North Korea on My Mind

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On May 1, I gave a short talk at the Annual Meeting of the National Academy of Sciences, which is available on the Web.[1]

The brief section on North Korea is reproduced here.

North Korea

As a member of the nine-person Commission to Assess the Ballistic Missile Threat to the United States (Rumsfeld Commission), in July 1998 I concurred in the commission's judgment that any of the three emerging powers of that time—Iraq, Iran, and North Korea—

> "would be able to inflict major destruction on the [United States] within about five years of a decision to acquire such a capability (10 years in the case of Iraq)."

We have already discussed Iran. Iraq is no longer in that category, but North Korea definitely is.

In its five underground nuclear explosion tests, North Korea has apparently achieved explosive yields on the order of 10–20 kilotons[2], and may have incorporated, or may soon incorporate, "boosting" technology, in which the exponentially growing neutron population in the exploding fissile material is boosted suddenly to a higher level by the rapid fusion of deuterium and tritium within the fissile core.

In February 2017, North Korea tested a solid-fuel missile, which, if the technology is transferred to its medium- and long-range missile program, will make these weapons more robust, easier to conceal, and potentially, with a shorter burn time, more difficult to intercept in flight. North Korea has long sold short- and mid-range ballistic missiles to other states, and has recently offered for sale lithium metal highly enriched in Li-6, indicating that North Korea has no shortage of the source material for producing tritium for boosted fission weapons.

Why is North Korea—with its population of 25 million and per capita GDP of only $1,800[3]—a problem for the United States? The answer lies in the Korean War, which ended, in July 1953, in an armistice rather than a peace settlement, so there is still an armed confrontation between North and South Korea, with the United States allied to

[1] https://fas.org/rlg/nas-challenges.pdf
2 (in its test of September 9, 2016)
[3] CIA World Factbook.

South Korea and China to North Korea. The United States based nuclear weapons in South Korea from 1958 to 1990 and still has 28,000 military personnel deployed there.

It is generally felt that the North Korean leader, Kim Jung-Un believes that the United States would take any opportunity to depose him, if necessary by force, and that North Korea must preserve and expand its military capability in order to prevent this.

The United States has been deterred from solving this problem militarily because half of South Korea's 50 million population is in the Seoul area, within range of North Korean guns and short-range rocketry. If North Korea were to initiate a shooting war, making political and economic demands as a condition to bringing it to an end, there would surely be a massive military response, but no one knows how much damage would be done to South Korea before the confrontation ended. Now that North Korea has a stock of perhaps 20 nuclear weapons, the potential damage to South Korea would be much greater, and North Korea could lash out against Japan as well.

North Korea, in turn, has also been deterred from military action—by the threat of massive US retaliation, as well as by sporadic intense negotiations. The United States is concerned (perhaps overly so) about the benchmark that would be constituted by a long-range missile capability to deliver a few nuclear weapons against the mainland USA. This threat is nothing new, in view of the long-standing vulnerability of U.S. coastal cities to attack by North Korean short-range missiles launched from ships near U.S. shores. Deterrence still works, but might be at risk if North Korea's leadership feels that the United States, with some defensive capability, is preparing a preemptive strike.

It has been proposed[4] also by former Defense Secretaries William J. Perry and Ashton B. Carter, that intercept be made "left of launch"—that the United States should destroy the test vehicle for a North Korean ICBM, while it is on its launch pad and not moving at all.

The best approach may be to work with China to provide enhanced sanctions against North Korea, to persuade it not to test missiles to a range beyond 2,000 km and not to conduct further nuclear explosion tests. Success is not assured, and both defense and the promise of deterrence by retaliation against actual use of these weapons are essential. A reduction in the U.S. military presence in South Korea could also be considered, as part of a negotiation to bring North Korea into compliance with U.N. Security Council resolutions.

Since then, on 09/03/2017, North Korea detonated its sixth and by far most powerful nuclear explosive, which it called a "hydrogen bomb." As of 09/06/17, the only information publicly available is in the form of seismic data, released, for instance, by the CTBTO. According to Paul Richards of Columbia University, a reasonable estimate of the explosive yield is 250 kt[5], with a factor 2 up or down uncertainty in yield.

[4] "If Necessary, Strike and Destroy," *The Washington Post*, June 22, 2006.
[5] http://www.popularmechanics.com/military/weapons/news/a28057/north-korea-nuclear-test-expert/

I have been involved with the U.S. nuclear weapons program since June of 1950, for the first 15 years or so primarily as a summer consultant to the nuclear weapons program at Los Alamos, and after that in conjunction with the President's Science Advisory Committee—PSAC, the Office of Science and Technology—OST, and the Department of Energy and the National Nuclear Security Administration, NNSA. Although the information had previously been provided by Edward Teller at large public meetings, my role in the development of early thermonuclear weapons was brought to wide public attention by Bill Broad in 2001[6] .

Specifically I learned from Edward Teller at Los Alamos in May 1951 of his classified paper of 03/09/51 with Stan Ulam[7] and I was asked by Teller to devise an experiment that would demonstrate beyond any doubt the validity of the preferred approach to burning thermonuclear fuel. This approach was to use the soft x-ray energy from the explosion of a "primary" nuclear explosive to compress and ignite a separate charge of thermonuclear fuel, with the primary and secondary charges contained within a radiation case.

On July 25, 1951 I published a four-page memo with large graphic foldout[8].

According to Edward Teller in a 1979 "testament" dictated to George A. Keyworth and transcribed[9] but sent to Teller only in 1987, *"Garwin's blueprint had been criticized by many people, including Hans Bethe. In the end the shot was fired almost precisely according to Garwin's design, and it worked as expected."* The Los Alamos website now states[10], *"Shortly after President Truman's directive to proceed with the hydrogen bomb program in January 1950, research began to bear fruit. Edward Teller and Stanislaw Ulam came up with a promising design, involving radiation implosion, which was translated by Richard Garwin into a working design."*

Now 65 years after the MIKE detonation of 11/01/52 at Eniwetok, the question is being asked whether North Korea has demonstrated a true hydrogen bomb. I don't see why not, given the truly enormous advances in both speed and especially convenience of computation, the, again, enormously greater depth and breadth of understanding of the processes involved in transport of radiation, and the dedication of the small group of nuclear technologists in North Korea to the development of nuclear weaponry.

Assuming that NK has demonstrated a true hydrogen bomb, probably with thermonuclear fuel composed of lithium and deuterium—specifically, LiD or lithium deuteride—what does this mean?

First, suppose this is not a true hydrogen bomb with separated primary and secondary charges, but more like the fourth Soviet nuclear explosive test, "Joe-4." In those days of atmospheric testing, far more information was available than simply an estimate of the explosive yield, primarily from the "radiochemistry" of the highly radioactive materials produced by the nuclear

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6 http://www.nytimes.com/2001/04/24/science/who-built-the-h-bomb-debate-revives.html
7 "On Heterocatalytic Detonations I: Hydrodynamic Lenses and Radiation Mirrors"
8 **RLG provide.**
9 http://nsarchive2.gwu.edu/nukevault/ebb507/docs/doc%209%20%2079.09.20%20Teller%20testament.pdf
10 http://www.lanl.gov/about/history-innovation/index.php?story_id=19

explosion, together with the tiny sample of plutonium or U-235 that could be collected by atmospheric sampling. In fact, with H.A. Bethe, E. Fermi, and L. Nordheim, I co-authored a report on Joe-4, [11] available in highly redacted form.

The implications for North Korean nuclear capability are quite different in the two cases.

Although the initial desire in the United States when President Truman authorized a program to develop the "hydrogen bomb" was to achieve explosive yields totally out of the range of ordinary fission bombs, after these were demonstrated (10 megatons with Ivy MIKE on 11/01/52, 15 MT with Castle BRAVO in 1954, and many deployed in the form of bombs and missile warheads (e.g., the Titan-II warhead of 9 MT), greater military capability was achieved with the advent of multiple warheads on ICBMs and multiple independently targeted reentry vehicles (MIRVs) on ICBMS, each with a much less powerful thermonuclear warhead. As I have written, the true benefit of the Teller-Ulam invention was the ability to make hydrogen bombs in the range of 100 kilotons, plus or minus a factor five, such that the average amount of plutonium in a warhead in the U.S. stockpile is on the order of 4 kg. If totally fissioned, that amount of plutonium or uranium would provide 68 kt of explosive yield, and at 30% efficiency only about 20 kt, not so different from the nuclear weapons tested at Trinity 07/16/45 and used a few weeks later to destroy the city of Nagasaki. That early implosion weapon used 8 kg of plutonium.

To obtain 250 kt from a pure fission weapon of plutonium or U235 would require the complete fission of 250/17 = 15 kg of the material, and the investment of far more.

The nuclear weapon engineer/designer has also in her tool box the option of "boosting," in which a small amount of thermonuclear fuel (deuterium and tritium gas in the case of many modern U.S. nuclear weapons) is used in the fissile core of the weapon to enhance the fission yield. Boosting, first demonstrated in Greenhouse ITEM in 1951, can be used to increase the yield of an implosion weapon, or reduce its weight or the amount of plutonium required, or all three.

If the nuclear explosive tested by NK 09/03/17 is light enough and sturdy enough to fit into a reentry vehicle, it might be weaponized for use to threaten Japan, Guam, South Korea, or even cities within the continental United States. If it is a true two-stage thermonuclear weapon, then more nuclear tests by NK are to be expected, as that country explores using two-stage weapons to achieve explosive yields in the range achievable by pure fission weapons, but with greater economy of fissile material. And if it is not yet a two-stage weapon, more tests are to be expected to obtain such. Few outside North Korea believe that such enhancements by North Korea are in the world's security interest.

DELIVERY MEANS

In 1998 I was a member of the nine-person Commission to Assess the Ballistic Missile Threat to the United States, chaired by Donald H. Rumsfeld, which reported in July, 1998. Even at that time we assessed that within five years, with foreign assistance, North Korea (or in the perspective at the time, Iran or Iraq) could develop a nuclear warhead and deliver it against the

[11] H.A. Bethe et al., "Analysis of Joe-4," (11 September 1953);

United States if not by ICBM, then by short-range cruise missiles or ballistic missiles launched from ships, These need not be military ships but cargo ships, and the cruise missile or the ballistic missile and its launcher could be built into an ordinary-looking shipping container on the deck of the ship, and fired therefrom. To imagine that U.S. coastal cities have not been for some time vulnerable to North Korean nuclear weapons is to have one's head in the sand. Although the United States has capabilities to defend against both cruise missiles and short-range ballistic missiles, but they are not deployed to protect American cities.

The major concern expressed to the American people over the past two decades has been the potential acquisition by North Korea of intercontinental-range delivery means (ICBMs) that could be mated with a nuclear warhead to threaten U.S. cities.

WHAT TO DO ABOUT THE NORTH KOREAN NUCLEAR THREAT?

First, I comment on the prospect for "extreme sanctions" against North Korea and those who trade with NK. What is the "ask?" If the purpose is to impose sanctions so crippling that millions of the 25 million people in North Korea starve, it is far from clear that the United States and its necessary allies in imposing sanctions will be able to hold out longer than North Korea, which has experience with mass starvation. But the main point is "What is the 'ask'? "

Presumably the purpose of unbearable sanctions is for the other side to take actions that are acceptable to the United States, and that would result in the removal of the sanctions. If other states are to cooperate with the United States against North Korea, the United States must appear to have legitimacy in its position and in its methods. It could well ask for NK not to fire missile in test over a range exceeding 5000 km, or which, if fired on a minimum energy trajectory to maximum range, rather than a highly lofted trajectory, would exceed 5000 km. And on the nuclear side, one could ask that NK not conduct any more nuclear explosive tests.

But my point is that the United States in asking for cooperation in imposing sanctions on North Korea must give an indication of what would be necessary for the relief of sanctions.

A second aspect of what to do to diminish the North Korean nuclear threat involves the possibility of defense against nuclear-armed ICBMs. Here, in my opinion, the United States has missed several boats. The Missile Defense Agency—MDA-- has not seen North Korea as a priority, or as a singular case of a country with very small area and subject, in principle, to boost-phase intercept of its ICBM launches. In 1999, I proposed boost-phase intercept against North Korea and with the cooperation of Ted Postol, was able to work out some of the requirements for an effective system. This was to depend primarily upon very large, high-speed, fast-burn interceptors based on cargo ships adapted by and operated by the U.S. Navy in waters adjacent to the Korean peninsula, perhaps supplemented (largely for political reasons) by similar interceptors based on Russian territory just north of North Korea. The purpose of involving Russia was not so much to have a more effective system, but to gain Russian cooperation while preserving the 1972 ABM Treaty that strongly limited Russian defenses against U.S. missiles, at the same time that it limited U.S. defenses against long-range Russian missiles.

The proposal for boost-phase intercept got little favorable response in view of the desire of many to support what is now the MDA to provide a defense of the United States against, frankly, missiles from any source. Although U.S. government declarations have emphasized that U.S. missile defense developments are not aimed to counter nuclear-armed strategic missiles from Russian (or even from China) it is clear that there are many influential people who have the opposite view. For instance, when I testified to the Senate Armed Services Committee, then headed by Senator Joseph Biden, on the same panel of witnesses was R. James Woolsey, who had the following exchange with the Chairman,

Biden: “Let’s level with the American people …” **RLG find the exact quote.**

Woolsey: “No I wouldn’t” (support a defense that was 100% effective against North Korea, Iran, and Iraq, but was not effective against Chinese ballistic missiles.)

I do believe that this desire to build defenses against China and against Russia have seriously interfered with the United States’s acquiring a limited capability for countering the long-range missile threat from North Korea.

On the technical side, I think a different set of arguments have been in play. In my long history of interactions with the Soviet and now the Russian bomber and missile threat, beginning with my tear-long involvement with the Project LAMP LIGHT study in 1953-54, I have, myself, always looked at alternatives and countermeasures, so as not to support a long and costly development and deployment that could be negated by simple countermeasures.

Of course, the better (or even the perfect) is the enemy of the good enough, and that even a low-cost, perfect countermeasure might have some hidden imperfection, or Achilles heel, but it is important to discuss countermeasures and not pretend that they don’t exist.

Against ICBMs, there has been from the very beginning the problem that countermeasures against sensors and weapons for intercept of the missiles in mid-course—in the vacuum of space—have to deal with the fact that the drag of the residual air is negligible, and that decoys that “look” just like the warheads can be made of very light, potentially inflatable material, and that even the gas to inflate them against the vacuum of space has negligible mass. This was evident from the beginning in the 1950s, but could, to some extent, be countered by the use of nuclear warheads on the interceptors.

Of course, a lot of effort went into estimating and confirming the effective range of nuclear explosions against nuclear warheads traveling through space, including some surprise vulnerabilities such as the shock or mechanical impulse delivered by the x-rays that are the principal output of nuclear explosions in space. But with the decision to avoid the use of nuclear-armed defensive weapons, the countermeasures against hit-to-kill interceptors became a lot easier. Perhaps still the best technical exposition of countermeasures to missile defense is to be found in the volume by that name, “Countermeasures,” published in 2000 by MIT and the Union of Concerned Scientists.[12]

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[12] "Countermeasures," A Technical Evaluation of the Operational Effectiveness of the Planned U.S. National Missile Defense System, (Executive Summary and full text) UCS-MIT Study, A.M. Sessler (Chair of the Study Group), J.M.

Playing an important role is the recognition from the 1960s of the utility of "anti-simulation," in which the king is protected by having many look-alike impostors (decoys), but rather than providing each with ermine robes and a gilded coach with four horses, one employs anti-simulation, so that the king is dressed as an ordinary person, with perhaps a Hyundai vehicle. And, of course, because there are so many decoys, it might be thought that a close study of all of the details of the decoy or the Hyundai fleet would yield a discriminant from the real thing. Evidently the vulnerability and the countermeasure could be addressed by having a large range of observables in the decoys (not all of them Hyundais), so that the real warhead would need to fall anyplace in this range, and not necessarily near the middle of the range.

So I have long maintained that even nascent ICBM powers can far more readily deploy inflated balloons or clusters of balloons around the warhead in space, with similar, but far from identical balloons or balloon clusters that could not by passive means be distinguished ("discriminated") from the real warhead in its anti-simulation dress. And I have advocated active means to discriminate, but such apparently have not been adopted, because the anti-simulation decoys are deemed an "advanced threat" beyond the capability of nascent missile powers.

Hence the interest in boost-phase intercept, where the booster with its enormous rocket motor is easily seen on radar or with long-range infrared sensors, the booster is mechanically fragile, and difficult to decoy.

Clearly I believe that a dedicated effort beginning in 2000 would have resulted within four or five years in an effective BPI capability against long-range North Korean missiles. Starting now, it is more difficult, first because North Korea now has access to solid-fuel technology, with potentially shorter burn time than the liquid-fuel rockets, and second, especially because we have lost 16 or 17 years of development. On the other hand, the technology of the hit-to-kill interceptors is somewhat more advanced than it was in those days, but the Department of Defense does not seem to have the agility that is required to mount a dedicated program toward a limited goal and to drive it to completion.

For BPI, there are other technologies, in principle, than the very large ship-based high-performance interceptor. Aside from the performance in a single ICBM launch, one might ask about whether the system is robust against multiple simultaneous launches, some of which would involve shorter-range missiles launched as boost-phase decoys against a limited magazine of BPI.

Ultimately, too, one needs to work out rules of engagement, as to when it is legitimate to destroy NK missiles in boost phase, before they can be determined to be a threat to a particular target structure, such as U.S. cities.

Cornwall, R. Dietz, S.A. Fetter, S. Frankel, R.L. Garwin, K. Gottfried, L. Gronlund, G.N. Lewis, T.A. Postol, and D.C. Wright, April 2000
http://www.ucsusa.org/sites/default/files/legacy/assets/documents/nwgs/cm_all.pdf

There, too, I think that the quest for perfection has gotten in the way of the practically good enough. For instance, in one of my illustrations of BPI capability from the 1999 era[13], I indicate that if the missile were intercepted and thrust curtailed ten seconds before planned burnout of the final stage, the payload would fall short of its target by 5000 km. So the question arises as to whether the nuclear warhead and reentry vehicle would survive stress of reentry, whether the weapon would be properly fuzed to detonate, and what would be the casualty toll for a weapon landing, for instance, in a random spot on U.S. territory, rather than in the city against which it is targeted. If, for instance, the expected number of people killed is reduced by a factor hundred, comparable with the ratio of average population density compared with that in a target city, this would be equivalent to a mid-course intercept with 99% effectiveness- beyond what is conceivable even with multiple interceptors and assumed perfect discrimination (no effective decoys).

But it would need to be decided in advance that such performance is acceptable. It would need to be further considered as to whether such a misdirected North Korean weapon landing in Canada would be acceptable, given the shared defense capability and responsibility between the United States and Canada. And if such relatively small damage from an imperfect intercept is unacceptable, why should nascent nuclear powers not be satisfied with holding adjacent states hostage, as stand-ins for the United States?

And finally, in intercepting North Korean missiles in test, and those without nuclear warheads, it is sometimes claimed that it would be unacceptable to have a BPI that would intercept after the booster got to a speed that would take the reentering debris outside the borders of NK, so that it might fall, for instance, on Japanese territory. I think that is the sort of thing that ought to be discussed in mutual defense circles with U.S. allies in the region.

oo- End of 09/07/17 draft of “North Korea on My Mind” -oo

[13] https://fas.org/rlg/991117.htm