Beyond a Threat Assessment: Evaluating the Effectiveness of Defenses and Other Countermeasures, and Counter-Countermeasures on the Part of the Offense

by

Richard L. Garwin
IBM Fellow Emeritus
IBM Thomas J. Watson Research Center
P.O. Box 218, Yorktown Heights, NY 10598
RLG2@us.ibm.com, www.fas.org/RLG/

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The deployment of a national defense against ballistic missiles has long been a contentious matter for the United States. When in 1953 I studied extending the air defenses of the U.S. and Canada to the sea lines of approach of Soviet nuclear-armed bombers, I insisted to our study leaders, Jerome Wiesner and Jerrold Zacharias, that by the time anything we recommended could be deployed, the threat would be Soviet ICBMs armed with nuclear warheads. And I went on to propose that the United States should immediately begin to launch inflated balloons about 2-m in diameter, from "rockoons" lifting a few-kg rocket above all but 1% of the mass of the atmosphere. A three-stage rocket, initially oriented by a permanent magnet with respect to the local horizontal magnetic field and tipped 22 degrees from the horizontal, would be used to launch an aluminum-coated plastic balloon that would inflate after rocket burnout to simulate a similar balloon that might contain a U.S. nuclear warhead after the U.S. developed and deployed ICBMs. This would ensure that the Soviet Union would not respond with a nuclear attack, in view of their every few days seeing such an object or objects approaching, that never were harmful. Of course, the light balloons would burn up in the upper atmosphere and would pose no threat to Soviet territory.

This was an early example of offensive countermeasures to a defensive system, and clearly must be taken into account by both sides. For many decades, the United States was unique in having technical consultants to the U.S. government largely from the academic (but in my case also from the industrial community), some of whom regarded it as their obligation to society not only to contribute to the government programs, but also to an analysis of the utility of a government program. This is particularly important in the United States, where the U.S. Congress plays a vital role, in addition to a supposedly informed Executive Branch that includes the Department of Defense, the nuclear weapons establishment in the Department of Energy, the intelligence community and the National Security Council.

An ignorant Congress or one captured by or unduely influenced by contractors or the armed services can result in dangerous, costly, and often unnecessary programs.

Despite the good work of the President's Science Advisory Committee and its influence on the Executive branch from its formation in 1956, until about 1968 the only testimony given in Congress in regard to national security programs was by the Executive Branch and by its contractors. Independent analysts were regarded as not having standing and were not invited by the Executive to testify on its behalf; nor were they invited by the committees of the Congress. This contrasted with much independent testimony on questions of public health, social security, monetary policy, and the like. That pattern was broken in 1968, with the controversy over strategic defense, when Congress somehow found it desirable to have independent testimony.

Many of us such as Hans Bethe of Cornell University, Jerome Wiesner of MIT, Ed Purcell of Harvard, and W.K.H. (Pief) Panofsky of Stanford University worked many days each year for the U.S. government to provide technical analyses, proposals, and invention, to seize opportunities and to counter threats. All those named had a four-year term on the President's Science Advisory Committee (PSAC) and I served two terms from 1962-1965 and 1969-1972. But none of us published unclassified critical papers on the topics on which we were working, and none testified in Congress until about 1968.

The PSAC Strategic Military Panel was composed of about ten highly qualified scientists and engineers from academe and industry. Each year it had the task of reviewing U.S. and Soviet strategic weapons (although strategic aircraft on both sides were the responsibility of my PSAC Military Aircraft Panel). The SMP met two days every month in the Old Executive Office Building, supported by an able staff person who arranged briefings from the Department of Defense, the intelligence community, and contractors. Among the latter were not only those who would or could build strategic defenses or strategic offensive weapons, but also, importantly, in the field of missile defense, Bell Telephone Laboratories and Lincoln Laboratory. These were two extremely competent organizations that worked for the U.S. Army especially in analyzing the phenomena of reentry and the "observables" --optical, infrared, and radar-- associated with reentry or for that matter with the passage of warheads through space. Any defense would not only need to detect the warhead itself and to be able to send an interceptor against it (nuclear-armed interceptor in those days) or some kind of directed-energy weapon would need to be used.

It was not obvious to our non-technical audience in the White House and National Security Council that even a system that detected very reliably and could kill very reliably would not constitute a defense unless the BMD system could distinguish ("discriminate") the warhead from other objects. Some of these would be the third stage of the rocket system or fragments thereof created by fragmenting the third stage with high explosives—"traffic decoys." Others might be decoys that were crafted to look to the greatest extent possible just like the warhead and to provide the same observables as the warhead upon reentry—"precision decoys."

Of course, systems that were to intercept in midcourse of the ICBM trajectory—while the warhead is above the sensible atmosphere—would have to cope with very light decoys—essentially inflated balloons.

In fact, the United States has very good inflated balloons (carried and dispensed uninflated) that within a few seconds assume the precise contour and radar and visible observables as the warhead from the Minuteman missile, for instance. But that precision decoy would in no way deceive a defensive system operating in the lower or the upper atmosphere, where it would soon be left far behind the dense warhead itself.

In general, until President Reagan conjured up the Strategic Defense Initiative in his speech of March 23, 1983, the military services (the Army in the case of national defense of the United States against ICBMs and SLBMs) needed to propose a specific system to be deployed, with a schedule and cost estimate. Year after year, the Strategic Military Panel analyzed each proposed system in turn, talking with the Army and its contractors, and found that it would not contribute to U.S. national security. Either it would not have the ability to handle the "traffic" of the many hundreds of Soviet warheads, or it would have an Achilles Heel that was subject to destruction so that the defensive system was a much easier target than the undefended United States.

In the Fall of 1972, the Administration of President Lyndon Johnson observed that it could be useful to deploy a "light area defense" against a Chinese ICBM that was even then on the launch pad and might be launched within a few weeks, Indeed, it took 11 years for China to deploy an ICBM.

When the Nixon Administration began its second term in January, 1973, it paid attention only to a small part of the SMP's analysis that was very negative on the benefits of deploying the Army SENTINEL system. Since SENTINEL had many fewer interceptors than the Soviet deployed warheads, it could readily be overcome. SENTINEL had other flaws as well. But the National Security Council staff in the Nixon White House argued that because the system that they decided to deploy with the same technology but with a different purpose—SAFEGUARD—had more interceptors than the Soviets were expected to throw at those 150 Minuteman missiles, it could succeed in its task. Predictable failure if the number of interceptors is less than the number of attack warheads does <u>not</u> imply successful defense if interceptors outnumber attacking warheads.

What they missed was even simpler: the individual missile silos and the control centers were hard to 1000 psi (about 70 atmospheres of overpressure from a nuclear blast), while the two radars to be deployed with SAFEGUARD (both of which were essential to the operation of the system) were hard at best to 25 psi). A warhead of similar accuracy as would destroy a missile silo could have about 2% of the yield and could still confidently destroy one of the radars at the same distance. Or the same warhead could be detonated about three times as far from the radar and still destroy it. And to destroy a single target, the offense can use tactics such a "ladder down" that would require at most ten warheads to nullify the entire defense, compared with the 150 or 300 that would be needed to destroy 150 silos.

David Packard, Deputy Secretary of Defense in the Nixon Administration, testified that although the SAFEGUARD System might not be perfect, it needed to be deployed in order to develop the software for ABM. Gerard Smith, the negotiation of the ABM Treaty, was persuaded to testify that deployment of SAFEGUARD was essential for the success of the arms control negotiations with the Soviet Union. So the system was funded by Congress, deployed and operated for a time variously stated as days to months before it was de-funded and eventually dismantled.

Clearly education was required, and not only for the administration but also and especially for the Congress. In part over dissatisfaction with lack of public support from PSAC for the Nixon ABM program and for the commercial Supersonic Transport aircraft (SST) President Nixon abolished

PSAC and the Office of Science and Technology (OST) in early 1973, thereby denying the entire government of the advice and reports, both private and public, of that organization. But the tradition of independent testimony to congressional committees on national defense programs had been set and continued.

Kurt Gottfried, Professor Physics at Cornell University, in 1982 took a sabbatical with the Union of Concerned Scientists—a year that he wanted to devote to work on national security and arms control. He asked my advice on the particular topic, and I suggested space weapons and anti-satellite capability were closely linked and a field that really demanded more understanding[1]. Kurt found this reasonable and we worked closely together for a year with what I think was a very fruitful outcome in my testimony of May 18, 1983, at which I presented a Draft Treaty to ban space weapons and anti-satellite tests[2]. Kurt and UCS had asked Leonard C. Meeker, former State

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[1] "The Militarization of Space," R.L. Garwin testimony given Senate Foreign Relations Committee Hearing, before the Subcommittee on Arms Control, Oceans, International Operations and Environment. 09/20/82 pp 56-60.

[2] A Treaty Limiting Antisatellite Weapons,"by R.L. Garwin. Oral testimony for a subcommittee of the Senate Foreign Relations Committee, May 18, 1983. (http://www.fas.org/rlg/051883TLAW_Draft_Treaty_Limiting_ASAT_Weapns.pdf or http://tinyurl.com/6qkf2e)

Department Legal Advisor, to help draft that treaty, so we avoided many of the problems that amateurs might have encountered. Our work on limiting space weapons and arms control was well under way when President Reagan announced his concept an SDI that would be an impenetrable barrier to Soviet nuclear weapons. After that announcement we worked with Hans Bethe of Cornell University and Henry Kendall of MIT and UCS to produce analyses of space-based missile defense, with a UCS report (and erratum) by that name in March 1984, followed in October 1984 by "The Fallacy of Star Wars."

The Heritage Foundation had been established in 1973 with a novel concept of having young staff members who would provide topical, timely few-page "briefs" on matters relevant to congressional legislation. Unfortunately, the staff and the papers often showed little relation to technical reality. Kurt and I thought that it would be valuable to create a counterpart to provide timely, objective material on national security programs with a substantial technical component.

We pondered this and with the assistance of the late Frank Long, former PSAC member and Deputy Director of the Arms Control Agency, and with the cooperation of the American Academy of Arts and Sciences, we formulated in August 1984 a draft proposal "For a New Center in the Area of International Security Affairs," that we called provisionally "The XYZ Center." We then adopted the working name "Center for Rational Security Policy." We discussed this over the months with potential funding sources and individuals who thought that it might fit in existing organizations or in a university. Discussions with university colleagues revealed, however, that departments run universities and that good young people who work in such programs from a departmental base have great difficulties being promoted and this reduces very much the involvement of people until they achieve tenure. So we were back to the proposal for a free-standing center.

We traveled to MIT July 1986 to discuss this with Jerome Wiesner, who had been John F. Kennedy's Science Advisor and Special Assistant to the President for Science and Technology. Wiesner asked which of us was going to give up his current job to head the Center. Neither Kurt nor I was willing to do this, and so the Center was never born.

Kurt, particularly, continued to work with UCS, and two Cornell physics PhDs, Lisbeth Gronlund and David Wright, later joined UCS and concentrated on national security problems. Twenty years ago they helped to create an annual one-week International Summer Symposium on Science and World Affairs[3] to bring new people, especially foreign scientists, into independent national security activities, and this continuing activity has been, in my opinion, extremely successful.

In recent years, to some extent the goal of the XYZ Center has been met by timely, topical papers from UCS, from the Federation of American Scientists (FAS), from the Natural Resources Defense Council (NRDC), and a few other organizations, but not at the level and with the staff we envisaged for the XYZ Center.

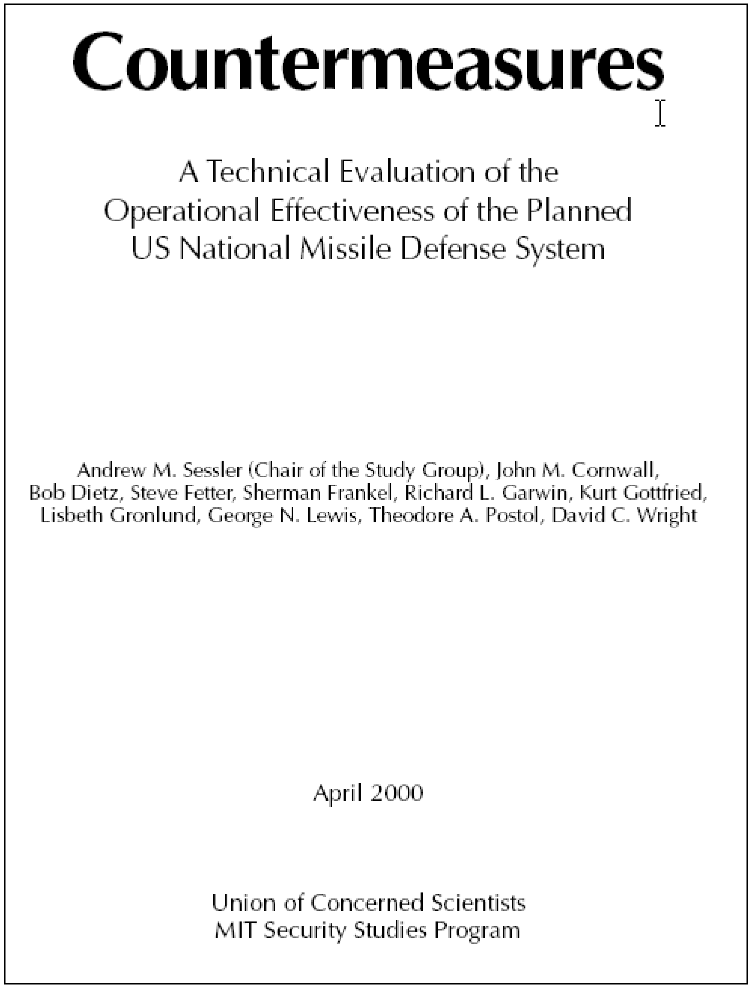
An example of a longer term but highly successful product is the volume "Countermeasures" published by a UCS-MIT collaboration in the year 2000.[4] The 11 authors included several who had had intimate involvement in various

[3] www.summersymposium.org/

[4] "Countermeasures," A Technical Evaluation of the Operational Effectiveness of the Planned U.S. National Missile Defense System, UCS-MIT Study, A.M. Sessler (Chair of the Study Group). (www.ucsusa.org/assets/documents/nwgs/cm_all.pdf *)*

U.S. missile programs and in missile defense, together with several who did not hold and had never held U.S. government clearances. In this way it was possible without transferring any Secret ("Classified") information to use basic physics to set limits on the performance of a defense and to provide concrete examples that would in any case be apparent to the technical leadership of any offensive missile program, of countermeasures that could defeat defenses that were not designed to handle them.

One of the countermeasures was that identified in 1953—the use of anti-simulation in the form of inflated aluminum-coated plastic balloons to mimic similar balloons around the actual warheads. But here the concept was fleshed out with the details of such balloons that NASA had developed and flown for the purpose of measuring air density at satellite altitudes. Substantial analysis was done to determine whether adequate simulation required a small battery and resistive heater for matching the heat transfer from a warm warhead inside the shielding balloon. Here are some of the figures published in "Countermeasures".



Countermeasures

A Technical Evaluation of the
Operational Effectiveness of the Planned
US National Missile Defense System

Andrew M. Sessler (Chair of the Study Group), John M. Cornwall,
Bob Dietz, Steve Fetter, Sherman Frankel, Richard L. Garwin, Kurt Gottfried,
Lisbeth Gronlund, George N. Lewis, Theodore A. Postol, David C. Wright

April 2000

Union of Concerned Scientists
MIT Security Studies Program

Cover page of Countermeasures Report.

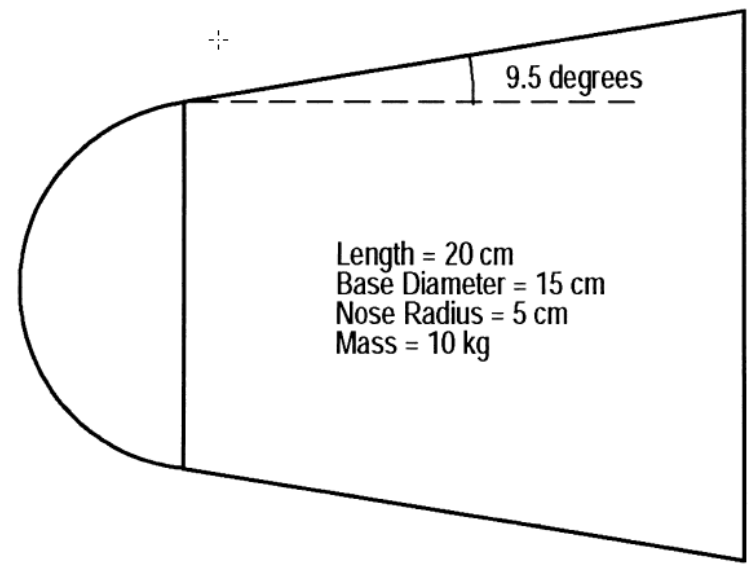


Figure 7-1. The configuration used for calculating the heating of a conical bomblet. *It has a nose radius of 5 cm, a base diameter of 15 cm, a length of 20 cm, a cone half-angle of 9.5 degrees, a mass of 10 kg, and a ballistic coefficient of 12,000 N/m² (250 lb/ft²).*

Figure 7.1 of “Countermeasures,” “Large Bomblets (10 kg). Small bomblets are about 1 kg.

Figure 8-1 of “Countermeasures,” photograph of NASA Air Density Explorer balloons, first launched in 1961

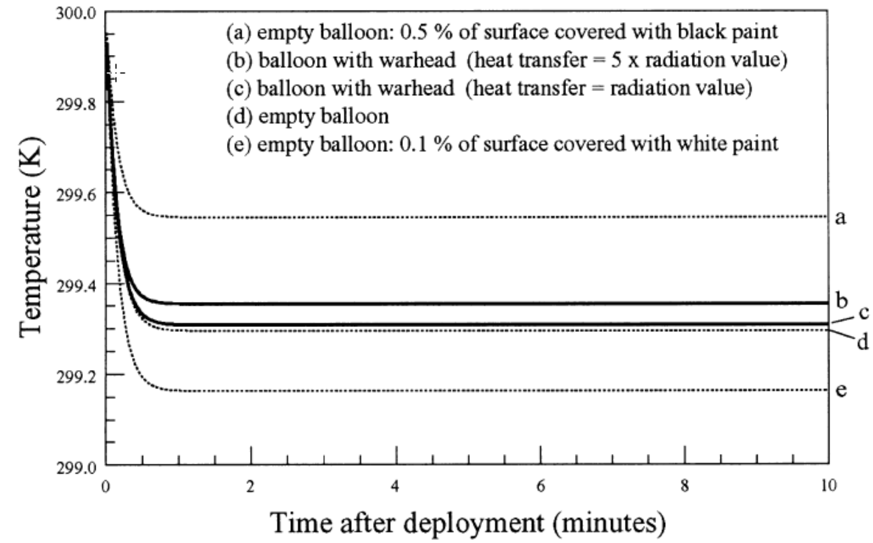


Figure H-2. Temperature variation after deployment of painted balloons with and without warheads, near room temperature.

This figure shows the daytime temperature variation after release of lightweight (0.5 kg) balloons with an outer surface covered with a thin layer of aluminum-silicone paint. The balloons are at a temperature of 300 K when released. One balloon is empty and two contain warheads with a surface emissivity of 0.036. For the balloons containing warheads, in one case the heat transfer between warhead and balloon is taken to be that due to radiation, in the other the heat transfer is taken to be five times that due to radiation (the inside surfaces of the balloons are assumed to be blackbodies). Also shown are two empty balloons with small fractions of their outer surfaces covered with another type of paint: in one case 0.1 percent by white enamel paint, and in the other 0.5 percent by black paint.

Figure H-2 of “Countermeasures.” Within less than a minute of deployment of the balloon, temperature of the antisimulation balloon and of the empty balloon has stabilized to within 0.01 deg. Note that the entire range of temperatures covers a band of 0.4 deg—a difference totally unobservable by any seeker involved in the National Missile Defense system.

Because the missile defense system was promised to protect not only against ballistic missiles armed with nuclear warheads, but those with chemical and biological weapon (BW) payloads, the team looked also at what an ICBM might look like that was configured for militarily significant delivery of BW. It became clear that maximum BW effectiveness in attack on a city would be achieved not with a single warhead containing 500 kg of anthrax or smallpox, but with dozens or hundreds of small reentry vehicles, each equipped with its own heat shield so that the payload would survive reentry. The natural way of handling these multiple bomblets would be to disperse them, for instance from a slowly rotating carrier attached to the third stage of the rocket, as soon as the stage had reached its final velocity and was falling toward the target at ICBM range.

In this way, with a 2000-s flight time, dispersal of 2 km would be achieved with a transverse speed of 1 m/s. Each of the bomblets would then penetrate through the atmosphere to the ground, where it would be activated to disseminate the BW payload, just as bomblets that had been developed by the United States in its abandoned and now proscribed BW program had been configured in the 1960s. The destructive capability would be greater because there would be no enormous excess of BW ("overkill") in the body of the plume that would stretch from the impact point or the in-air dissemination point of the massive 500-kg BW payload.

In addition to the increase in destructive capability of a single ICBM carrying BW agent, this approach would make the BW attack immune to the mid-course missile defense system (and to any terminal system operating within the atmosphere). It may be an indication of the effectiveness of the Countermeasures study that the Missile Defense Agency no longer claims that the defense it is deploying will protect against BW attack by long-range missiles.

I hope that this rather detailed and personal history provides an indication of the broader development of independent technical analysis of national security programs in the United States.

Thank you for the opportunity to present this material at the NATO Advanced Research Workshop in Zagreb.