Space-Based Missile Defense: Has Its Time Come?[*]

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Let me begin by noting that while I am associated with a number of organizations, whatever I say today represents my own experience, ideas and analyses.

Dr. Jastrow suggested the title of my remarks, "Space-Based Missile Defense: Has Its Time Come?" It is a trick title, in a sense. Space-based defense has been with us ever since the dawn of the space age. For over thirty years, we have had a defense support program as a primary missile-warning sensor. It is soon to be upgraded by the Space Based Infrared System (SBIRS) High Component, a third version of the system; and of course there is the SBIRS Low Component, a constellation of lower-altitude satellites to provide both better warning and metrics for missiles. So having something in space is not a new thing.

What is different, it seems, is that it now looks like defenses are possible in all available layers – terminal, mid-course and boost. This is a marked departure from the time I entered the business (in, roughly 1961), when the United States was interested in developing a system based only on a mid-course and a terminal layer. That generated a series of debates that went on for the better part of a decade, which unearthed most of the problems of a defense built on just those two layers.

The problem is that while terminal defenses are very good at providing localized coverage to specific high-value targets, unless you have such defenses everywhere, an attacker can simply move over to attack another high-value target. Mid-course defenses, on the other hand, get you into very sophisticated, complicated issues of discriminating decoys from re-entry vehicles: while mid-course is the longest portion of a weapon's trajectory, it is also where all objects fly ballistic trajectories, so it is not possible to differentiate decoys from reentry vehicles on the basis of their kinematics only.

The boost phase is the new element that's been added. A serious attempt at boost phase goes back about fifteen years. That's the first time that Edward Teller and I were able to postulate a version of a space-based interceptor, subsequently known as the Brilliant Pebble (BP), that was capable and agile enough, but also light and cheap enough, to do two things: hit with high probability in boost, and survive long enough to be able to attack or to defend. So boost phase is an additional, key element.

Of course, boost phase doesn't have to be from space. In limited circumstances, surface-based possibilities are quite efficient for the threats which are accessible to them – addressing missiles and boost from, say, North Korea, Iraq, parts of Iran, and some Libyan launches, by putting interceptors on nearby ships in international waters or on secure Allied bases. But as threats grow – either in number or extent inland – the easy defenses go away. If you want to have a survivable, global missile defense with a boost-phase layer, then you are driven to a space-based system.

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But the key element is this: if you have multi-layer defenses with a 90 percent effectiveness in each of three layers, then the overall probability of a given weapon penetrating is about a tenth of a percent. And that is the level you have to get down to, before you are serious about protecting an urban value.

The Power of Sensors

One important capability that is opened up by sensor-based space defense is an appreciably larger "defended footprint" than that of theater missile defense (TMD). When you calculate the defended footprint of a ground-based, hit-to-kill interceptor with excellent radar support, you find that it can be appreciable – instead of TMD's tiny footprint, you get one the size of Europe. That's because rather than depending on an onboard radar detecting a reentry vehicle coming nose on, with very little cross-section, your SBIRS metrics can detect the missile launch, and you can take advantage of the full kinematic fly-out of the interceptor.

I mention this for three purposes. First, simply to point out the very interesting capabilities that are made possible by connecting sensors in space, quite independently from putting weapons in space.

Second, to point out an anomaly in the ABM Treaty: while the treaty defines national missile defense and theater defense (defense of troops in the field), it leaves regional missile defenses nebulous. When you have a nebulous area in a treaty, everyone avoids it. People developing systems that might be relevant are loathe to have their systems tested, lest through testing they are captured by the ABM Treaty. The strong pressure to stay out of regional defenses has created an artificial barrier in our thinking, particularly in the last eight or ten years: we could talk about purely theater or purely national defenses, but we could not talk about missiles of a few thousand kilometers range, which are being developed all over the world.

My third point is that the key element in making missile defense work is our ability to take metric information from the satellite sensor system – a system that can see the whole globe and the whole launch, and is able to transmit that information to the interceptor, so that the interceptor can most efficiently do its fly-out and take advantage of its full kinematic footprint. Although this seems very natural – taking sensor information and using it to get the most that you can out of your interceptors – in actuality, the possibility of doing so is not being resolved for national missile defense, let alone for regional missile defense. That is one reason to eliminate that distinction and clarify the ability to take advantage of space-based assets.

Development of Space-Based Interceptors

Regarding boost-stage intercept options, I noted earlier that where the trajectories allow, interceptors from the surface can be very effective, but when you move inland or where you do not have secure basing, then you are driven to space-based interceptors. The state of play regarding space-based interceptors tends to get confused, and in the last decade, has almost been forgotten, so let me say a word in review.

Space-based interceptors got their principal development during the Strategic Defense Initiative in the mid-1980s. After intensive, quiet development and several major reviews, they were formally approved as a major defense acquisition program and went into an engineering and manufacturing development (EMD) program, which was to have been about twenty tests. Of these, they got through, I believe, eight, with success that I would characterize as roughly comparable to that of the ground-based intercept system we are in the process of building today. That is, some things were completely successful, some things flopped, some things were partially successful.

Overall, EMD testing brought the Brilliant Pebble to a reasonably good state of development. The National Missile Defense (NMD) system has had some problems, but it also has had some notable successes, so I regard it as a reasonably successful program; the other system is halfway through its testing program.

Brilliant Pebbles, however, was reduced in the 1991 authorization bill to a "robust technology program" and then was abolished altogether in 1993, freezing the technology at about that point. Yet a nucleus of the technology and capability was resident in the National Laboratories and industry, and with them, the SDI program was able to execute the Clementine experiment in 1994.

The Clementine experiment used a collection of SDI sensors to re-map the surface of the moon at the highest accuracy ever seen. In the process of the experiment, ice was discovered at the southern pole of the moon, which has always been the great hope of people who want to use ice as a fuel for further exploration of the solar system. The Clementine experiment was very well and efficiently executed. (For more, see the special issue of *Science Magazine*, Volume 266, No. 5192, December 1994.)

There is sometimes a little confusion about Clementine because there were actually two experiments. On the way back from moon mapping, while in translunar orbit, the satellite was reprogrammed to perform a second phase of the experiment, to rendezvous with an asteroid. A mistake in the software left it unable to do its rendezvous. A second Clementine was designed to complete the asteroid research. I had to design the science package for that, and it would have been a very nice experiment, but it was cancelled before launch because it looked too much like a space-based interceptor.

In terms of its meaning for space-based interceptors, the first Clementine experiment exercised all of the sensor-package and autonomous-maneuvering capabilities required for station-keeping, surveillance and initiation of the track, while the second part would have done the hit-to-kill demonstration. The hit-to-kill physics is essentially the same as, and the velocities are comparable to, those involved in THAADS (theater high altitude area defense system), ERINT (extended range interceptor) and other hit-to-kill theater systems, which have since been quite successful. So for all practical purposes, all the different pieces of this space-based interceptor technology have been pretty thoroughly drawn out now.

<u>Speed and Size</u>

Let me say a word about constellation-size versus time-delay. The time delay is the delay for the release of the interceptor (ground-based or space-based) after you detect liftoff of the missile. With current missile defense systems, that release time is at a minimum – some tens of seconds. In actual point of fact, it would be more like a minute; with future faster-cycling missile defense systems, that time could be much shorter.

The point is that while constellations might be in the range of 50 or 100, you could get off without being degraded too badly if you could get release-delay times on the order of a minute. If, on the other hand, your delay times are on the order of two minutes or three minutes, you waste too much of the time before you release your interceptor and there is not enough time left to fly out. Make no bones about it, if you want to operate in the boost phase, you have to operate fast. You cannot tolerate big delays.

The other sensitive issue is range versus interceptor maximum velocity. If the interceptor maximum velocity gets up to about 6 km per second, as we did with the first Brilliant Pebbles, you can only get missiles out to an effective range of about 700 km, because you can't accelerate and take advantage of higher velocities. For higher-acceleration interceptors, you can take advantage of much higher velocities. Recently, the use of solid engines will get you an average of 20 Gs, although you don't really need anything like that for ICBMs. You need that for very short-run theater rockets but not necessarily for ICBMs.

Finally, there is the question of cost. Taking the average cost per interceptor and multiplying it times the constellation size, you can get the total cost to handle a single shot and a single launch. For a system that is what I would call "current performance" and velocities on the order of 6 km per second or so, one would pay somewhere in the range of .05 to .1 billion dollars. That sounds like such a wonderful deal, but you do have to take into account the fact that you don't shoot just one interceptor; you'd probably shoot two, so that you have a 99% rather than a 90% probability of intercept. And in order to have a margin against expected threats, you should probably be in a position to go against five missiles simultaneously launched. That moves things up by a factor of ten, and you wind up with a boost-phase layer which would cost on the order of four billion dollars for stuff in orbit. This actually still seems sort of cheap. Theater defense is only cheaper by a factor of three or four than the strategic systems and its much larger absentee ratios take away much of the advantage of the smaller launch.

A word about the Kinetic Kill Vehicle (KKV). The lightweight KKV that was developed back during the Brilliant Pebble program had attributes that would be very useful for other phases of engagement. It had all the sensors needed to do intercepts, and it had Lidar (light detecting and ranging) on board, which makes the endgame much less noisy (in terms of signal-to-noise) than the optical systems in theatre and ground-based interceptors.

The BP actually had a very nice front end. Part of the reason that it got in trouble was that they found it very difficult to build a booster that could throw the 100 kg EKV (exo-atmospheric kill vehicle). Having a lighter EKV would enable you to get more performance out of the given booster, and would also enable you to throw multiple interceptors on each booster. Then you don't have to turn yourself inside out trying to precisely discriminate decoys that have very little signature, or differential signature. Because you can either go to infinite precision and cost trying to do that; or you can say, if I can come up with a kill package that weighs four or five kilograms, I can afford to kill 10, 20, 30 and forget all this subtle discrimination stuff.

I have worked on this discrimination for forty years and I am very good at the math and I dearly love it. But at the same time, there's a lot to be said for putting yourself in a position where you can kill everything. Elegance has its limits.

If you want to kill everything, then the lighter your kill vehicle, the smaller the decoy you can engage on a cost-efficient basis – say, four or five kilograms. Lower than that, you don't care that much: the benefits of going to zero are not that impressive just for a space-based interceptor. If instead of having a five kilogram BP, you have a one kilogram BP, then you can start killing balloons at that rate.

The Issue of Stability

To turn from interceptor performance, I'd like to talk about the issue of stability. For two decades, I have been interested in how the Russians and the Chinese view stability and how they view the impact of our deployment of defenses.

What we would like to do is get out of the Cold War, to get rid of its weapons in a stable fashion. To analyze stability, I charted "first-strike cost" as a function of the number of weapons (specifically, re-entry vehicles, or RVs). First-strike cost is simply the cost of striking first: a combination of the damage that is done to us and whatever damage objective that we have that we do not inflict ourselves. If I put up a defense, the first-strike cost goes down, because it negates the other side's second strike.

I use first-strike cost as a surrogate for stability because in the Russian or Chinese analysis, the first-strike costs are the primary decision-makers. If you don't change them, you don't change stability. And interestingly to me, and in agreement with guesses that people have made over the years, the first-strike cost does not change when you trade 1,500 RVs for 1,500 interceptors.

So, I think there really is a logic, even a quantitative logic, to the approach that the Administration is taking, though I don't think that it is taking it for the same reasons. The basic argument has been that we can decouple offenses and defenses. We're going to build down as much as we want to on offenses, and we will build up on defenses to whatever suits our needs. But it strikes me that if you did the two in a consistent fashion, you could do so in a way that would not be threatening to either the Russians or the Chinese.

Current Issues

Let me conclude with the current issues in space-based interceptors.

First is the technology. A serious program for development needs to be instituted, especially if we want to infuse this technology into the other phases – which I think would add tremendous leverage in each of them.

Second is the freedom to develop a test. Even under the Reagan and Bush administrations, we ran into some fairly serious constraints on the kinds of tests we were allowed to do. So this problem is not unique. But relief from the restrictions on testing that are implicit in the treaty would certainly be helpful.

A third issue, of concern to me as a member of the Advisory Group to the Space Command, is the need to start thinking more carefully about how strategic offenses and defenses fit together.

Finally, let me say that in the forty years that I've been associated with missile defense, I've never seen a better or more encouraging time for achieving it. The only way that the missile defenders can really lose it this time is to get to fighting among themselves over naval systems vs. land-based systems vs. space. Unfortunately, as the philosopher Pogo once said, "We have met the enemy, and he is us."

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QUESTION AND ANSWER PERIOD

Q: Doesn't your point regarding stability argue that we should reduce the START level to, say, 1,500 but not below that until we see what the situation is? Put a floor on the number of RVs for the time being?

Canavan: I think that you're probably right for a lot of reasons, most having to do the shift of targeting policy. As you go below 1,500 or 1,000 RVs, you are invariably pushed to targeting higher value targets, which is a direction I don't want to go.

Q: How about lasers in space?

Canavan: There have been technically lasers in space for decades; various government and contractor teams have worked on them. They have been very productive, and have hung in there through some tough times.

Those tough times were largely driven by change in mission. When we started the laser in space, it was the only way that we could see to go after the SS-9 in boost-phase. The SS-9 was essentially a titanium can or balloon full of gas; it was a very easy, soft target. But the SS-9 got rolled into the SS-18, which was intrinsically harder in its structure. So you go into this race of laser-hardening vs. the missile. The net result, twenty years later, is that the space laser, although having started first, because it got pushed back and because it's bigger and in some ways more complex, is somewhat less mature. The goal now is to bring space lasers along by a time like 2012 or 2015. In a sense, it is a little bit delayed.

That doesn't bother me, though, because there is an important role for the space laser. If you do something in boost, you have to do it very fast. In that situation, it is good to be able to count on a speed-of-light weapon, rather than a kinetic energy interceptor. So you can see a time when a combination of faster missiles, shorter-range missiles that you want to hit, and targets other than missiles, could drive you to want to have a speed-of-light weapon.

I personally fell off the boat on lasers twenty years ago because I couldn't figure out how to make them really survivable. They're fairly visible, and the concern was that someone could drop a ton of gravel in the path or something like that. But you could arguably put a kinetic-energy set of interceptors together with a space-based laser, and that combination is actually quite survivable.

Lasers are hard and big, and they take time, but I think they are worth the time. They will be an important piece of the puzzle whenever they come in.

Q: If the constraints were removed, when could you put the kinetic kill vehicles in space?

Canavan: You really could do that pretty fast. We were halfway through a four-year development program eight years ago, so I think that today we could finish development of the kinetic kill vehicle probably in four years.

Q: Can you say something about how the ABM Treaty constrained your freedom to test?

Canavan: We were not allowed to do orbital tests. Nobody will ever believe that you have an orbital interceptor until you do an orbital test. Instead, what you were forced to do is intercept targets going down with interceptors going down, sub-orbital both. Such tests were complicated and expensive, and introduced a whole bunch of issues which had nothing to do with what you were actually intending to exercise.

Q: Could an honest test be done if you called it an inspection, rather than an intercept?

Canavan: I think it would be very unwise for the Department of Defense to risk its reputation for candor by doing something like that. It would be seen as duplicitous. I don't like to try to fool people. If you're going to do something, you ought to make up your mind that it is important enough to do openly.

Q: What are the barriers to multi-launch systems?

Canavan: We went through that in some detail some years ago, and I found almost no barriers. I went through that as a theoretical exercise for Brilliant Pebbles and I went through it for real with a Motorola system called Iridium which also had multiple launches of large, high-tech satellites.

Q: In talking about the boost phase, you seem to suggest that effective counter-measures cannot be used.

Canavan: It's a relative matter. In the mid-course phase, everything looks like an RV because everything is ballistic. In the boost phase, if you try to offload flares or pieces of junk, they are immediately stripped out by the airstream. So it has been very difficult to produce a good decoy for a booster. The only thing that makes a good decoy for a booster is a booster, which leads to the idea, "Okay, I won't put bomb in it, saving $50 million, and I won't put a good guidance package on it, saving some more money." But by the time you get through going through all the steps to make a boost-phase decoy look like a real booster, it is a booster. You might as well put a bomb on it. That's the answer that everybody comes to, even critics.

Q: How do these issues relate to limited defense against rogue states and accidental launches?

Canavan: An ICBM is an ICBM. Whether you're going after a rogue state or an accidental Chinese or Russian launch, it's still the same set of space-based interceptors or Brilliant Pebbles to do the job. You don't have to develop a different set of interceptors for rogue and for strategic launches, which I think is an important advantage.

Q: Is the current SBIRS program adequate?

Canavan: I think we'd want the SBIRS High in pretty much the current configuration, whether you had the Brilliant Pebbles space-based interceptor constellation or not. For SBIRS Low, you have to think about it. The SBIRS Low has a metric mission for NMD. If you were to put on a Brilliant Pebble layer, which would do the metric job for itself, then you probably wouldn't want to have SBIRS Low duplicate that. You would like to change its focus to battlefield characterization and a technical intelligence role – a down-looking role as opposed to an up-looking role.

Q: Should the Brilliant Pebbles system have, basically, a dead-man's switch -- something that would protect against a preemptive info-op shutting out our ability to turn on the system?

Canavan: As envisioned in the Reagan and Bush administrations, Brilliant Pebbles was enabled; in other words, it would be relatively autonomous in pursuing missiles as they were launched, as long as we were at Defcon. When it was over, there would be a weapons withdrawal. That's the way you run any weapons system, any strategic system in particular. I think that you'd probably stick with pretty much that system for a rogue threat as well as for a strategic threat. The only difference would be that you could have one or two differentiated or "graded" states of alertness, so that you could wake Pebbles that were flying out of a suspected theater launch, to make them capable of reacting quickly.

Q: Would the sensors on the killer vehicles have any ancillary capability, such as national intelligence?

Canavan: Well I wouldn't say national intelligence in the usual sense. You're not going to do very much staring at the ground, looking for tanks, because your resolution isn't going to be that great. But if you want to be a space-faring nation, you have to know your environment and you have to know who you're sharing it with. Unless you're just going to deny access to everybody, you have to be able to take care of threats as they come at you. So I think that you could turn a sensor of this quality up and look at other things in space.

Q: If you were Secretary of Defense, what space policy would you recommend?

Canavan: The report of the second Rumsfeld Commission includes statements that are tantamount to policy – that the United States has legitimate needs for space; that it should be free to address those needs; that it should be free to protect access to space and its assets in space, civilian as well as military. I think the United States is on the verge of recognizing that it has a responsibility in space which is very much like the one the U.S. Navy has executed, to maintain order on the high seas. Taking that principle into space, we need to recognize that space is a vital area in which we have real interests; an area in which we are willing to cooperate with other countries that share our stewardship of space.

Q: I get the impression that the Brilliant Pebble technology is more mature than I had realized.

Canavan: In 1992 we were arguably two years from the end of engineering and manufacturing development. Today, if you wanted to deploy the system in four years, you could do that comfortably. There is nothing magic here. If we wanted to deploy land-based or sea-based NMD in four years, we could do it. It's not a matter of can or can't, as my old coach said – it's a matter of will or won't.

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