occur. Furthermore, one of their fundamental assumptions has been that technological developments in the foreseeable future will shift the strategic balance in favour of the United States, providing an extraordinary opportunity to ensure US security. It is also on such a prediction that the Reagan Administration based its policy of the so-called "competitive strategies" (15). Exploiting this supposed historical opportunity has been seen as a sort of categorical imperative by SDI proponents. Indeed, no one doubts that the United States holds a great advantage in practically all the key sophisticated technologies needed to deploy an advanced BMD system: sensors, lasers, computing technology, software development, electronics and miniaturization. Given such a technological imbalance, it is natural for the Soviets to be anxious about any military competition based on advanced technologies. For that reason, some have argued that defensive systems could represent the most advantageous front on which to challenge the Soviet Union, while putting pressure on its economy and society at the same time.

To sum up, the ideological background of the SDI program consists of a mixture of different elements typical of the Reagan Administration, particularly its first phase: the desire to escape the unquestionable contradictions of the MAD doctrine; the emphasis on the immorality as well as the instability of a balance of terror; the deep dissatisfaction with arms control (given its record); the optimistic faith in the capacity of technology to solve human problems; the belief that future technological developments will offer the opportunity to restore US superiority in some crucial areas of the competition between the superpowers. Undoubtedly, some of these aspects of the original vision of SDI have lost most of their attractiveness in the last few years; nevertheless they require analysis if the strategic rationale of the program is to be discussed and understood.

THE IMPACT OF BMD ON THE STRATEGIC BALANCE

To evaluate the probable effects of the deployment of a US BMD on the strategic balance and on US security, it is useful to begin with a critical assessment of the most important missions that have been assigned to the SDI system by its proponents. Some of these missions are alternatives, others can be considered complementary to one another.

Perfect or near-perfect defense. The possibility of constructing a shield capable of defending not only US retaliatory capabilities, but also US cities and population, thereby eliminating the threat of nuclear destruction (Reagan's original dream) is excluded for the forseeable future by practically the entire scientific community and by almost all politicians. Apart from the serious doubts about the technological feasibility and effectiveness of individual devices and of the system as a whole, which is supposed to provide the desired impenetrable shield, there are a series of factors that make it unlikely that the US population and society can ever be made invulnerable.

First, it is likely that the Soviets would have a broad range of countermeasures at their disposal that would render a US nation-wide defense ineffective. Such countermeasures include qualitative improvements (such as penetration aids) as well as quantitative ones (increase in the number of nuclear missile forces). Some countermeasures which could fail against a more limited defense -- a defense aimed at protecting only ICBMs, for example, -- could instead prove successful against a "perfect" or "near-perfect" defense. Second, a defensive system designed to counter ballistic missiles -- like the SDI system -- would fail to ensure a complete protection because of the threat posed by the remaining weapons of mass destruction, such as bombers and cruise missiles. Third, and perhaps most important, the cost-exchange ratio between offense and defense would be much more disadvantageous to a perfect or near-perfect defense than to an imperfect one.

However, even if a perfect defense against nuclear threat could be constructed, it is far from evident that it would create a situation of stability. In fact, it could increase the probability of conventional wars, today deterred by nuclear forces. In any case, if both superpowers were invulnerable to nuclear attacks, any, even small, technological step ahead or, worse, a breakthrough in offensive forces capabilities, would immediately create a very dangerous situation of instability: the first side to get the new technology would inevitably be tempted to use it as it could enjoy impunity. Paradoxically, from this standpoint, a situation of mutual perfect defense would be very similar to the one resulting from an agreement that would radically cut offensive capabilities on both sides. Thus, analysis of the case of perfect defense clearly shows the groundlessness of Reagan's dream of basing stability on something as unstable as technological progress.

Avoidance of limited attacks. Some advocates of SDI have developed the following line of reasoning: a solely offensive-oriented deterrent is not sufficiently credible against a limited attack because there will always be doubts about the readiness of political leaders to risk nuclear escalation by unleashing nuclear retaliation forces in response to a limited attack; the employment of defensive systems would, in principle, be absolutely credibile. In other words, according to this view, a defense-oriented deterrent would be more effective because it would force the opponent to plan only large-scale attacks, thus strongly reducing its options.

This argument can work only if one assumes the possibility of a perfect or near-perfect defense, which is, as we have seen, very unlikely; a less effective defense would not have the desired effect. Indeed, in this case, if the Soviets planned to launch a limited attack, they would not be forced to increase the number of targets of their attack -- thus risking a more extensive retaliation -- but would only use a larger number of forces against the same number of targets. The cost of the attack would increase, but the damage caused to the United States and, hence, the probable level of its reaction would not change.

Moreover, it is clear that this argument in favour of SDI displays a deep lack of confidence in the efficacy of flexible response doctrine, that is, the current official doctrine of Nato. The doctrine of flexible response is far from being sacrosanct, but it is evident that any attempt to replace it involves political risks for the Western alliance.

Introducing uncertainty in the calculations of an attacker. According to Fred Hoffmann, "ballistic missiles now offer an attack planner a degree of simplicity and predictability associated with no other weapon system. Planning a ballistic missile attack is much more like building a bridge than it is like fighting a war. The distinguishing characteristics of warfare, an active and unpredictable opponent, is missing. Introduction of defenses will change that radically and the change will reduce the strategic utility of ballistic missiles, now the keystone of US and Soviet military forces" (16). Many other SDI advocates have used such an argument, claiming that a BMD system can enhance deterrence and stability because it increases the uncertainty of a nuclear attack. A close examination of this argument, however, reveals several relevant objections:

First, it must be observed that a strategic balance based on mutual assured destruction, in which it is certain that neither side can win a war, is much more stable than a hypothetical balance, in which one or both sides are only uncertain about the outcome of a military confrontation. Uncertainty, in and of itself, can by no means provide an effective deterrence. At best, it can be considered a complementary condition for deterrence. Moreover, according to many analysts, there are already several strong elements of uncertainty in planning today.

Second, an attacker could solve the problem of uncertainty about the effectiveness of the enemy defense system by increasing the scope of its attack. That is particularly true of military plans for limited attacks. More generally, increasing the uncertainties of each side about the military capabilities of the other would necessarily accelerate the arms race.

Third, assuming that each side has a BMD system, uncertainty would reduce the confidence both sides have in their retaliatory capabilities more than the confidence they have in their first strike capabilities. In other words, uncertainty deriving from a mutual deployment of BMD systems would deter a second strike more than it would a first strike. Thus, the net effect would likely not be to enhance deterrence, but to weaken it.

Fourth, as a general rule, uncertainty tends to have a destabilizing effect in any crisis situation. When the risk of a first strike by the opponent is high, uncertainty can represent a further incentive to pre-empt (17).

Fifth, the calculation of the net effect of uncertainty can be complicated by the fact that the perceptions of the two sides could be different. Assuming, for instance, that the US political leadership has a conservative approach -- that is, it overestimates Soviet military capabilities and underestimates its own -- and, on the contrary, that the Soviet political leadership has an overconfident approach -- that is, it overestimates Soviet military capabilities and underestimates those of the US -- and if it is further assumed that each side knows the perceptions of the other, uncertainty would have an asymmetrical effect on the two sides and, as a result, weaken deterrence.

Avoidance of nuclear holocaust. Should deterrence fail, argue the SDI supporters, a BMD system could avoid a nuclear holocaust by limiting damage.

One can naturally imagine very different thresholds of "tolerable" damage. Some assume that survival would be assured if casualties do not exceed a given number. Others prefer to use a more qualitative criterion, assuming survival would be guaranteed if a society were able to recover its industrial and

military potential after being hit by an all-out nuclear strike. As far as the superpowers are concerned, others add, the prerequisite would be their capacity to restore their military superiority over the other countries. Thus, depending on the values and the numbers assumed, there is a broad range of opinions on the matter.

However, only an extremely effective defense could plausibly provide a sufficiently high level of damage limitation to ensure survival. Indeed, given the current size of the superpowers' nuclear stockpiles, if even a small portion of the missile warheads of a massive nuclear attack were to penetrate the defense system, the consequence would be catastrophic.

Protection of ICBMs. Most analysts argue that a defense designed to protect ICBMs would prove more successful than other, more ambitious, types of defense. That is probably true because a more limited defense would require less complicated battle management and could be more easily protected against countermeasures. But the problem is whether it would provide significant improvements in strategic stability compared with today's offense-dominated strategic balance.

First, it must be stressed that an attacker could raise the probabilities of success by saturating the enemy defense with an increase in the number of ballistic missiles launched in the attack. With the current cost-exchange ratio between offense and defense, which is very advantageous to the former, that simple quantitative countermeasure would probably be very effective.

Moreover, it is hardly conceivable that nuclear exchanges between the two superpowers would only be directed against military forces. Both the first striker and the second striker would probably use a portion of their forces to hit the enemy cities and population. However, after a hypothetical pure counterforce attack, the military value of the surviving ICBMs would not be the same as they had been prior to it. Indeed, the ICBMs are more capable of destroying hard targets than are the other two legs of the triad, but if, as is assumed in this case, the first striker were to launch a large portion of its nuclear forces, the number of hard targets in the first striker's hands would substantially diminish after the attack.

In general, the other two elements of the triad (bombers and SLBMs) seem capable of ensuring a sufficient retaliatory capability for the United States even if all ICBMs were destroyed.

Furthermore, should the SDI program also provoke the deployment of a Soviet BMD, a portion of the surviving US ICBMs would be destroyed before hitting their targets. As a result, the number of ICBMs that would reach Soviet territory would not change.

Most importantly, the deployment of mobile systems and the hardening of silos seem to be effective alternative methods of solving the problem of ICBMs protection.

Protection of C3. If the Soviets were to launch an attack, whether or not they would be interested in destroying US command, control and communication systems is a controversial issue. With such a move, the opportunity to induce the United States to make concessions at a negotiating table would be lost. On the other

hand, the Soviets could decide to adopt a strategy that would not involve bargaining, or may prefer to negotiate with a new, presumably more docile, leadership.

At least three major counter-arguments must be considered: First, should the Soviets consider attacking US C3, it is very unlikely they would expect anything less than a massive retaliation. This prospect alone could sufficiently deter them from such an attack. Second, according to many analysts, there is a very high likelihood that the United States would maintain a massive retaliation capacity even after a Soviet attack against its C3. Third, given the small number of US C3 targets and, consequently, the possibility the Soviets would have to concentrate their forces on them, it is far from certain that even a very effective US BMD would be capable of protecting C3.

Compensation for risks of Soviet noncompliance with arms control agreements contemplating massive offensive reductions. As Keith Payne and Colin Gray have argued, "the United States could never verify strict Soviet compliance with a possible START regime that mandated reductions in offensive forces down to the low hundreds of weapons. But, with strategic defenses deployed, the superpowers could be confident that cheating would have to be conducted on a massive scale before it could provide a capability sufficient to yield important military or political advantage. If we assume that the United States and the Soviet Union will be political rivals for many years into the future, strategic defenses offer the only path to a nuclear disarmament agreement with which both parties could live" (18).

The very significant progress made recently by the superpowers in agreeing on effective strict methods -- including intrusive on-site inspections -- to verify compliance with arms control treaties, makes it possible to be much less pessimistic about the prospect of a verifiable START agreement. It is true that some verification problems remain (those concerning mobile missiles, for example), but in principle, they are not irresolvable.

Moreover, the reductions that the two sides are currently discussing in Geneva is not at a level that would warrant concerns such as those raised by Payne and Gray. Indeed, an imperfect BMD would be useful to compensate for risks of Soviet non-compliance with an offensive arms control agreement only if that agreement reduced offensive weapons to a very low level.

Finally, it is very unlikely that the decision to deploy a US BMD would encourage a START agreement, as will be demonstrated in the following discussion. An assessment of the strategic balance from the standpoint of its dynamic development also raises objections to the arguments of the SDI proponents. A brief analysis of three of these arguments is presented below.

Probable evolution of the current offense-dominated strategic balance. The need for a US BMD has also been justified with the fear that the current, exclusively offensive, strategic balance may become more favourable to the Soviets in the future as a result of both technological progress and the Soviet military build-up.

The main concern is of an eventual Soviet acquisition of a disarming first strike capability. Some argue the Soviets are already not far from reaching such a capability. The problem is the following: what is the likelihood that the

United States will be able to maintain a sufficient retaliatory capability for decades to come if the strategic environment remains an offense-dominated one? At least three factors suggest that a Soviet strike aimed at disarming the United States is unlikely to be successful in the forseeable future.

First, the strategic triad (IBMs, bombers ad SLBMs) provides a broad range of options for timely retaliation even under the unfavourable conditions of a Soviet first strike. In fact, detection of the first launch by the Soviets would make it possible to alert and launch a significant portion of retaliation forces before the Soviet missiles arrive. Even if not SLBMs are not taken into account, many bombers could be alerted quickly enough to escape. Moreover, if the Soviets concentrated a part of their forces against the closest American bomber bases, the United States would have sufficient time to launch its ICBMs.

Second, the threshold of ICBM vulnerability could be raised in the future through a series of measures such as silo hardening and an increase in the portion of mobile missiles.

Third, the key element of the current US retaliation capability, the invulnerability of SLBMs, is likely to remain assured in the foreseeable future. According to most analysts, in fact, the submarine detectability is not likely to improve significantly; consequently, submarine warfare would not become easier to carry out.

The transition to a defense-dominated strategic balance. SDI proponents have recognized that the destabilizing factors working during the transition from an offense-dominated strategic balance to a defense-dominated one are by no means negligible. The solution they have suggested is a concomitant reinforcement of the US offensive capabilities. Thus, offensive forces would have the additional mission of ensuring a stable defensive transition.

It must be stressed that such a line of reasoning sounds like an implicit, unintentional acknowledgement that an offense-based military posture is an adequate deterrent today and is likely to continue to be so in the future.

Even if the United States should engage in a further strong offensive build-up, however, the transitional period towards a hypothetical defense-dominated world would present many risks of instability. In fact, in a situation characterized by a mix of offensive and defensive weapons, deterrence would not be assured. Neither the principle of mutual destruction, nor that of mutual survival would prevail. Neither side would be confident of the effectiveness of its own defensive and offensive systems, nor would it be able to calculate the effectiveness of the opponent's systems with acceptable margin of error. The outcome of a nuclear exchange would become even more difficult to predict than it is today, inevitably increasing the frustration of military planners. This would result in fueling the arms race since each side would desperately attempt to eliminate uncertainty by strengthening its retaliatory capabilities. Crisis stability, as well as the possibility of reaching agreements on co-operative measures, would be seriously undermined. Furthermore, the very high likelihood that technological advances in both offensive and defensive systems would be asymmetrical and would foster a climate of mutual suspicion, thereby increasing instability.

Similar conclusions about the so-called defensive transition have been drawn by the Office of Technological Assessment (OTA) in its report on Ballistic Missile Defense Technologies: "the transition from the current situation to one of defense dominance could require passing through an interim stage which might last for many years; there could be a serious risk that a crisis would arise during that period" (19). Since most scientists and analysts believe that it is impossible to achieve a perfect or near-perfect defense, the so-called "transitional" period would necessarily become a permanent one. This would undermine the current foundation of deterrence, without providing an alternative.

The resistance of defense to technological changes. The deployment of defensive systems would have the inevitable effect of prompting the adoption of increasingly sophisticated offensive counter-measures. Therefore, even the defensive systems would, in turn, have to be continually modernized. But it is hard to believe that defensive systems would be capable of keeping up with offensive systems in what would probably by an endless competition. It is inevitable that offense would always be ahead since counter-measures would be devised in advance.

Moreover, if the defense systems were only designed to counter the threat of ballistic missiles, eventual quantitative and qualitative improvements in other types of offensive weapons (such as bombers and cruise missiles) would be very destabilizing, especially if they were asymmetrical. Generally, the larger the coverage ensured through BMDs, the higher the risk that improvements in the capability of penetrating them could undermine deterrence (see the case of perfect defense analysed above.). To sum up, it is legitimate to have serious doubts about the robustness of defensive systems -- that is, their ability to withstand future technological changes.

Several attempts have been made to use computer simulation models of nuclear exchange to calculate the impact of mutual deployment of BMD systems on the strategic balance. These models are based on various and often very complex assumptions. They usually involve not only quantitative factors (such as the levels of defensive and offensive capabilities on both sides projected for the years to come), but also targeting plans and fundamental judgements (such as the value both sides attach to their own targets and those of the opponent; the estimates they have made of the reliability of their own weapons and those of their opponent, etc.). Since many factors cannot be calculated, simulation models are necessarily imperfect and cannot be regarded as substitutes for more concrete analyses. Furthermore, they are paradoxical: the more exactly they seek to represent reality through the addition of assumptions, the greater the margin of error they risk, since an error in the calculation of a single factor compounds the total error.

However, there is a set of predictions regarding the strategic effects of a mutual deployment of BMD systems which appears highly plausible because it coincides with the conclusions of most simulation models. These predictions are as follows:

(i) Only BMD systems with a high degree of effectiveness -- that is, one capable of intercepting a significant portion of enemy ballistic missiles -- might change the strategic balance substantially.

(ii) Mutual defenses against ballistic missiles (especially if they were equally, or almost equally effective) would have the effect of reducing the retaliation capabilities on both sides. In fact, the number of nuclear warheads surviving the attack would increase, but the number of those reaching their targets would decrease. The net effect would be negative in terms of retaliation capability because even the currently invulnerable component of offensive forces (SLBMs) would be partially destroyed by the enemy BMD. However, it must be underlined that the size of retaliatory forces per se is only of relative significance for deterrence. A smaller retaliatory capability might suffice if the BMD system were capable of intercepting a large number of missiles launched by the adversary in a first strike.

(iii) The deployment of air defenses along with BMDs would significantly increase stability.

(iv) Arms control agreements on mutual reductions of offensive stockpiles would not necessarily increase stability during the defensive transition. In general, if BMD systems had only a limited capability, the weakening of the offensive posture would be destabilizing.

(vi) If BMD systems suffered from mutual vulnerability, instability would be very high, especially if the defense-suppression forces were also vulnerable. In that case, in fact, the first striker would enjoy a great advantage.

TECHNOLOGICAL ASPECTS

The issue of the feasibility and effectiveness of BMD systems has been addressed in several studies, some of which have been dedicated specifically to a technological assessment of the SDI system as planned by the Strategic Defense Initiative Organization. In the last few years, experts have become increasingly more pessimistic about the possibility of developing and constructing a BMD system capable of performing the missions for which SDI was conceived. Some technological options that seemed at hand have proved much harder to pursue, others have become progressively less attractive or have been set aside. This section presents a brief summary of the conclusions drawn by the most recent studies on the technological aspects of a US BMD .

According to the latest report on SDI by the Office of Technological Assessment (OTA), SDI Technology, Survivability and Software, the achievement of 'phase one' of the SDI program (including ground-based as well as space-based interceptors) given the state of the art, would lead to the construction of a defensive system capable of destroying one fourth of Soviet warheads at best (assuming a full-out attack). In 'phase two', the kill capability of the US BMD would increase to one half of the Soviet warheads, assuming that the United States is able to put a very large number of interceptors into orbit. Finally, the success of 'phase three' depends on the future technological progress in the field of directed-energy weapon systems whose feasibility and effectiveness are very uncertain today.

The most challenging problem concerning kinetic energy weapons is not their feasibility, but their capacity of intercepting a useful fraction of Soviet missiles, given the very high likelihood that the Soviets would be able to adopt a large set of effective counter-measures. More precisely, the problem is not

the lethality of the impact (as in the case of directed-energy weapons), but the likelihood itself of intercepting the booster (or the warheads).

The ERIS (Exo-Atmospheric Reentry Interceptors System) designed to destroy Soviet missiles in their late mid-course phase is one of the most mature technologies of the defensive system planned by the SDIO. But it remains uncertain whether the sensors needed for the functioning of the ERIS would be capable of ensuring adequate discrimination between warheads and decoys. The discrimination task is likely to become ever more difficult to accomplish because the Soviets, according to most predictions, will be able to improve their systems of missile penetration aids significantly in the years to come.

Space-based interceptors would have the mission of destroying Soviet missiles before the release of Rvs. As a counter-measure against SBIs, the Soviets would intensify their efforts to shorten booster burn times. The outcome of such a competition also remains uncertain. Once improved, SBIs could have some utility as a kill mechanism in the mid-course, but it is likely that this utility would be marginal. Furthermore, major problems regarding the deployment of a SBI system, including its costs, have not yet been solved.

The SDIO has planned the deployment of directed-energy weapons (free-electron lasers, chemical lasers, neutral particle beams, nuclear bomb-pumped x-ray lasers) only in the third phase of the SDI program. Today, the brightness these weapons are capable of producing is thousands of times lower than the level needed to destroy boosters. The Soviets could also adopt a set of counter-measures against directed-energy weapons. In particular, they could deploy fast-burn, laser-hardened and spinning boosters and concentrate the new missiles only in a few areas in order to raise the so-called "absentee ratio", thereby increasing the number of satellites required for adequate coverage. Against these counter-measures, the Americans, in turn, would be forced to increase and improve several elements of their system based on directed-energy weapons, such as the number of the weapons and the amount of power in orbit. Even in this case, the outcome of the competition is unpredictable.

In the last few years, the most promising steps forward have been made in the development of the directed-energy weapon system based on a neutral particle beam (NPB). Its brightness is still insufficient, but it is probable that it will be progressively increased through reductions in the beam divergence angle. Given that particle beams cannot penetrate the atmosphere because of the disruptive effect of collisions with air molecules, however, this type of weapon cannot prove useful against fast-burn (MX-like) boosters, and could only serve in the mid-course. Moreover, its cost still appears too high, assuming that the objective is to ensure significant coverage.

The kill-mechanism based on free-electron lasers (FEL) and space-based mirrors is also considered promising by the SDIO. But several major issues (such as the disruption caused by the passage through the atmosphere, the mirror damage, the level of unused energy, the fragility of the system as a whole) remain unresolved.

As for chemical lasers, apart from the level of brightness (which is still much lower than required), the greatest obstacle is the weight of battle stations and chemical reactants to be put in orbit as they require a very high launch capability.

Finally, the pop-up x ray laser technology is still in such a primitive stage of development that its feasibility and effectiveness cannot be predicted.

Many scientists have stressed that, once significant progress in the field of kill-mechanisms is made, the technological debate will tend to concentrate on the other aspects of BMD systems, as was the case in the controversy on the previous form of BMD (20).

There remain serious doubts that sensor technology will soon be able to distinguish enemy warheads from decoys. The latter will tend to become more and more sophisticated, creating complications for tracking missions. To solve that problem, the most promising technology today appears to be interactive discrimination through neutral particle beams. But that technology will not be available before the second decade of next century at the earliest.

The architectural problems will also be very hard to solve. Research in this field is only beginning.The communication system should be very sophisticated, since it would involve both ground-based and space-based elements. Sensors, weapons, surveillance satellites and battle managers should be able to exchange information in a secure and rapid way. During a nuclear exchange, the entire system would be subject to many different disruptive effects that are very difficult to represent realistically enough to make reliable predictions. The large number of architectural elements and interactions among them make designing the system a very complex task. Computing technology would require a much higher level of processing speed and memory than that which is currently available.

Heavy reliance on software would reduce the human factor in the battle management system of BMD to few initial decisions and operations. But this would decrease the possibility of realistic simulations as it is impossible to create artificial conditions analogous to those of a nuclear exchange environment. Any attempt to draw conclusions by taking other software systems as examples is necessarily doomed to failure. The magnitude of the system itself represents a formidable challenge for software technology. To date, the development of software technology has proceeded at a slower pace than that of hardware and many scientists think the gap will persist in the foreseeable future. Given these unfavourable factors, it cannot be excluded that software may prove totally unsuccessfull. Nevertheless, decision-makers could choose to run such a risk, confident that the enemy, in turn, could never know exactly how high the likelihood of a failure of software would be. Indeed, such a situation exists today with respect to the reliability of ballistic missiles.

In several documents and statements regarding the SDI program, Reagan Administration officials emphasized that survivability is an absolutely necessary requirement for a US BMD (21). The need to ensure the survival of the BMD system in case of an enemy attack against it is also recognized by all analysts. Its vulnerability would have a very destabilizing effect, especially in a scenario of crisis and in terms of first strike incentive.

All the BMD systems, including those with ground-based weapons, would have an essential part of their components based in space. They would thus suffer from the vulnerability of satellites. Since space-based lasers must orbit at low altitude in order to be sufficiently close to their targets, they would be

particularly vulnerable to ground-based ASAT weapons. The Soviets will possess the technology needed to deploy effective DANASATs (Direct Ascent Nuclear Anti-Satellite Weapons) by the mid-1990s. Therefore, even the first phase of the SDI system depoyment would face an ASAT threat. Both satellites for surveillance and tracking and those designed to carry interceptors would be vulnerable. During the second phase, the situation may be no more favourable to the BMD system, since improved ASAT weapons will be at the disposal of the Soviets. Finally, in the third phase, the survivability issue may become even more serious because of two factorss: the increased number of components in space (such as mirrors) and the possibility of using directed-energy weapons in an ASAT role. Therefore, the threat posed by ASAT weapons would remain constant during all three phases of deployment of the BMD system and would likely be increased by the new technologies. The rule, as far as the SDI systems are concerned, seems to be: the more exotic the technologies, the higher their degree of vulnerability. Consequently, the most destabilizing effect may derive from mutual deployment of ballistic missile defense systems based on directed-energy weapons.

In response to the deployment of a US BMD, the Soviets could find it more advantageous to deploy ASAT weapons rather than BMD weapons. The technologies of these two types of weapons are often the same: most BMD weapons will be capable of destroying or damaging satellites before they become effective against ballistic missiles. The probable result would be a new destabilizing arms race whose outcome is unpredictable.

Even if the United States enjoyed a clear supremacy in space or could convince the Soviets to keep their spacecrafts away from American ones, the ASAT threat would remain because the Soviets could use their ground-based weapon systems as an alternative.

In general, the assumptions by SDIO regarding BMD vulnerability appear, at the very least, too optimistic. The latest report on SDI has underlined that "no analysis assumed that the Soviets might deploy in space a BMD system comparable to that of the United States; thus, the potential vulnerabilities of such weapon systems to one another were not considered. Instead, it was assumed that the United States would, for the most part, militarily dominate near-Earth space" (22).

THE SDI AND US-SOVIET RELATIONS

SDI advocates argue that the deployment of a US BMD would not necessarily result in a deterioration of the relations with the Soviet Union and provoke a new cold-war climate. They add that it might take place in a co-operative environment which could also make an agreement on substantial reductions in offensive weapons possible on both sides. The underlying idea of such an argument is that BMD systems may increase the incentive for negotiated cuts in ballistic missile forces by reducing their effectiveness. But it remains to be demonstrated that such a reaction would be the most natural one for the Soviets. Instead, they could be induced to seek to improve and enhance their offensive forces both by increasing their numbers and by developing counter-measures. It appears very unlikely that the Soviets will be willing to eliminate a portion of their offensive forces only because they become less effective. A defense-oriented arms control would be plausible only if the two sides had the same technological capabilities of deploying a BMD system. In such a case, in

fact, each side would be confident that the other could not gain superiority. But, as has always been the case with new technologies, it is inevitable that asymmetries would emerge, creating a climate of suspicion unfavourable to arms control agreements.

Some SDI proponents argue that the Soviets would be ready, or could be convinced, to accept defense-oriented arms control agreements because their military doctrine is strongly oriented towards damage limitation, as has also been demonstrated by their constant efforts to improve their defensive posture even after (and likely in non-compliance with) the ABM treaty. It is certainly true that Soviet military thought puts particular emphasis on damage limitation, but that does not mean that it is unaware of the inevitable superiority of offensive forces. That point has been stressed by many experts in Soviet military policy (23). The strong Soviet commitment to enhance its defense suggests neither an overestimation of the capabilities of defensive forces, nor an underestimation of those of offensive ones. The Soviets have an arms acquisition policy which tends to attach great importance to prompt operational applications. That is one of the most important reasons for which they have so far been much more willing than the Americans have been to devote a large amount of resources to imperfect defensive systems. The SDI proponents exaggerate the importance of strategic ideas in this Soviet approach.

On several occasions, SDI advocates have expressed the hope of establishing an agreement with the Soviets on the value of defensive systems as a preliminary condition for negotiated reductions in offensive forces and, in general, for a cooperative transition towards a defense-dominated world. Acoording to that view, it would be possible to reach a comprehensive arms control arrangement based on the acknowledgement by both sides of the strategic supremacy of defensive systems. Yet, the Reagan Administration never clarified in detail how the new, defense-oriented arms control approach could be established successfully. Even the statements by its spokesmen have been contradictory, because they have also emphasized the need for considerable enhancement of offensive forces, particularly in the so-called defensive transition.

Indeed, among the reasons the Reagan Administration had for its massive offensive build-up, was concern about a possible threatening increase in Soviet offensive forces before the deployment of the US BMD system. More explicitly, some analysts who advocate SDI recognize that the decision to deploy a BMD system cannot have a beneficial short-term effect on the arms control process. They add that the main political goal the United States should seek to achieve through its defensive system (at most and only in the long-run) is gaining a negotiating leverage over the Soviets (24).

There can be only few, if any, doubts that the Soviets would seek to respond in a timely and energetic manner to a unilateral decision by the United States to deploy a BMD system. After such a decision, indeed, the whole strategic environment would be upset or, at least, both sides would have such a perception and, consequently, each would seek to strengthen its own military posture unilaterally.

The Soviets could choose among several options: (i) With regard to offensive weapons, they could engage in an accelerated deployment of ballistic missiles by exploiting their great production capacity. Their goal in this case would be to saturate the US defense system. (ii) They could boost their ballistic missiles

modernization program by aiming at operational, design or technological innovations, including those (such as new types of boosters with a greater capacity to survive) which could serve as counter-measures against a BMD system. (iii) They could launch a program to increase their ASAT capabilities as rapidly as possible. (iv) They could seek to avoid the obstacle of the US BMD system by increasing the stockpiles of offensive weapons other than ballistic missiles. In the latter case, the most promising weapon would be the cruise missile. It is quite probable that the Soviets would devote a large part of their efforts to enhancing their overall offensive capabilities. In fact, according to most analysts, the cost-exchange ratio is still strongly against defense and will not change in the foreseeable future.

Some are of opinion, however, that the Soviets, far from limiting their efforts to adopt counter-measures and increase their offensive capability, will attempt to emulate the United States in defensive technologies; they must defend their military-technological prestige before the international community (25). In any case, the most unlikely response by the Soviets would be to agree to limit competition only to defensive technologies, by agreeing to negotiated reductions in offensive weapons. They have, in fact, too much consideration for US technological capabilities to be confident in the outcome of a competition in which the leading technologies would play an essential role.

To sum up, the only certain, indeed inevitable, effect of the decision to deploy a US BMD system in the arms control process would be the abrogation of the ABM treaty. The SDI supporters argue that the ABM treaty has not proven useful to its goal, that is, reductions in offensive weapons (26). But it is doubtful that the failure of the negotiations on strategic offensive arms in the late seventies can be attributed to the regime created by the ABM treaty. Rather, the principal factor was the deterioration of the international climate. Moreover, it is far from certain that today's strategic balance would be not be more unstable if the restraints on defensive weapons introduced by the ABM treaty had not worked in the last seventeen years.

The philosophy of SDI upsets the strategic logic underlying the ABM treaty, according to which the renunciation of defensive weapons is a decisive condition for reaching a lower level of offensive weapons. Instead, the SDI proponents, as has been seen, argue that the best way to achieve the goal to reduce offensive stockpiles is the mutual deployment of BMD systems. But such a connection is much more uncertain and controversial. The ABM treaty is based on the realistic recognition that stability requires an assured retaliation capability on both sides and that the loss of such a capability (or the perception of one side or the other that it may be cancelled in the future) would fatally undermine stability. Indeed, the ABM treaty represents the most solid pillar of the current arms control regime: its collapse would be decisive.

CONCLUSIONS

Most of the assumptions underlying the original vision behind SDI have not withstood the force of the facts. A long time before the beginning of the new century, the illusory nature of the technological millenarism has become evident. The hope of eliminating the disturbing dilemmas of the nuclear age by constructing an impregnable shield against enemy ballistic missiles -- a hope that had aroused the enthusiasm of the public -- is now generally regarded as nothing but wishful thinking. The intellectual challenge issued to the

scientific community by the SDI proponents seemed promising; so far, however, technology has progressed at a very different pace and in quire another direction from those anticipated. A more thorough technological assessment has shown that the dream of a total protection of cities and population is attainable. The notion of 'defensive transition' itself has become less and less credible. Indeed, it is likely that such a transition would always be in progress. Therefore, the deployment of BMD systems would result in undermining the current offense-dominated form of deterrence without creating an alternative one. There remains the possibility that the cost-exchange ratio between offense and defense might favour the latter in the future. If that should occur, defense could play a greater role in ensuring deterrence. Unfortunately, however, there are as yet no signs that such a ratio is significantly changing or could change in the forseeable future. Even the cost-effectiveness of the SDI program has proven much less advantageous than projected at first. For some technological systems, originally considered promising, the costs now appear prohibitive.

As a consequence of such major developments, interest has been shifting towards the deployment of less-than-perfect defenses that could be capable of performing some limited missions such as the protection of US retaliatory capabilities. But there is doubt that such missions could be performed (more effectively and at lower cost) by systems other than those planned under SDI.

Even the decision to deploy a limited BMD would inevitably aggravate US-Soviet relations since it would also lead to a unilateral abrogation of the ABM treaty. The entire arms control process regress significantly. An involutional phase in the relations between the two blocs would be inevitable.

Furthermore, recent results in the field of arms control have shown that the conviction of most SDI proponents that it is impossible to reach advantageous and verifiable agreements on strategic weapons with the Soviets in the short-run is unfounded.

Finally, the Soviet intention to renounce the Krasnojarsk radar (the most worrying violation of the ABM treaty, according to the United States) suggests that they could be ready to make substantial concessions on their defensive capabilities in exchange for American renunciation of SDI.

Given these elements, the following are recommended:

(i) In order to preserve the current conceptual structure -- indeed, the only plausible one -- of the arms control process and pave the way to mutual reductions in offensive weapons, it is essential that both sides reaffirm their confidence in a deterrence based on mutual assured retaliation capabilities and recognize the destabilizing character of ballistic missile defence systems; in other words, both sides must reaffirm the two key principles underlying the ABM treaty.

(ii) There is no longer scope for a strategy aimed at defending the letter of the treaty. Indeed, such a strategy would not be successful for at least two reasons. First, too many elements of dissatisfaction with the treaty and, consequently, of mutual suspicion have accumulated since the treaty was signed in 1972. According to the Americans, both sides have not been equally compliant with the treaty: while the United States has complied fully with the treaty, the Soviet Union has committed several, more or less concealed infringements, some

of which have aroused the legitimate fear of a gradual creep-out or, worse, a sudden break-out from the treaty. Second, technological progress has also contributed to eroding the effectiveness of the treaty. In particular, its provisions regarding development and testing have become increasingly inadequate given the most recent technological developments. Therefore, adopting active measures to improve and strengthen the treaty is the only way to ensure its preservation. That requires review aimed at solving the terminological controversies and establishing stronger restraints on testing and development. New forms of on-site inspections could also be included.

(iii) There are several reasons for which such a revision of the ABM treaty should allow for research and laboratory testing. Three of them appear particularly worth mentioning: no reliable system exists that could verify violation of eventual provisions banning these two types of activities; it cannot in principle be excluded that future technological developments -- not foreseeable today -- might provide the opportunity for a defense-dominated world; each side is interested in being as well prepared as possible, should the other break the treaty.

(iv) As for procedure, the adoption of a new additional protocol would be too limited a measure to ensure an adequate revision of the ABM treaty. The text of the treaty itself should probably be modified. Moreover, such a modification should be provided for, or worked out as a part of a more comprehensive agreement including reductions in offensive forces. Indeed, as the experience of the last few years has confirmed, the destiny of the ABM treaty is strictly connected with the evolution of START negotiations. For that reason, the revision of the treaty should not be assigned to the Standing Consultative Commission, but should involve a much more complex bargaining process.

(v) The agreement on the preservation and enhancement of the ABM treaty should be accompanied by one that bans ASAT weapons, which are highly destabilizing -- especially in crisis situations because they can effectively be used against the surveillance, tracking and communication satellite systems. (It must be underlined that any agreement to ban ASAT weapons would also imply a ban on BMD systems because the latter often have ASAT capabilities). Such an agreement could be the first step towards a general arrangement aimed at controlling and limiting the military occupation of outer space.

(vi) It is unquestionable that the SDI program has indirectly contributed to convincing the Soviets to re-open the negotiations on strategic weapons and, more recently, to making significant concessions, such as the renunciation of the Krasnoyarsk radar. This Soviet attitude shows that they are very concerned about the possible impact of a US BMD on the strategic balance. Therefore, the SDI program could still be a useful bargaining chip to convince the Soviets to limit or suspend their activities and plans which can have a strategic defense role, such as the development and deployment of SAM systems and their radars.

Notes

1. See Office of Technology Assessment, Ballistic Missile Defense Technologies, September 1985, p. 298.

2 According to the new version of the program, smaller weapons would be put in orbit and each of them would carry fewer rockets and less complex targeting mechanisms (such as homing sensors).

3.See Office of Technology Assessment, Ballistic Missile Defense Technologies, September 1985, p. 298.

4. See Office of Technology Assessment, Ballistic Missile Defense Technologies, September 1985, p. 298.

5. That deep sentiment of dissatisfaction with MAD is described by Harold Brown as follows: "From my own experience, the fact of American vulnerability to utter destruction by nuclear attack erodes the confidence that political leaders have in US nuclear policy. It affects all of US national security policies and limits American military and diplomatic behaviour. I have seen this in the five presidents I have served, and in my own action as Secretary of Defense. I have also seen the frustation that this vulnerability has created in senior US military leaders, as well as their frustation with public and Congressional criticism of efforts to modernize strategic offensive systems. Their advocacy of defensive systems, and even a defensive strategy, can thus be explained even though they may have doubts about its efficacy" H. Brown "The Strategic Defense Initiative: Defensive Systems and the Strategic Debate", Survival, March/April 1985, Vol. XXVII, No. 2, p. 55.

6. "A rational strategy for the employment of nuclear weapons is a contradiction in terms. The enormous destructive power of these weapons creates insoluble problems. For this reason, much of the history of nuclear strategy has been a series of attempts to find a way out of this predicament and return to the simpler, more comforting prenuclear world in which safety did not depend on the adversary's restraint." R. Jervis, The Illogic of American Nuclear Strategy, Cornell University Press, Ithaca, 1985, p. 19.

7. "Because of our relative ignorance of Soviet perceptions, US planners tend to rely on their own calculations. But all the evidence we have suggest that preparing to deter an attack only by assembling conditions adequate to deter us under similar conditions could provide too little to deter the Soviets" C. Weinberger, "US Defense Strategy", Foreign Affairs, Spring 1986, Vol. 64, No. 4, p. 682.

8. See Caspar W. Weinberger, "Why Offense needs Defense", Foreign Policy, Fall 1987, No. 68, p. 10.

9. See Caspar W. Weinberger, "US Defense Strategy",.Foreign Affairs, Vol. 64, No. 4, Spring 1986, p. 679.

10. "I firmly believe that human beings possess the necessary genius to solve today's most pressing strategic problem: radically reducing and eventually eliminating the threat of nuclear war". Caspar W. Weinberger, "Why Offense Needs Defense", Foreign Policy, Fall 1987, No. 68, p. 4.

11. "No one can say what the balance of technological and tactical advantage between offense and defense will be in 20 or 30 years. But we do know that the history of military technology records swings of the pendulum of advantage from one to the other; and that strategic offensive technologies today are relatively mature, while strategic defensive technologies are very immature.-- meaning that for the next several decades at least the advantage in growth in performance potential ought plainly to lie with the defence." Colin S. Gray "A case for Strategic Defence", Survival, March/April, Vol. XXVII, No. 2, 1985, p.??

12. "The record is replete with istances of faulty predictions about the impossibility of technological accomplishments by those with highest scientific credentials, and we should view current predictions about the impossibility of effective ballistic missile defenses in the perspective of that record." Fred S. Hoffman, "The SDI in US Nuclear Strategy", International Security, Summer 1985, Vol. 10, No. 1.

13. "It is a little surprising to say the least that the United States should commit itself to a long-term program rooted in ill-defined scientific promise." Sayre Stevens, "The Soviet Factor in SDI", Orbis, Vol. 29, No. 4, Winter 1986, p. 688.
The author adds that by committing to SDI, the United States has paradoxically adopted an approach similar to the traditional one of the Soviet Union, where "the population as a whole is well-schooled in coping with the enduring pursuit of an uncertain objective" and "there is an underlying anthusiasm about the contributions that ill-defined science can make in such an effort" (ivi, p. 692)

14. "If one is serious about nuclear disarmament, as one should be, and given that no one knows how to achieve a general political settlement with the Soviet Union that would render issues of competitive nuclear armament politically irrelevant, there is no prudent choice available other than to press on carefully to explore the possibilities of strategic defense." Colin S.Gray, cit., p.51)

15. "There are a number of reasons for believing we can successfully develop strategies for competing more effectively in selected areas. We are entering into a period of rapid technological change that can work to our advantage. We have superior skills in the development of military systems embodying some of the leading technologies and superior manufacturing techniques and skills".Caspar W.Weinberger, "US Defense Strategy", op. cit., p.696.

16. Fred S.Hoffmann, "The SDI in US Nuclear Strategy", op. cit., p. 23.

17. This point is clearly explained in OTA 1985 p. 133: "There is a degree of paradox associated with uncertainties that BMD deployment could introduce in the calculations of the two sides. On the one hand, increased uncertainty about the likelihood of successful attacks could increase crisis stability by making the aggressor less willing to gamble on a favorable outcome from a first strike. On the other hand, in the face of growing uncertainty about the effectiveness of its military forces, each side will have an incentive to try to reduce that uncertainty by deploying additional offensive and defensive weapons and countermeasures."

18. Keith B.Payne, Colin S.Gray, "Nuclear Policy and the Defensive Transition", Foreign Affairs, Spring 1984, Vol. 62, No. 4, p. 840.

19. See Office of Technology Assessment, Directed Energy Missile Defense in Space, Background Paper, by Ashton B. Carter, MIT, Washington D.C., 1984, p. 39.

20. "The interceptor missile in traditional BMDs has not been the central focus of attention or technical debate since the 1950s, when it became clear that a "bullet could hit a bullet". Discussion of BMD at that point passed to the difficult issues of radar performance, data processing capability, and vulnerable basing of defensive components - issues that had nothing to do with the kill mechanism. In a similar manner, the other essential elements of a boost-phase intercept system will figure more prominently in discussion of boost-phase BMD if and when the kill mechanisms - lasers, mirrors, accelerators According to the last OTA report, "Until an architectural description is available that clearly specifies battle management structure and allocates battle management functions both physically and within that structure, better predictions will not be possible"(OTA 1988, p.215).

21. As an example, the special report on SDI - published in June 1985 - stated: "If a defensive system were not adequately survivable, an adversary could very well have an incentive in a crisis to strike first at vulnerable elements of the defense. Applications of this criterion will ensure that such a vulnerable system would not be deployed and, consequently, that the Soviets would have no incentive or prospect of overwhelming it"(See the special report "The Strategic Defense Initiative", United States Department of State, Bureau of Public Affairs, Washington D.C., June 1985, in OTA 1985, p.307. See further the statement on this matter by Ambassador Paul H. Nitze in his speech to the Philadelphia World Affairs Council on February 20, 1985 in OTA 1985, p. 301: "The criteria by which we will judge the feasibility of such technologies will be demanding. The technologies must produce defensive systems that are survivable; if not, the defenses would themselves be tempting targets for a first strike. This would decrease rather than enhance stability")

22. Office of Technological Assessment, SDI Technology, Survivability and Software, Princeton University Press, Princeton, New Jersey, 1988, PP. 68-69.

23. "Although the Soviets Union has been committed for some time to the development and deployment of active defenses, it has concluded that, in general, the offense will overpower the defense." (Sayre Stevens, "The Soviet BMD Program", in Ashton B.Carter and David N. Schwartz, Ballistic Missile Defense, The Brookings Institution, Washington DC, 1984, chapter V, p. 188.) See also the article "The Kremlin and SDI" by Benjamin Lambeth and Kevin Lewis, Foreign Affairs, Spring 1988, p. 764: "The offense remains the linchpin of Soviet strategy. It is only through well-endowed intercontinental attack forces that Soviet planners contemplate surviving any war they may have to fight in the wake of a catastrophic failure of deterrence. In this outlook, active defenses are merely seen as a backstop for what remains essentially a counterforce strategy. Defenses certainly are not viewed as a substitute for offensive forces or a suitable guarantor in and of themselves of Soviet security". The authors conclude that "any serious Soviet willingness to partecipate in a joint transition to a defence-dominated world will require their acceptance of a concept of security very different from the one that currently undergirds their force modernization". Stephen Mayer is of same opinion: "strategic defence is inexorably linked to the strategic offence in Soviet thinking. Every authoritative Soviet discussion of military strategy -- in both their 'open' and

'closed' literature -- makes it clear that strategic defence, in and of itself, cannot be the basis of national military policy" (Stephen M.Mayer, "Soviet Strategic Programmes and the US SDI", Survival, November-December 1985, Vol. XXVII, No. 6, p. 285.)

24. To cite Colin Gray, "Those who, like this author, strongly favour the possibility inherent in the SDI are under no illusions about the limitations of a 'technological peace'. Even if the SDI should prove to be a magnificent technological success story, which -- looking forward 20 or 30 years from now -- is certainly possible, strategic defence will not be a panacea for deeply political security problems. The SDI and a defensive transition can change the terms of deterrence, away from retaliatory nuclear threat (which would be no small accomplishment), but, in and of itself, it cannot arrest the arms competition. The 'last move' in that competition must be political, not military-technological" (Colin S. Gray, "A Case for Strategic Defense", op. cit., pp. 50-51).

25. As it was observed, "Soviet military and political leaders do not see SDI as simply another military challenge or another spiral in the continuing nuclear arms competition where off-setting measures would suffice. Rather, SDI is seen as a profound technological challenge...This technological challenge, Soviet political and military leaders have repeatedly observed, is one the Soviet Union cannot afford to ignore. In other words, an off-setting response to SDI is not sufficient; an emulating response is required as well"(Stephen S.Mayer, "Soviet Strategic Programmes and the US SDI", op. cit., p.275)

26. See, for istance, Caspar W. Weinberger, "Why Offense needs Defense", op. cit., p.12.

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