Ballistic Missile Defense and Space Weapons

by
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History is replete with human conflict, and in pre-history we have evidence from human skeletons of wounds from spears, clubs, and missiles. Long before Clausewitz, individuals and groups were pursuing political goals by violent means.

Faced with an opponent with a spear or knife, one could reply in kind, but often a more passive protection was available, such as a protective wall, or a shield or armor of various kinds. We are all familiar with "air defense" usually based on radars and interceptors or guns, that attempts to destroy or disable enemy aircraft before they can deliver their offensive payload—bombs or short-range ballistic missiles or cruise missiles with warheads that may be loaded with high explosive or biological or chemical or nuclear agents.

Ballistic missiles of range varying from tens of kilometers to tens of megameters can have similar payloads. They have been used by the hundreds or even by the tens of thousands in warfare, although thus far never with a nuclear explosive warhead.

It is perfectly natural for the military to want to defend itself and its weapons from destruction by ballistic missiles, and populations have demanded to be protected as well, beginning perhaps with the Nazi use of cruise missiles (V-1) and ballistic missiles (V-2) against England in World War II. For a time, some 20% of the British war effort was devoted to countering the V-1 and the V-2, mostly by attempting to destroy the bases from which they were launched. As for defenses, some V-1s ran into cables mooring barrage balloons, and some were shot down by fighter aircraft or, in the latest stages of the campaign, simply tipped with the wingtip of a fighter aircraft, so that they would miss their targets.

I have worked on U.S. defense against aircraft and missiles since 1953, initially on a project to extend to the sea lines of approach the semiautomatic ground environment (SAGE System) that was widely deployed in the United States and Canada to guard against Soviet bombers armed with nuclear warheads.

I recall discussing with the study leaders, Jerome Wiesner and Jerrold Zacharias, that by the time anything our year-long study recommended could be deployed, the threat from the Soviet Union would be ballistic missiles armed with nuclear warheads rather than aircraft-delivered bombs. And I proposed that the United States should at that time (1953 or 1954) begin to launch decoy warheads against

the Soviet Union, before they had radars that might see them. These decoys would be spherical balloons of aluminum-coated plastic, inflated to a very low pressure with air or other gas, and would be launched, deflated, via a "rockoon"—essentially a weather balloon at 30 km altitude that would lift a 1-kg three-stage unguided rocket that would deploy such a balloon after its three stages had fired to give the payload sufficient speed to travel on ballistic trajectory to Soviet territory. At the termination of powered flight, by which time the third stage would be far out of the atmosphere, the balloon would inflate and would be essentially indistinguishable from a similar balloon that might in the future be deployed around the reentry vehicle of a nuclear warhead of the time.

Naturally, when the United States obtained real ICBMs and nuclear warheads, it could have equipped the warhead with such an enclosing balloon and could have deployed many tens of similar but empty balloons that would "simulate" the now-dressed warhead. Thus instead of having to make many decoys to closely resemble the actual warhead, the warhead itself would be dressed to resemble the cheapest possible decoy.

This was the origin of “antisimulation” that was taken up by the Strategic Military Panel (SMP) of the President’s Science Advisory Committee some 14 years later as one of the schemes that the U.S. could use to ensure the viability of its retaliatory or deterrent force against the Soviet Union. The SMP was well aware that Soviet missiles might also deploy such antisimulation means, and we reviewed at our meetings (two days each month) the latest work by Lincoln Laboratory and the Bell Telephone Laboratories on their radar and optical studies of “penetration aids” typically launched by U.S. Air Force missiles from Vandenberg Air Force Base into the US missile defense test site at Kwajalein.

The SMP also had the obligation every year to write a highly classified summary report for the President of the United States on the advisability of deploying missile defense, as advocated typically each year by the United States Army and its contractors. We carefully evaluated the capability of the proposed defense not simply against the naked missiles and warheads of the other side, but against feasible countermeasures, and our conclusion was always that the proposed defensive system could be readily defeated or otherwise rendered ineffective, perhaps by being destroyed.

From the early 1950s, a broad range of missile defenses was advocated and analyzed, ranging from the mid-course defense, which is the most natural because the offensive missile spends most of its time in midcourse, to boost-phase intercept while the launch rocket is still burning, and to terminal defense in order to protect a particular city or a missile silo from destruction by a nuclear warhead.

Although President's Reagan's Strategic Defense Initiative (SDI) as sketched in his broadcast of March 1983 was projected to consist of a mid-course phase to be supplemented by boost-phase and terminal phase defenses, the Missile Defense Agency's work[1] on countering ICBM-range missiles has been focused largely on mid-course. This uses satellites to detect launch and then powerful radars to detect the "threat cloud" in midcourse and to instruct the homing kill-vehicle (HKV) or kinetic interceptor payload to acquire with its visual or infrared sensor the warhead from among other objects in the threat cloud. I have long attempted to help Missile Defense Agency (MDA) and its predecessors to carry out this mission as best as possible, but it makes no sense to have the leading officials of the government and of the U.S. Congress believe that a missile defense will be effective when it can predictably be nullified. So it is important to publish such

[1] And that of its predecessors, the Strategic Defense Initiative Organization (SDIO) and the Ballistic Missile Defense Organization (BMDO).

conclusions in Congressional testimony; they are already apparent to the scientists and engineers who are involved in creating the missile systems against which the defenses might be used.

A good way to see what I have written about such matters and posted on my website at www.fas.org/RLG/ is to use a "focused search" by putting in the Google search box:

site:fas.org/RLG/ missiles interceptor countermeasures

The search gives 37 "hits." To see what I have said about the National Intelligence Estimate (NIE) in this regard, one can simply add that to the search box so that the search now reads

site:fas.org/RLG/ missiles interceptor countermeasures NIE

Now there are only 7 hits, one of which is my testimony of April 16, 2008; looking in that testimony for the occurrence of "NIE" one finds, "A 1999 NIE judges specifically that Iran or North Korea could have such effective countermeasures by the time of their first ICBM test."

It is just this predictable collapse in the face of feasible countermeasures that in a more sensible era led U.S. administrations to decide not to deploy missile defenses.

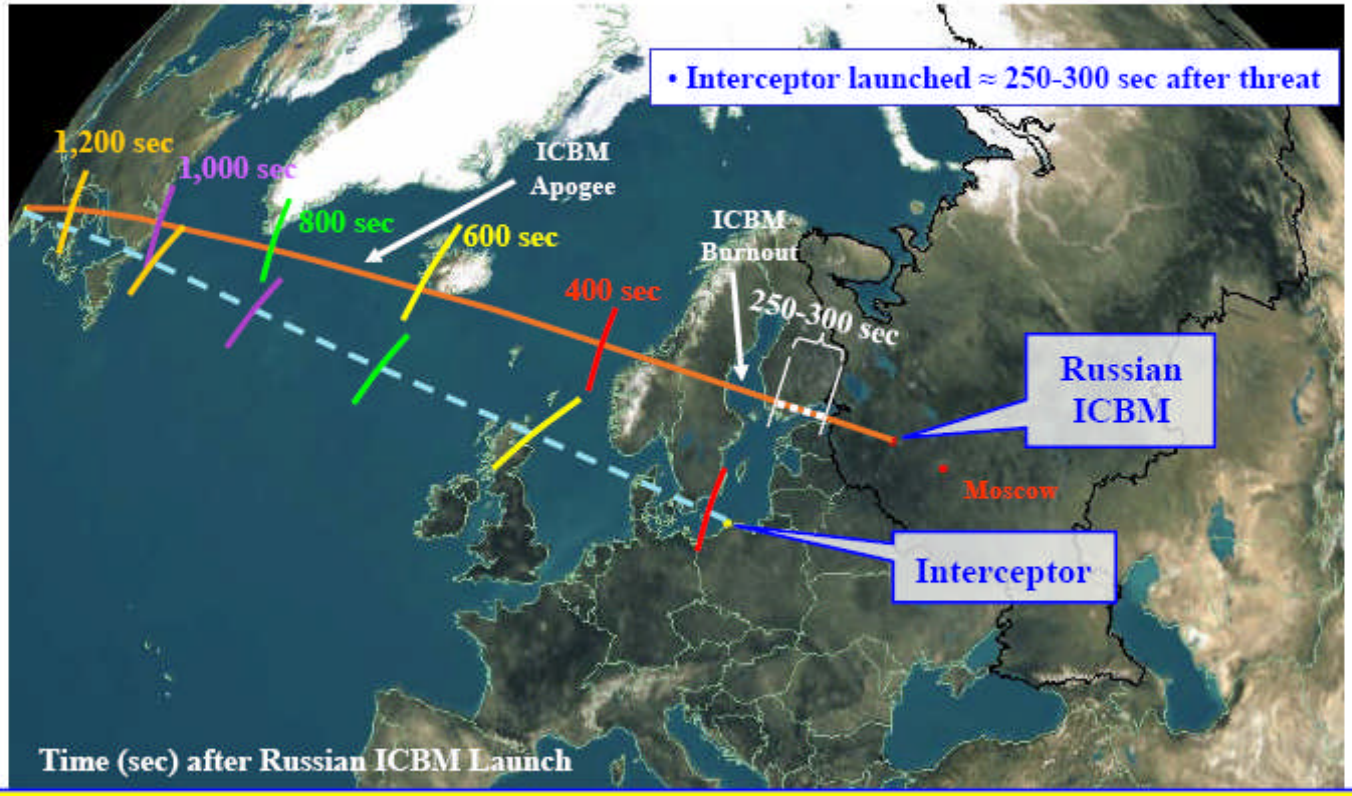
Beyond my own personal interventions with elements of the U.S. Defense Department and publications in order to reach the leaders of Congress and of the George W. Bush Administration, I participated in an effort of the Union of Concerned Scientists and MIT to write a technically based 200-page volume, “Countermeasures” (published in the year 2000 and available on my website) that goes into detail about the inflatable balloons deployed by NASA for other purposes that might be used for this antisimulation exercise.

MDA now simply states that they are working on interceptors with multiple kinetic kill-vehicle (KKV) payloads so as to counter such a threat and that they hope to have this capability in the year 2015. But the U.S. intelligence community according to its 1999 NIE, expecting to have North Korea test an ICBM soon after that (or even having expected them to test before 1999) stated that they would already have such countermeasures at that time.

MDA has provided no analysis to show that they can deploy enough effective multiple KKVs to counter this feasible antisimulation technique for penetrating such a defense, and their authoritative public statements do not give confidence that they are reporting objectively to their managers in the Congress or the U.S. administration. For instance, in my publications I have challenged the statement that the ten interceptors planned to be based in Poland for use with the mid-course intercept system against ICBMs launched from Iran could not intercept even a single Russian strategic missile launched toward the United States. I certainly agree that ten interceptors could not destroy more than ten such missiles, a tiny part of the overall Russian force, but MDA goes further and says in a speech by its Executive Director, Dr. Patricia Sanders, June 28, 2007 that these missiles could not intercept even a single Russian strategic weapon. MDA does not explain what is clearly stated as an assumption in the briefing-- the interceptors in Poland are not fired until 250-300 seconds after the launch of the Russian ICBM[2]. Waiting four or five minutes makes a considerable difference in capability.

[2] This slide figures in my paper, "Ballistic Missile Defense Deployment to Poland and the Czech Republic," August 21, 2007.

Interceptors Cannot Catch Russian Missiles



U.S. European Interceptor Site Cannot Affect Russian Strategic Capability

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THIS FIGURE IS HIGHLY MISLEADING IN VIEW OF 250-300 SEC LAUNCH DELAY

However, now that powerful voices close to the George W. Bush Administration have identified not only North Korea and Iran, but also China as the target of the mid-course defense, China will be forced to deploy such countermeasures, although it probably has already prepared to do so as the MDA mid-course is strengthened. In particular, "To avoid the emerging creep toward a Chinese assured destruction capability, the United States will need to pursue new missile defense capabilities, including taking full advantage of space. The United States must explore the potential that space provides for missile defenses across the spectrum of threats."[3] I have previously reported testimony by James Woolsey to the Senate Foreign Relations Committee that he would not support a fully effective system of missile defense against North Korean and Iranian strategic ballistic missiles unless it were also effective against China.

A recent independent study for the Executive Director of MDA[4] is largely directed toward organizational aspects of MDA and missile defense. It does emphasize, however, "*For the ground-based midcourse interceptor component, the balance between qualitative improvements and deploying more of existing capabilities should be strongly in favor of qualitative improvements. Without*

[3] From a draft report of a Task Force of the International Security Advisory Board (ISAB), US Department of State, 'China's Strategic Modenrization."
[4] "Study on the Mission, Roles, and Structure of the Missile Defense Agency (MDA)" General Larry D. Welch, USAF (Ret.), Project Co-leader Dr. David L. Briggs, Project Co-leader, Institute for Defense Analyses (IDA), August 2008. *www.insidedefense.com/secure/data_extra/pdf7/dplus2008_2693.pdf*

such a focus, the current system capabilities will become obsolete regardless of the number of interceptors deployed."

Following China's destruction of the Fengyun-1C Chinese satellite January 11, 2007 by a direct-ascent ASAT launched from Xichang Space Center, which, as was predicted from the orbital altitude of 850 km, greatly increased the total amount of long-lived debris in space, the United States followed suit on February 20, 2008, by destroying the disabled USA-193 satellite at an orbital altitude of 247 km, from which there is no significant debris. A US Navy SM-3 interceptor missile was used, in conjunction with the full system of missile defense communications and command and control, thereby demonstrating what had been completely clear for many years—that a system designed to counter strategic ballistic missiles could far more readily be used to destroy satellites in orbit.

MDA declared that the purpose of the intercept was to avoid potential harm from contact with some of the 450 kg of toxic hydrazine if the fuel tank had reached land intact[5]. No estimate of probability or magnitude of harm was published to demonstrate that it was a valid use of public funds to avoid such harm, although

[5] James Oberg has published a paper picturing the hydrazine tank and arguing the correctness of the decision to intercept: *http://www.thespacereview.com/article/1195/1*

Oberg quotes NASA experts as indicating that the risk was unacceptable. A NASA White Paper[6] analyzes the heat transfer to the frozen hydrazine during uncontrolled reentry of the spacecraft, but it has a fatal flaw in assuming a single "zone" within the frozen hydrazine; as a result no part of the hydrazine reaches the melting point in the computation. The authors state that on the contrary,

> *"It is extremely likely that the N2H4 in contact with the Ti wall will melt away inlayers. As modeled in this analysis, the N2H4 is treated as a single layer, meaning thatenough heat must be absorbed to raise the temperature of the entire mass of N2H4, and then enough heat must be absorbed to melt the entire mass. Current limitations in the process being used prevent the option of splitting the N2H4 into multiple layers, thereby impacting the fidelity of the model in this scenario. As noted previously, any melted N2H4 might be expect to be expelled from the tank through the open propellant outlet or even through the pressurants inlet, if the bladder is ruptured. In such a case, the principal heat transfer mode would reset to conduction."*

The authors state further, "*During this time the Ti tank does reach 1943 K, its melting temperature, and four of its five nodes do ablate, but the heat absorbed into the Ti is insufficient for it to ablate the final node based on Eq. (15)*." That is,

[6] "Atmospheric Reentry of a Hydrazine Tank," by Robert L. Kelley, William C. Rochelle, at *www.thebulletin.org/files/NASA_White_Paper.pdf*

the spinning of the tank is assumed to spread the reentry heat so uniformly over the surface of the nearly spherical tank that 80% of the tank thickness can be melted and lost, without any large holes appearing in the tank. The tragic loss on reentry of the Columbia space shuttle shows the result of such a hole in the protective skin, and it is simply unreasonable to believe such uniform heating[7].

Instead, the temperature of the titanium tank where it is in contact with the hydrazine will be reduced[8]. There would be essentially no reradiation from hot Ti, and all the reentry heat would be conducted into the N2H4 where it is in contact with the wall by centrifugal force or (at the forward, heated pole of the tank) by deceleration. If NASA or MDA had been serious about learning whether the tank would reenter intact, better calculations should have been commissioned, and even laboratory experiments. The criterion, of course, is not whether all the hydrazine would melt in an intact tank, but whether the burnthrough of some of the tank on reentry would result in the dispersal of hydrazine at high altitude.

[7] Much comment on this matter is to be found at http://www.armscontrolwonk.com/2009/bullsht-hydrazine-story

[8] A heat rate on the order of 30 W/cm^2 through a Ti layer 0.356 cm thick and at a thermal conductivity 8 W/mK (80 mW/cmK) would give a temperature rise above the melting point of N2H4 of about 30 x 0.356/ 0.08 = 135 C.

If not NASA, then the Freedom of Information Act (FOIA) is to be congratulated on publishing[9] a detailed, signed, technical paper showing the state of US government knowledge of the possibility of intact reentry of the hydrazine tank and its contents, but the paper does not provide a credible basis for decision, as clearly stated by the authors.

I judge that the US government must believe that there was substantial geopolitical benefit in this demonstration of capability[10]. My own view is that there was, instead, substantial geopolitical loss involved, although not nearly so much as in the case of the debris-producing intercept of Fengyun-1C, which demonstrated Chinese technical capability, but also either ignorance at high levels or disregard for the damage that debris can do to civil and military space programs—including to those of China.

I do believe that international security would be well served by a treaty banning space weapons and antisatellite tests, as I proposed with support of the Union of Concerned scientists in my testimony of May 18, 1983[11]. Articles I and II of that Draft Treaty read:

[9] Although this paper was obtained through FOIA request by Yousaf Butt.
[10] An analysis of the intercept and of foreign reactions has been published by the US Defense Threat Reduction Agency at *www.wmdinsights.com/temp/PDF/WMDInsights_Apr08Issue.pdf*
[11] *http://www.fas.org/rlg/051883TLAW_Draft_Treaty_Limiting_ASAT_Weapns.pdf*

ARTICLE I

Each Party undertakes not to destroy, damage, render inoperable or change the flight trajectory of space objects of other states.

ARTICLE II

1. Each Party undertakes not to place in orbit around the earth weapons for destroying, damaging, rendering inoperable, or changing the flight trajectory of space objects, or for damaging objects in the atmosphere or on the ground.

2. Each Party undertakes not to install such weapons on celestial bodies, or station such weapons in outer space in any other manner.

3. Each Party undertakes not to test such weapons in space or against space objects.

I urge both governments to do a better job of bringing technical input to political and military decisions. As our late colleague Richard Feynman stated in regard to the loss of the Challenger space shuttle and its crew, “For a successful technology, reality must take precedence over public relations, for nature cannot be fooled.”