A REPORT OF THE CSIS PROJECT ON NUCLEAR ISSUES

Nuclear Notes

Volume 2, Issue 2

Editors
Stephanie Spies
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About *Nuclear Notes*

Nuclear Notes is a biannual publication of the CSIS Project on Nuclear Issues (PONI) featuring innovative thinking by rising experts. Its goal is to advance the public debate about nuclear weapons strategy and policy. We welcome submissions of 2,000-3,000 words on contemporary topics pertaining to nuclear weapons strategy or policy. Submissions can be sent to PONI coordinator Stephanie Spies (SSpies@csis.org) for review by PONI staff and senior members.

Cover image: PACIFIC OCEAN (March 1, 2011) An unarmed Trident II D5 missile launches from the Ohio-class fleet ballistic-missile submarine USS Nevada (SSBN 733) off the coast of Southern California.

http://www.cpf.navy.mil/news.aspx/000303.

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CONTENTS

SHOULD THE UNITED STATES RECONSIDER NUCLEAR-TIPPED INTERCEPTORS FOR BALLISTIC MISSILE DEFENSE?

Jonathan Bergner[1]

German development of the V-2 rocket in World War II ushered in the missile age and hinted at the ability of one country to launch a devastating attack on another from across the globe. The V-2 rockets were highly inaccurate—a fortunate flaw for the Allies because defense against these weapons was not feasible in view of the technology at the time. It was not long, however, before midflight interception was made possible because of improvements in missile design and radar capability. The early intercontinental ballistic missile (ICBM) defense systems of the 1950s were not very accurate, and, as a result, the early designs employed nuclear-tipped interceptors. Over time, because of concerns about the effects of exo- and endo-atmospheric nuclear explosions, as well as the political resistance to the possible locations of bases, the use of nuclear-tipped interceptors was rejected.

Instead, U.S. national missile defense programs over the last two decades have focused on "hit-to-kill" interceptors. These interceptors are tipped with kill vehicles that rely on the kinetic energy generated by a high-speed collision with an incoming warhead to destroy it. This system requires an exceptional level of accuracy for success. Although technology has continued to improve and much higher levels of interceptor accuracy are indeed now possible, questions remain over whether such systems are reliable and cost-effective. And yet the Obama administration's number-one policy priority in the February 2010 "Ballistic Missile Defense Review Report" was to "continue to defend the homeland from the threat of limited ballistic missile attack."[2] If the United States is serious about this goal, it may be time to reevaluate the use of nuclear-tipped interceptors for its ballistic missile defense (BMD) system.

It is clear that there are some significant challenges in making the U.S. ICBM defense shield nuclear. Indeed, the Obama administration has stated that it is also seeking to "reduce the role and number of nuclear weapons in the future."[3] However, the use of nuclear weapons in this nonoffensive capacity is a different discussion than the usual ones of nuclear drawdowns and arms control. The debate should be over whether, of all the feasible options, the nuclear destruction of incoming warheads provides the best, most reliable defense against a limited missile attack. If this assertion is correct—as the Russians have believed for decades—serious analysis of what such a system

1. Jonathan Bergner is a recent graduate of Georgetown University's Security Studies Program and the author of a recent article on comparative strategy, "Going Nuclear: Does the Non-Proliferation Treaty Matter?"

2. U.S. Department of Defense, "Ballistic Missile Defense Review Report," February 2010, iii, http://www.defense.gov/bmdr/docs/BMDR%20as%20of%2026JAN10%200630_for%20web.pdf.

3. U.S. Department of Defense, "Nuclear Posture Review Report," April 2010, 48, http://www.defense.gov/npr/docs/2010%20nuclear%20posture%20review%20report.pdf.

would look like and how the United States could take steps to address the remaining challenges is necessary. One possibility might be to consider how to replace the kinetic kill vehicles on the interceptors currently deployed for the ground-based, midcourse defense system with low-yield, nuclear kill vehicles.

Historical Survey of U.S. Nuclear Ballistic Missile Defense Systems

Research on antiballistic missile systems began in the mid-1950s; the army funded the Nike-Zeus Guided Missile Defense System Project conducted by Bell and Western Electric in which nuclear-tipped interceptors were designed to destroy incoming warheads outside the atmosphere. By the early 1960s, there had been 13 successful "intercepts" (although the exact number of test flights is unknown) in which the dummy payload passed close enough that a nuclear detonation would have annihilated its target.[4]

Even at this early stage of development, most high-level Pentagon officials had a realistic understanding of the limitations of the Nike-Zeus system. For one thing, the system itself was vulnerable to attack. Even if the radars or interceptor batteries were not targeted, everyone understood that the system could be overwhelmed by a saturation attack or by sophisticated ICBMs with screening decoys.[5] Because the main purpose of developing a BMD system had always been to counter the Soviet missile force, researchers were legitimately skeptical of deploying something that increasingly looked incapable of performing this mission. Furthermore, Defense Secretary Robert McNamara argued against deploying any BMD whatsoever against the Soviets for fear of needlessly destabilizing the superpowers' relationship.

Eventually, however, Chinese development of a nuclear capability, coupled with advances in radar technology and the belief that Chinese missiles would soon be able to reach the United States, spurred the development of a new type of layered defensive system. This new system, which was first called Nike-X and later Sentinel, employed two types of missiles: the long-range Nike-Zeus (later upgraded to the Spartan) and the new high-acceleration Sprint missile for short-range intercepts after the atmosphere had filtered out any decoys.[6] The Spartan had a 460-mile range and a 350-mile ceiling—the interceptor could not destroy the reentry vehicle by blast at that altitude, but instead relied on a thermal X-ray flux.[7] The second interceptor, called the Sprint, was designed as a last-ditch defense. It had a range of 25 miles and a ceiling of about 19 miles that would destroy a reentry vehicle inside the atmosphere with a low-yield warhead.[8] Because the Sprint was intended to destroy its target after it had reached its very high terminal velocity, the entire process from launch to intercept took about 15 seconds. The Sentinel system also relied on new electronic phased-array radars that enhanced the accuracy of the intercept and allowed for the tracking of

4. "Nuclear ABMs of the USA," February 3, 2012, http://www.nuclearabms.info/index.html.

5. Robert McNamara, *Department of Defense Appropriations for 1962: Hearings Before a Subcommittee on Appropriations,* 87th Cong., 1st sess., 1961, 3: 16–17.

6. Daniel Papp, "From Project Thumper to SDI: The Role of Ballistic Missile Defense in U.S. Security Policy," *Airpower Journal* (Winter 1987–88), http://www.airpower.au.af.mil/airchronicles/apj/apj87/win87/papp.html.

7. "Nuclear ABMs of the USA."

8. Bell Laboratories, "ABM: Research and Development at Bell Laboratories—Project History," October 1975, 9-3–9-4, http://www.srmsc.org/pdf/004421p0.pdf.

more than one object at once. The initial deployment plan, estimated to cost about $5 billion, included "6 perimeter acquisition radars, 17 missile site radars, 480 Spartan missiles, and 220 Sprints," to be placed in 17 locations around the continental United States and Hawaii.[9]

The decision to deploy the Sentinel system was based on a four-pronged rationale. The system was designed to (1) protect against the Chinese threat and thus would be lighter, relatively less expensive, and have a higher degree of reliability than a system intended to defend against the Soviets; (2) deter China from "nuclear blackmail," thereby discouraging proliferation by reducing the perceived utility of a nuclear arsenal; (3) defend Minuteman silos, thereby enhancing the survivability of the U.S. offensive forces and lessening the need to expand them; and (4) provide protection for U.S. cities against an accidental or rogue launch of an ICBM.[10] Updated for the geopolitical realities of modern times, these goals mirror the objectives and arguments of BMD proponents today.

In 1969, upon taking office, President Richard Nixon immediately suspended the Sentinel deployment. The program eventually launched was largely "a short-term response to public outcry over initial site selection and proposed construction."[11] Indeed, many Americans objected to basing nuclear weapons in their backyards. President Nixon chose instead to launch a new system called Safeguard that would focus first on the defense of U.S. land-based retaliatory forces and would pursue only a more limited area defense against a Chinese attack. The initial deployment included the defense of the Minuteman fields in Grand Forks, North Dakota, and Malmstrom, Montana, with two more fields, two more cities, and Washington, DC, to follow.

Construction of the first sites had only just begun when the Anti-Ballistic Missile Treaty between the United States and the Soviet Union was signed in 1972. The treaty limited both sides to two BMD sites—one for the capital and one to protect an ICBM field—and only 100 interceptor missiles and launchers at each site.[12] An additional protocol amending the treaty in 1974 further restricted the signatories to only one site. The United States opted to protect its Grand Forks ICBM field and completed construction of the facility in 1975, deploying 70 Sprint and 30 Spartan missiles. However, one day after the facility was declared fully operational, Congress voted to defund the system. Put simply, the view accepted at the time was that the technology worked well enough to provide an additional security benefit, but not well enough to justify the additional costs.[13] The Grand Forks site was therefore shut down after operating for barely five months. The Safeguard experience was the last time the United States seriously considered using nuclear-tipped interceptors for BMD.

9. Ibid., I-45, 3-2.

10. Robert McNamara, "Speech on Anti-China Missile Defense and U.S. Nuclear Strategy" (address to editors of United Press International, San Francisco, September 18, 1967).

11. Roger Handberg, *Ballistic Missile Defense and the Future of American Security: Agendas, Perceptions, Technology, and Policy* (Westport, CT: Praeger, 2002), 54.

12. U.S. Department of State, "Anti-Ballistic Missile Treaty," May 26, 1972, http://www.state.gov/www/global/arms/treaties/abm/abm2.html.

13. Handberg, *Ballistic Missile Defense,* 57.

The Effects of High-Altitude Nuclear Explosions

When a nuclear weapon is detonated close to the earth's surface, the air density is a factor: the nuclear radiation effects of the explosion (neutrons and gamma rays) are generally less impactful than the blast and thermal pulse.[14] By contrast, in a vacuum there is no atmosphere to push out or heat, and so the blast and thermal effects (as traditionally defined) disappear completely. Instead, the nuclear explosion emits much higher frequency nuclear radiation that attenuates over much longer distances. A nuclear detonation in space also produces an artificial radiation belt—similar to the naturally occurring Van Allen belt—the duration and intensity of which are determined by the altitude, latitude, and yield of the explosion.[15]

Much of the information available on high-altitude explosions was garnered from a series of 13 tests undertaken before 1963 when the United States and the Soviet Union signed the Limited Test Ban Treaty outlawing nuclear testing in space. Those tests indicated the potential problems in the use of nuclear-tipped interceptors for BMD. First, at high altitudes ionization of the upper atmosphere can produce an intense pulse of electromagnetic energy (EMP) that can seriously damage or disrupt electronic equipment over very large areas.[16] The EMP was of serious concern to early BMD planners anticipating a large-scale Soviet assault. What good would the system be if after the very first intercept the radars were damaged? Similarly, if the atmosphere became ionized, radio and other communications signals could be degraded for short periods.

A second problem is the production of artificial radiation belts. After detonation of the nuclear device Starfish Prime in a high-altitude test in July 1962, three U.S. satellites were damaged or degraded after traversing the newly created radiation.[17] Space assets that are not hardened against increased radiation are vulnerable to these belts following a nuclear detonation. Although the harmful level of radiation dissipates after at most a few months, scientists have argued that some energized electrons can last up to 10,000 years.[18] Both domestic and foreign military and commercial space assets could be damaged by passing through these belts, to say nothing of being in the vicinity of the actual detonation.

Third, the potential effects on the ground from a detonation in space, particularly to people, are a concern as well. What good is it to protect Americans from nuclear weapons if they are showered with harmful nuclear radiation in the process? As it turns out, there is less to be concerned about in this area than originally thought during the tests. For one thing, "prompt thermal effects on the ground were negligible."[19] There was an instance during a test on Johnston Island

14. National Aeronautics and Space Administration, *The Space Handbook: Aeronautics and Its Applications* (Washington, DC: Government Printing Office, 1959), chap. 17, http://history.nasa.gov/conghand/nuclear.htm.

15. Wilmot Hess, "The Effects of High Altitude Explosions," NASA Technical Note, National Aeronautics and Space Administration, Washington, DC, September 1964, 2.

16. Robert Johnston, "High-Altitude Nuclear Explosions," Johnston's Archive, 2009, http://www.johnstonsarchive.net/nuclear/hane.html.

17. "Nuclear Physics: Radiation by Mistake," *Time,* September 21, 1962, http://www.time.com/time/magazine/article/0,9171,827561,00.html.

18. Ibid.

19. Herman Hoerlin, "United States High-Altitude Test Experiences: A Review Emphasizing the Impact on the Environment," Los Alamos Scientific Laboratory of the University of California, October 1976,

in which two military personnel who were not wearing the appropriate eyewear at ground zero experienced severe eye burn. The eye burn problem, however, is highly dependent on the altitude and yield of the explosion.[20] In general, a study of the high-altitude tests concluded that the effects "on the normal activities of the populations were either insignificant or under protective control involving little harassment or irritation."[21]

In the end, it was concluded that the prompt fallout from the test explosions was nil. Also, the residence time of special tracers in the stratosphere was 14 years and dispersed over the whole globe, making the biological effects on the environment much less than those produced by low-altitude atmospheric explosions.[22] Nor could any effect on the natural ozone layer be ascertained. However, these tests said nothing about the massive use of nuclear force in space, which theoretically might have unanticipated consequences for the environment.

Deploying Nuclear-Tipped Interceptors Today

Key to the debate today are several assumptions about the current defense of the U.S. homeland against ICBMs. First, U.S. territorial BMD is not—and is not intended to be—able to protect the United States from a Cold War–style U.S.-Soviet nuclear exchange. Second, a successful strike against the homeland using a nuclear, biological, chemical, or radiological warhead constitutes an unacceptable outcome of a limited or accidental attack launched against the United States. And, third, any system must be feasible from both a technological and a budgetary standpoint. Given these parameters, a discussion of what provides the best possible defense against a limited ICBM attack—an accuracy-dependent, hit-to-kill system, or a system relying on nuclear-tipped interceptors—is warranted. As mentioned, one possibility might involve using the current ground-based, midcourse defense system and replacing the kinetic kill vehicles with low-yield nuclear kill vehicles.

It is clear that there are indeed serious challenges to developing and deploying a shield against ICBMs. However, those challenges might be overcome with a properly constructed system with a clearly defined mission. When Safeguard was deployed, the issue of nuclear interference in communications, through either an EMP or an ionized atmosphere, was critical because "the system must defend against a *mass attack* of ICBMs [emphasis added]."[23] Degraded radar capability in a longer-term nuclear exchange is, of course, an issue. The system deployed today, however, is designed to handle a very limited attack by a rogue nation or an accidental launch—the nuclear deterrent is in place to prevent an all-out attack. Degraded communications are not as important in a limited attack, and it may be the price to be paid for ensuring that an enemy ICBM does not strike the U.S. homeland.

Furthermore, it is possible that the United States could mitigate this and the other effects of a high-altitude nuclear blast. The use of low-yield nuclear weapons at the higher altitudes of the midcourse of ballistic missile flight would do much to limit the significant side effects created by the explosion. The EMP would be limited in size and force and, with hardened military assets,

1, http://www.fas.org/sgp/othergov/doe/lanl/docs1/00322994.pdf.

20. Ibid., 11–16.

21. Ibid., 2.

22. Ibid.

23. Maj. Roger Ailles, "Antiballistic Missile System Evaluation," *Army Research and Development News Magazine*, May–June 1974, 20–21.

would be unlikely to knock out key equipment in a crisis. In terms of radio communications, although the low-frequency, medium-frequency, and high-frequency ranges experienced interference for several days following high-altitude tests, the effect was less severe for the very high frequency (VHF) and very low frequency (VLF) ranges—and sometimes it provided a beneficial boost to signal ranges.[24] Advanced planning for emergency communications could provide backup should the lower yield not prevent communication interference. Also, the use of "a fusion or hydrogen bomb explosion will produce a quite insignificant artificial radiation belt compared with fission or an atom bomb explosion of the same yield."[25] If the nuclear interceptors could be tailored to the right type of explosion, the United States could limit the longer-term radiation effects, thereby doing more to protect both foreign and domestic space assets.

The use of a lower-yield nuclear interceptor would not necessarily erase the inherent advantage over a kinetic kill vehicle. Because the current system relies on acquisition, tracking, and discrimination radars, interceptor missiles, and data processors that are designed to produce a direct hit, surely the same system could more easily bring the interceptor into the necessary range for a small nuclear explosion. That would do much to overcome some of the specific criticisms of opponents of the hit-to-kill systems. BMD experts have argued that "with pure hit-to-kill, and with little or no advance information about the details in such an attack, the miss distances will always be too large."[26] A nuclear detonation would provide confidence that the interceptors could get close enough to the incoming warhead to actually destroy it.

There is concern about significant public opposition from both international and domestic sources to the deployment of nuclear weapons. The reasons vary from concerns about the environment or personal safety to the belief that such a deployment will damage nonproliferation efforts. Others will protest the deployment of nuclear weapons in "their backyard," although the number of sites will theoretically be far fewer than the proposed number of Sentinel sites. At the very least, people will argue that deploying nuclear-tipped BMD will negatively affect the relationships of the United States with both its enemies and its friends (although one might recall the almost entirely inaccurate diplomatic doomsday scenarios outlined when President George W. Bush pulled the United States out of the Anti-Ballistic Missile Treaty[27]). The country does, however, have the technology to assure its citizens that they do not have to fear a rogue state strike or an accidental missile launch. Stopping an ICBM attack on the U.S. homeland is of paramount importance.

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24. Hoerlin, "United States High-Altitude Test Experiences," 17–22.

25. Hess, "Effects of High Altitude Explosions," 3.

26. Philip Coyle, "Defense Officials Nix Nuclear-Tipped Interceptor Language from RFP," *Inside the Pentagon*, January 5, 2006, http://defensenewsstand.com/index.php?option=com_ppvuser&view=login-&return=aHR0cDovL2RlZmVuc2VuZXdzc3RhbmQuY29tL2NvbXBvbmVudC9vcHRpb24sY29tX3Bwdi9JdGVtaWQsMjkxL2lkLDE3Njk4NjEv.

27. As an example, at the time Sen. Carl Levin, D-Mich., chair of the Senate Armed Services Committee, said of the decision to pull out of the ABM Treaty, "Unilateral withdrawal will likely lead to an action-reaction cycle in offensive and defensive technologies, including countermeasures, and that kind of arms race would not make us more secure."

Conclusion

Although skeptical of the deployment of an actual system at the time, Defense Secretary McNamara offered a succinct explanation of the value of BMD:

> Successful development [of a system] may force an aggressor to expend additional resources to increase his ICBM force. It would also make accurate estimates of our defensive capabilities more difficult for a potential enemy and complicate the achievement of a successful attack. Furthermore, the protection that it would provide, even if for only a portion of our population, would be better than none at all.[28]

For the foreseeable future, there is likely to be a vociferous debate over BMD and whether it is possible or worth the cost. The addition of nuclear weapons to the mix only makes this discussion more difficult. Even so, some defense is better than none at all, and because the United States has decided to invest in these capabilities, they should be as effective as possible. The country has already spent an incredible amount of money on the systems it has without significantly boosting Americans' confidence that they are adequately protected.

The science of exactly what type of yield or explosion would be most appropriate to alleviate some of the concerns covered here is beyond the scope of this article. Furthermore, "nuclearizing" the currently deployed ground-based interceptors may not be possible, and a new system may be required, although in view of U.S. budgetary constraints it would likely not be feasible. Nevertheless, more extensive research on the possibility of using a nuclear kill vehicle should be conducted. Because of advances in the United States' current BMD systems and the modernization of U.S. nuclear forces, it is probable that a highly effective and reliable kill vehicle could be produced. Although controversial, the benefits of using nuclear-tipped interceptors for U.S. BMD might outweigh the costs. At the very least, this question should be opened for serious debate.

28. McNamara, *Department of Defense Appropriations for 1962*, 3: 16–17.

THE NAVAL PROPULSION LOOPHOLE

Nathan Donohue[1]

In June 2012, Iran's deputy navy commander, Abbas Zamini, announced that Iran had taken the first steps toward designing and building nuclear submarine propulsion systems, with the intention of later incorporating them into Iranian naval vessels.[2] This announcement was poorly received by the international community, which perceived it to be just another tenuous Iranian justification for continuing the country's ongoing uranium enrichment activities. The move has raised concerns that Iran is adopting this new position not merely to continue its enrichment activities but also to justify achieving higher levels of enrichment suitable for producing nuclear weapons–usable uranium.

This was not the first instance of international concern about the proliferation potential associated with naval propulsion reactors (NPRs). The issue of access to NPR technology was debated during the original negotiations on the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), but it was intentionally not addressed in the final treaty agreement, reportedly because of a lack of consensus among participants in the negotiations.[3] Currently, concern surrounds the lack of an international agreement to restrict highly enriched uranium (HEU) production when enrichment is pursued under the pretext of fueling an NPR.

As Greg Thielmann and Wyatt Hoffman of the Arms Control Association noted in their article "Submarine Nuclear Reactors: A Worsening Proliferation Challenge,"[4] NPRs, and the subsequent right to develop HEU to fuel them, are a "long submerged flaw in the nuclear Non-Proliferation Treaty."[5] Accordingly, says the *Wall Street Journal,* one of the few "pretexts for weapon-grade uranium are nuclear submarines."[6] This reality calls into question the efficacy of allowing such a loophole to exist and raises the question of why more stringent restrictions have not been agreed upon and applied to NPRs. Meanwhile, the United States is one of the leading proponents of utilizing HEU to power its domestic naval fleet. In view of U.S. naval propulsion needs, as well as U.S.

1. Nathan Donohue is a senior analyst at Guardian Six Consulting.
2. "Iran Claims Designing Nuclear Submarine," *Al Arabiya News*, June 12, 2012, http://english.alarabiya.net/articles/2012/06/12/220176.html.
3. James Clay Moltz, "Closing the NPT Loophole on Exports of Naval Propulsion Reactors," *Nonproliferation Review* (Fall 2008): 109.
4. In 1998 James Clay Moltz argued that NPR technology exports to nonnuclear weapon states would undermine international nonproliferation goals.
5. Greg Thielmann, with Wyatt Hoffman, "Submarine Nuclear Reactors: A Worsening Proliferation Challenge," Threat Assessment Brief, Arms Control Association, July 26, 2012, http://www.armscontrol.org/files/TAB_Submarine_Nuclear_Reactors.pdf.
6. Jay Solomon, "Iran Says It Plans Nuclear Submarine," *Wall Street Journal*, June 12, 2012, http://online.wsj.com/article/SB10001424052702303444204577462702132818704.html?mod=googlenews_wsj.

desires to prevent the proliferation of nuclear weapons, how should the United States address this dangerous loophole, and what should U.S. policy be?

Since the 1940s, roughly 500 vessels[7] have been constructed utilizing NPRs, and, according to the World Nuclear Association, currently about 140 ships throughout the world's navies are powered by more than 180 small nuclear reactors.[8] The majority of these NPRs are used to power submarines possessed by nuclear weapon states (NWS). These NPRs are powered by uranium-based fuel, ranging from 20 percent uranium-235 (U-235) to roughly 93 percent U-235 (see Table 2.1).[9] The United States and the United Kingdom reportedly incorporate the highest levels of enrichment to fuel their NPRs, utilizing weapons-grade uranium containing more than 93 percent U-235.[10] Russia and India reportedly use lower enrichment levels, enriching their HEU fuel to approximately 40 percent U-235.[11] Nuclear submarines that utilize low enriched uranium (LEU) currently exist as well. Specifically, submarines in the Chinese and the French navies utilize NPRs operating with fuel containing less than 20 percent U-235.

Table 2.1 Global Outlook 2012: Nuclear-Powered Submarines

Country	Number operational (or planned)	Percentage of U-235 enrichment
United States	71	93
United Kingdom	12	93
Russia	30	40–90
France	10	7.5
China	7–8	5
India	(3–5)	40
Brazil	(6)	< 20
Iran	?	?

Source: Based on Greg Thielmann, with Wyatt Hoffman, "Submarine Nuclear Reactors: A Worsening Proliferation Challenge," Threat Assessment Brief, Arms Control Association, July 26, 2012, http://www.armscontrol.org/files/TAB_Submarine_Nuclear_Reactors.pdf.

Utilizing NPRs offers advantages to any country's navy because they can power a naval platform for longer periods of time without refueling. This advantage in turn allows a vessel to "proceed faster and farther."[12] More important, there is a distinct advantage to utilizing NPRs in

7. Olli Heinonen, "Nuclear Submarine Program Surfaces in Iran," *Power and Policy*, July 23, 2012, http://www.powerandpolicy.com/2012/07/23/nuclear-submarine-program-surfaces-in-iran/.

8. "Nuclear-Powered Ships," World Nuclear Association, August 2012, http://www.world-nuclear.org/info/inf34.html.

9. Solomon, "Iran Says It Plans Nuclear Submarine."

10. Chunyan Ma and Frank Von Hippel, "Ending the Production of Highly Enriched Uranium for Naval Reactors," *Nonproliferation Review* 8 (Spring 2001): 87.

11. "Global Fissile Material Report 2011," International Panel on Fissile Materials, January 2012, 5–7, http://fissilematerials.org/library/gfmr11.pdf.

12. Cole J. Harvey, "At Sea over Naval HEU: Expanding Interest in Nuclear Propulsion Poses Proliferation Challenges," Nuclear Threat Initiative Issue Brief, November 29, 2010, http://www.nti.org/analysis/

submarines: "Unlike diesel submarines, which need to surface every few days and carry heavy loads of liquid fuel, nuclear submarines can remain submerged for months at a time and carry several years' fuel supply on board."[13] However, the benefit derived from a given NPR depends significantly on the level of enrichment of the fissile material used to power the reactor. NPRs powered by HEU produce significantly more propulsion by fuel volume than those powered by LEU owing to the larger amount of nonfissile uranium in LEU fuel cores.[14] In the United States, the demands for longer fuel life and more powerful reactors reinforced its early decisions to use HEU.[15] In addition, the use of HEU for fuel in a naval reactor allows the construction of a smaller reactor, a paramount issue in submarine construction.

Although HEU fuel has obvious benefits over LEU fuel for naval propulsion, it comes with a risk. HEU is still an essential component of most nuclear weapons. Currently, as members of the NPT, nonnuclear weapon states (NNWS) such as Iran are monitored by the International Atomic Energy Agency (IAEA) to ensure that they do not develop weapons-grade fissile material such as HEU. However, there is a loophole. Specifically, Article II of the NPT states:

> Each non-nuclear-weapon State Party to the Treaty undertakes not to receive the transfer from any transferor whatsoever of nuclear weapons or other nuclear explosive devices or of control over such weapons or explosive devices directly, or indirectly; not to manufacture or otherwise acquire nuclear weapons or other nuclear explosive devices.[16]

By its omission, fissile material intended for use in a military reactor is understood to be precluded from the application of international safeguards and therefore "non-nuclear-weapon states are allowed to remove from IAEA safeguards nuclear material intended for non-proscribed military use."[17] Moreover, the "IAEA Safeguards Glossary" specifically notes that "there may be non-peaceful uses of nuclear material which would not be proscribed under the NPT and to which safeguards would not apply during the period of such use (e.g. nuclear propulsion of submarines or other warships)."[18] In short, the NPT does not ban a NNWS party to the NPT from either removing enriched uranium from international safeguards and accountability or enriching uranium to levels suitable for use in a nuclear weapon, so long as the country specifies that such activities are being conducted as part of a military nuclear propulsion system.

Accordingly, the NPR loophole is a significant danger to the global nonproliferation regime and the NPT by facilitating the possible development and proliferation of weapons-grade HEU, and not just in terms of Iran's nuclear program but by all NNWS as well. Similar concerns were expressed about Brazil's nuclear program after Brazilian president Luiz Inácio Lula da Silva announced in 2007 his country's plans to fund the construction of a nuclear-powered attack sub-

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articles/expanding-nuclear-propulsion-challenges/.

13. Moltz, "Closing the NPT Loophole."

14. Director of Naval Nuclear Propulsion, "Report on Use of Low Enriched Uranium in Naval Nuclear Propulsion," June 1995, http://fissilematerials.org/library/onnp95.pdf.

15. See "Appendix D: Military Reactors," in U.S. Department of Energy, *Highly Enriched Uranium: Striking a Balance*, 143, http://fissilematerials.org/library/doe01.pdf.

16. Treaty on the Non-Proliferation of Nuclear Weapons, July 1, 1968, UNTS 10485.

17. Heinonen, "Nuclear Submarine Program Surfaces in Iran."

18. International Atomic Energy Agency (IAEA), "IAEA Safeguards Glossary 2001 Edition," in *International Nuclear Verification Series*, no. 3 (Vienna: IAEA, 2002).

marine.[19] Much like Iran, Brazil's stated NPR intentions were met by overall skepticism from the international community and were perceived as a possible smokescreen for reconstituting Brazil's nuclear weapons program. Today, only four NNWS—Iran, Brazil, Argentina, and Venezuela—have expressed intent to lease or build nuclear-powered submarines.[20] However, because other countries are facing rising security demands, the interest in this technology by NNWS is only likely to increase. Moreover, the continued preferences of NWS such as the United States to utilize HEU to power their nuclear submarines only strengthen the justification by NNWS for similarly utilizing HEU propulsion to address their security demands. How, then, should the United States address this dangerous loophole, and what should U.S. policy be?

Previous arguments related to this issue have called for international initiatives such as a Nuclear Propulsion Reactor Control Regime, which would limit exports of NPRs,[21] or the adoption of the Fissile Material Cutoff Treaty (FMCT), which would specifically outlaw the production of HEU for naval reactors.[22] The former, although laudable, would do little to address the failure of the NPT to prohibit HEU production for NPRs, while the latter remains deadlocked in the Conference on Disarmament. A more practical approach would begin by implementing a policy in the United States of shifting from the current use of HEU-powered NPRs to LEU-powered NPRs within the U.S. naval fleet. Such a step would not only align with the U.S.-stated policy of seeking the reduced production and use of HEU, but could also serve as the first step toward proposing a multilateral convention prohibiting the production or use of HEU in naval propulsion reactors.[23] Trying to negotiate such a naval propulsion treaty would be a more incremental and a more plausible goal than the FMCT, and, more important, it would finally close the door on the NPR loophole. However, such a treaty is impossible when the United States, the United Kingdom, Russia, and most recently India all maintain a contingent of nuclear submarines that utilize HEU. Therefore, one of the first steps is to address this issue of HEU-powered submarines.

In fact, a 1995 U.S. Navy study investigated the idea of shifting from HEU-powered NPRs to LEU-powered NPRs.[24] At that time, a comprehensive analysis conducted by the Office of Nuclear Naval Propulsion (ONNP) posited that this shift could be achieved in one of two ways: either by adapting current naval platforms or by designing brand-new naval platforms. However, both possibilities were found wanting. Option one meant a "significant increase in life-cycle costs, far greater reactor servicing workload, [and] reduction in ship availability."[25] Option two meant that reactor core volume would have to be cubed to reach current power demands in U.S. attack submarines and to maintain mission requirements, resulting in significant costs for redesigning the U.S. nuclear fleet (see Table 2.2).

19. Hans Rühle, "Is Brazil Developing the Bomb?" *Der Spiegel*, May 7, 2010, http://www.spiegel.de/international/world/nuclear-proliferation-in-latin-america-is-brazil-developing-the-bomb-a-693336.html.

20. In 2012 India, which is not formally considered a NWS, leased an Akula class Russian submarine, which runs on 21–45 percent U-235.

21. Moltz, "Closing the NPT Loophole," 111.

22. Ma and Hippel, "Ending the Production of Highly Enriched Uranium for Naval Reactors," 98.

23. The White House Office of the Press Secretary, "Fact Sheet: Nonproliferation and Export Control Policy," September 27, 1993, http://www.fas.org/spp/starwars/offdocs/w930927.htm.

24. Director of Naval Nuclear Propulsion, "Report on Use of Low Enriched Uranium."

25. Ibid.

Table 2.2 1995 Economic Impact of LEU on Nuclear Submarine Propulsion (billions of U.S. dollars)		
	LEU cores in existing design ships	LEU life-of-the-ship cores in redesigned ships
One-time costs	$0.9	$4.00
Increase in annual costs	$1.3	$0.77

Source: Table adapted from Table 9 in Director of Naval Nuclear Propulsion, "Report on Use of Low Enriched Uranium in Naval Nuclear Propulsion," June 1995, http://fissilematerials.org/library/onnp95.pdf.

Note: "Increase in annual costs" indicates the amount the United States must pay each year in addition to funds already allocated for nuclear submarine propulsion.

In brief, shifting to LEU would either come at significant increased annual costs or would involve significant upfront engineering and design costs, which would then still require higher annual costs. Accordingly, the ONNP decided that "the use of LEU for cores in U.S. nuclear powered warships offers no technical advantage to the Navy, provides no significant non-proliferation advantage, and is detrimental from . . . cost perspectives."[26] However, it is imperative that the United States look once again at this scenario both because of the importance of restraining Iran from abusing the NPR loophole and because of recent developments related to LEU-powered submarine designs.[27]

In the first development, recent evidence has shown that French LEU-powered submarines have been able to demonstrate "more efficient operation than was assumed possible by the U.S. Navy and Department of Energy."[28] The 1995 ONNP report originally projected that effectively shifting from HEU to LEU without substantial loss of power production capability would involve an expansive redesign greatly increasing the size of the reactor and the ship. However, this assumption was based on an antiquated reactor design featuring a separated reactor and steam generator. The French have shown that, by utilizing an integrated reactor design, substantial space savings can be realized.[29] This development suggests that incorporating a similar but modified design in the Ohio-, Virginia-, or Seawolf-class U.S. nuclear-powered submarines could realize similar gains in design efficiency and could reduce projected redesign costs.

Second, there have also been advances in the designs related to reactor core life. Based on a French "caramel" fuel design, nuclear engineer Thomas Ippolito Jr. designed an LEU-fueled reactor that would double the estimate of a 10-year core life (contained in the 1995 ONNP report) to a 20-year core life.[30] Thus incorporating such a fuel design could cut the annual costs of utilizing an LEU-powered NPR by more than 50 percent, possibly saving hundreds of millions of dollars each year.

26. Ibid.
27. Thielmann, with Hoffman, "Submarine Nuclear Reactors."
28. Ibid.
29. Ma and Hippel, "Ending the Production of Highly Enriched Uranium for Naval Reactors," 95.
30. The fuel is made of flat squares of uranium-dioxide ceramic imbedded in a zirconium-alloy grid. This fuel

"meat" is covered top and bottom with thin layers of zirconium alloy. Caramel fuel is able to contain the pressure buildup from fission product gases up to a fission fraction of at least 6 percent of the total uranium. For 20 percent enriched uranium, this would correspond to fission of 30 percent of the U-235, allowing for the achievement of 20 years in refueling intervals.

These factors reveal that previous estimates of the costs of shifting from HEU-powered NPRs to LEU-powered NPRs may have overstated the actual costs. At the same time, making such a shift would still come at a cost, possibly necessitating from millions to billions of dollars in investments. Yet these costs should be understood not only in terms of the efficacy of the U.S. naval fleet but also in terms of producing greater international security. In light of this information, it is imperative that these earlier findings be revisited. To that end, Congress has asked the director of naval reactors to produce an update to the 1995 ONNP report by March 1, 2013, which should further clarify the competing cost differentials.[31]

As Gen. Robert Kehler, chief of the U.S. Strategic Command, recently emphasized, "The [U.S. "Nuclear Posture Review Report"] elevated the prevention of nuclear proliferation and nuclear terrorism to the top of the policy agenda."[32] By shifting to LEU-powered NPRs, the United States would take the first step toward contributing to the development of a "norm against the use of highly enriched uranium that would in turn reduce the likelihood that a state could utilize naval HEU production as a front for a nuclear weapons program."[33] Moreover, it would set the stage for proposing a naval propulsion treaty that could finally close the NPR loophole. This is not to say that a shift by the United States to LEU-powered NPRs would cause an automatic policy change in countries such as Russia, India, and the United Kingdom. In fact, international buy-in would likely be fraught with difficulties. However, these difficulties should be measured against the danger to the global nonproliferation regime and the NPT posed by the NPR loophole. And as Thielmann and Hoffman have suggested, a reevaluation of the current U.S. policy is crucial, now more than ever, as the United States plans future updates to its naval fleet.[34]

31. Committee on Armed Services, National Defense Authorization Act for Fiscal Year 2013, H.R. Rep. No. 112-479, pt. 328 (2012).

32. Thielmann, with Hoffman, "Submarine Nuclear Reactors."

33. Harvey, "At Sea over Naval HEU."

34. Ronald O'Rourke, "Navy Ohio Replacement (SSBN[X]) Ballistic Missile Submarine Program: Background and Issues for Congress," Congressional Research Service, October 18, 2012, http://www.fas.org/sgp/crs/weapons/R41129.pdf.

AVOIDING THE DESTABILIZING FUTURE OF CONVENTIONAL STRATEGIC WEAPONS

Matthew Fargo[1]

The United States has pledged to move nuclear weapons increasingly to the periphery of its defense posture and to amplify the role of conventional forces in their stead. The Defense Department's 2010 "Nuclear Posture Review Report" outlines the opportunity for the United States to reduce its reliance on nuclear weapons through "the growth of unrivaled U.S. conventional military capabilities."[2] This shift has been facilitated by the continuous evolution of precision-guided munitions (PGMs). Conventional prompt global strike (PGS) weapons, which would allow the United States to strike targets with greatly enhanced speed, represent the quintessential next-generation PGMs. However, the strategic consequences of developing these weapons have been overlooked by Congress. Originally conceived as a means of pursuing fleeting targets of opportunity in otherwise inaccessible terrain, expansion of the prompt global strike's role as a strategic deterrent has been misguided and has the potential to incite international instability.

The overwhelming conventional forces and increased use of PGMs by the United States have affected how great powers and putative adversaries attempt to counterbalance U.S. military developments. Other nuclear powers such as Russia and China have already reacted to advances in U.S. conventional capabilities by beginning to develop new nuclear capabilities. The governments of so-called rogue nations may be encouraged to develop military capabilities (including unconventional weapons) intimidating enough to deter outside military intervention. Consequently, the United States must consider other avenues to address these threats, such as diplomacy, and focus U.S. military advancement in areas in which there is a smaller chance of generating precarious security dilemmas. It also must answer this question: do next-generation conventional capabilities actually address a particular foe or expected conflict, or are they motivated by domestic political concerns?

A reevaluation of the investments made in prompt global strike weapons reveals significant flaws in the overly specialized and potentially destabilizing aspects of the concept. Because of the impending budgetary pressures on the U.S. military, money spent on deficient systems such as PGS reduces the resources available for programs that will better suit U.S. strategic requirements. Therefore, alternatives should address the flaws in PGS weapons, thereby not only helping stabilize global relations while continuing to improve existing systems, but also alleviating the potentially catastrophic results of mistaking the use of conventional weapons for nuclear weapons.

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2. U.S. Department of Defense, "Nuclear Posture Review Report," April 2010, http://www.defense.gov/npr/docs/2010%20nuclear%20posture%20review%20report.pdf.

Conventional Prompt Global Strike

In response to a perceived conventional capability gap, the United States launched in 2002 a program to develop a conventionally armed weapon that could strike targets anywhere in the world in about one hour—a degree of responsiveness currently achievable only with nuclear weapons. The 2006 "Quadrennial Defense Review" (QDR) provided the first explicit enumeration of the operational requirements for a prompt global strike: "[to strike] fixed, hard and deeply buried, mobile and re-locatable targets with improved accuracy."[3] In addition, it is hoped that prompt global strike technology can serve as a more credible deterrent than existing nuclear weapons against nonnuclear powers or nonstate actors, further reducing the role that nuclear weapons play in the U.S. national security strategy.[4] This mission has gained prominence because the United States must increasingly balance the competing priorities of restructuring its global military presence in the face of fiscal austerity and increasing its reliance on conventional U.S. military assets. However, the prompt global strike program is a poorly conceived and overly expensive one based on a fabricated capability requirement, and it has almost no viable applications because of the danger of accidently triggering nuclear escalation.

Some of the first concepts designed to satisfy the newly defined PGS mission involved retrofitting existing Trident II D5 submarine-launched ballistic missiles or Minuteman III intercontinental ballistic missiles (ICBMs) with conventional warheads. These converted systems were expected to be made operational by the mid-2010s. However, Congress balked at funding the Conventional Trident Modification program, citing concerns about inadvertent Russian retaliation if a PGS launch were mistaken for a nuclear first strike. During his 2006 address to the Federal Assembly of Russia, President Vladimir Putin said, "The launch of such a [conventionally-armed ballistic] missile could provoke an inappropriate response from one of the nuclear powers, could provoke a full-scale counterattack using strategic nuclear forces."[5]

Another prompt global strike concept would utilize hypersonic reentry vehicles. One such vehicle is being developed by the Force Application and Launch from Continental United States (FALCON) Project in the Defense Advanced Research Projects Agency (DARPA). Initially propelled by ballistic missiles, these weapons follow a nonballistic trajectory throughout the remainder of their flight by utilizing highly maneuverable hypersonic glide vehicles to deliver their payload to the target. Hypersonic vehicles could theoretically satisfy the promptness criterion and would be capable of penetrating sophisticated air and missile defense systems without putting U.S. military personnel at risk.

One thing a boost-glide weapon cannot do, however, is resolve ambiguity over nuclear use. At a news briefing, Gen. Martin Dempsey, chairman of the Joint Chiefs of Staff, noted that depressing the trajectory of conventional strike weapons would create no issues of discrimination between conventional and nuclear-armed ballistic missiles.[6] This assertion assumes that a potential enemy

3. U.S. Department of Defense, "Quadrennial Defense Review Report," February 6, 2006, http://www.defense.gov/qdr/report/report20060203.pdf.

4. Craig Whitlock, "U.S. Looks to Nonnuclear Weapons to Use as Deterrent," *Washington Post*, April 8, 2010, http://www.washingtonpost.com/wp-dyn/content/article/2010/04/07/AR2010040704920.html.

5. Vladimir Putin, "Annual Address to the Federal Assembly," Moscow, May 10, 2006, http://archive.kremlin.ru/eng/speeches/2006/05/10/1823_type70029type82912_105566.shtml.

6. U.S. Department of Defense, "Major Budget Decisions Briefing from the Pentagon," January 26, 2012, http://www.defense.gov/transcripts/transcript.aspx?transcriptid=4962.

trusts the United States about the types of warheads attached to different delivery vehicles. This may not be the case, however. An enemy may not be able to determine the payload of a prompt strike weapon until it strikes its target and may not even choose to acknowledge the distinction between conventional and nuclear strategic weapons. This factor could have serious ramifications if PGS weapons were used anywhere on the periphery of, let alone inside, the territory of a nation with prompt-launch weapons of its own (including nuclear weapons capable of launch-on-warning). This potentially catastrophic shortcoming has not been adequately addressed by military officials or policymakers.

Furthermore, the FALCON Project has cost taxpayers $320 million to date, and yet it has failed to perform satisfactorily in airborne proof of concept demonstrations. Repeated test failures have plagued the hypersonic test program and have significantly delayed the air force's projected deployment of these systems.[7]

Nevertheless, hypersonic reentry vehicles have remained a congressional budgetary priority for years. Congress appropriated $180 million for prompt global strike development for fiscal year (FY) 2012 alone, and the Department of Defense's FY 2011 budget estimate assessed that conventional prompt strike research and development will cost over $2 billion through FY 2015.[8] Because of the laggard progress of these programs, more than three years—and even more taxpayer dollars—will likely be required before the military can start to incorporate prompt global strike weapons into contingency plans. In view of other problems with the program and the growing pressure on the Department of Defense to spend more efficiently, one has to wonder whether continuing the program will be worth the cost.

Strategic Implications

Deploying prompt global strike weapons could lead to numerous negative consequences, including eroding the stabilizing effect of nuclear deterrence on great power relations or contributing to a growing sense of unease between the United States and rising regional powers. By limiting the role of nuclear weapons through the deployment of unmatched conventional military capabilities, the United States risks severely degrading the security environment of other nations that cannot hope to match U.S. defense spending and technology. This situation may inadvertently lead other nations to view unconventional weapons proliferation as a defense against U.S. conventional military superiority. Paradoxically, this security dilemma may spur further nuclear weapons proliferation in the twenty-first century.

Deterrence is based on understanding and influencing the intentions of one's adversaries, but to influence other decisionmakers successfully, the defender must effectively communicate his intentions.[9] Signaling those intentions, however, especially in crisis situations, is a notoriously difficult and inexact discipline. The credibility of reprisal is often determined more through the

7. Zach Rosenberg, "DARPA Loses Contact with HTV-2," *Flight Global*, August 11, 2011, http://www.flightglobal.com/news/articles/darpa-loses-contact-with-htv-2-360647/.

8. Elaine Grossman, "Pentagon's Conventional Prompt-Strike Effort Takes 2012 Funding Hit," *Global Security Newswire*, December 23, 2011, http://www.nti.org/gsn/article/pentagons-conventional-prompt-strike-effort-takes-2012-funding-hit/; U.S. Department of Defense, "Fiscal Year 2011 Budget Estimates: Research, Development, Test and Evaluation, Defense-Wide," February 2010, http://comptroller.defense.gov/defbudget/fy2011/budget_justification/pdfs/03_RDT_and_E/OSD%20RDTE_PB_2011_Volume%203B.pdf.

9. Thomas Schelling, *Arms and Influence* (New Haven, CT: Yale University Press, 1966), 35.

"persuasiveness of the message about those capabilities rather than the capabilities themselves."[10] One of the inherent difficulties in crafting a successful policy of deterrence is that it often relies on an imprecise understanding of the opposing state's security perspective. Consequently, deterrence is frequently predicated on inaccurate assumptions about the impact of deterrence policies. What a defending state may see as perfectly warranted in support of its security needs, an aggressor may view as an unacceptable deviance from the status quo.[11]

Concordantly, there is a significant risk that China and Russia will view U.S. advances in conventional weapons as a departure from, and not merely an evolution of, the status quo, and perhaps even as a deliberate effort to disrupt the balance of power. Because of the continuous application of precision-guided munitions in tactical operations over the last decade, some analysts have become concerned that U.S. PGMs could succeed in strategic counterforce operations—such as destroying nuclear missiles in their silos—where even the effectiveness of nuclear weapons has been questioned.[12]

Indeed, the destabilizing impact of other precision conventional munitions has been observed by Russian major general Vladimir Dvorkin: "The growing counterforce capability of U.S. PGMs may present a considerable threat to the survivability of Russia's strategic forces."[13] Similarly, China's People's Liberation Army has declared that a strategy of "destroying or capturing satellites and other sensors . . . will deprive an opponent of initiative on the battlefield and [make it difficult] for them to bring their precision guided weapons into full play."[14]

In an effort to reduce their vulnerability to U.S. conventional military operations, both Russia and China are developing new ballistic missile submarines and road-mobile ICBMs capable of striking the United States from their coastal waters or deep within their territories.[15] In addition, China has spent considerable effort on developing anti-satellite weapons. In 2007 China's anti-satellite missile test demonstrated that China could potentially destroy U.S. military reconnaissance satellites in low-earth orbit (altitudes of less than 1,200 miles), thereby hindering U.S. conventional capabilities, which are heavily dependent on space-based assets for precision tracking and timing.[16]

Because of the potential of anti-satellite weapons to severely disrupt the U.S. military's operational effectiveness, China (and U.S. military strategists) may view its anti-satellite capabilities as a deterrent against any direct U.S. military action. The deployment of conventional prompt global strike weapons would threaten any Chinese anti-satellite capabilities positioned far inland, and

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10. Robert Jervis, Richard Lebow, and Janice Gross Stein, *Psychology and Deterrence* (Baltimore: Johns Hopkins University Press, 1985), 125.

11. Ibid., 30.

12. Dennis Gromley. "Nuclear Disarmament and Russian Perceptions of US Conventional Superiority," *Security Challenges* 6 (Summer 2010): 83–101.

13. Vladimir Dvorkin, "Reducing Russia's Reliance on Nuclear Weapons in Security Policies," *Engaging China and Russia on Nuclear Disarmament,* ed. Cristina Hansell and William C. Potter (Monterey, CA: James Martin Center or Nonproliferation Studies, 2009), 89–102.

14. Office of the Secretary of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2011," U.S. Defense Department, http://www.defense.gov/pubs/pdfs/2011_CMPR_Final.pdf.

15. Lt. Gen. Ronald L. Burgess Jr., "Annual Threat Assessment," U.S. Defense Intelligence Agency, February 16, 2012, http://www.armed-services.senate.gov/statemnt/2012/02%20February/Burgess%2002-16-12.pdf.

16. William Broad and David Sanger. "China Tests Anti-Satellite Weapon, Unnerving U.S.," *New York Times*, January 18, 2007, http://www.nytimes.com/2007/01/18/world/asia/18cnd-china.html.

thus would continue to unnerve China. In any event, the ability to degrade or deny the United States the use of its space assets in a conflict will continue to be a primary concern for Chinese military strategists.

Determining the future role of prompt global strike weapons in a new U.S. security strategy will present policymakers with a critical dilemma. Because of the growing strategic focus on the Asia-Pacific region and the increasing concerns about the sophisticated anti-access/area-denial technologies being developed by China and other potential rivals, PGS may serve a role in destroying heavily defended targets or neutralizing defense systems so that other assets can be safely deployed in-theater. Although it is not discussed often, it is in this context that the argument in favor of developing PGS capabilities is most compelling, and it is in this limited role that PGS may offer the greatest potential against future threats. However, official recognition of this potential application would only exacerbate the dilemmas pointed out earlier.

The perceived power imbalances created by further advancements of U.S. conventional munitions may force foreign policymakers to adapt in unexpected ways. Because both Russia and China have less extensive experience with sophisticated combined arms operations, they may both miscalculate the capabilities of advanced U.S. weapon systems, thereby increasing nuclear modernization efforts in both countries—a decision likely to be interpreted as threatening by U.S. observers.

Deploying weapons whose capabilities or purpose is not entirely understood by potential adversaries threatens to disrupt the precarious strategic balance. There has been a great deal of discussion on how this shift may begin to destabilize great-power relations in the twenty-first century, but how can the United States avoid this pitfall?

Alternatives and Supporting Technologies

Fortunately, unproven and potentially destabilizing prompt global strike systems are not the only weapons on which the United States will rely in future conflicts. Unlike the currently planned prompt global strike systems, the existing precision-guided munitions such as the Tactical Tomahawk cruise missile have the ability to loiter in a target area for extended periods of time.[17] By means of their on-board infrared and electro-optical sensors, they can gather intelligence and search for and engage more significant targets as they arise, making them usable in a wide array of circumstances. Cruise missiles are also more stabilizing because they do not possess enough kinetic energy to threaten hardened silos and therefore are not suitable for a first strike against an opponent's nuclear arsenal.[18] In addition, research to develop inexpensive backup guidance systems that will ensure the operational effectiveness of existing precision-guided munitions will further reduce the utility of prompt global strike weapons.

With the conversion of four Ohio-class ballistic missile submarines to cruise missile submarines capable of carrying 154 Tomahawk cruise missiles each, the U.S. military has already developed an interim global strike capability with exceptional accuracy that can be deployed in the

17. Naval Air Systems Command, "Tomahawk," U.S. Navy, no date, http://www.navair.navy.mil/index.cfm?fuseaction=home.display&key=F4E98B0F-33F5-413B-9FAE-8B8F7C5F0766.

18. Nancy Swinford and Dean Kudlick, "A Hard and Deeply Buried Target Defeat Concept," Defense Technical Information Center, Lockheed Martin Missiles and Space, Bethesda, MD, 1996, http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA318768.

event of a crisis, although a gap remains in the theoretical case of immediate need.[19] And yet even as the United States continues to spend billions of dollars on ballistic missile defense systems, the development of cruise missile defenses has been slower to materialize. During the early stages of the Iraq War, the absence of effective cruise missile defenses proved problematic for the United States.[20] Although some progress has since been made, cruise missiles will continue to pose significant challenges to potential defenders—including the United States— for the foreseeable future. As a result, more advanced, as well as less destabilizing and less costly, cruise missiles and other precision-guided conventional munitions may limit the need for prompt global strike weapons.

Research aimed at developing inexpensive and miniature inertial guidance systems— such as DARPA's Micro-Technology for Positioning, Navigation, and Timing (Micro-PNT) program—that will allow precision-guided munitions to operate reliably even in contested environments will be one critical component of this endeavor. By allowing U.S. PGMs to continue to function even without satellite or other external support, Micro-PNT could actually contribute to deterrence by denying a putative enemy any advantage bestowed by disabling or destroying U.S. space assets—a move that otherwise could compromise U.S. operational effectiveness and would risk significant conflict escalation. In addition, more research and development should be concentrated on creating network exploitation programs and electronic warfare that can breach an adversary's network communications, gather data from enemy sensors, and even disable parts of an enemy's integrated sensor network. Both of these technologies will allow the United States to better approach anti-access/area-denial environments, but unlike PGS, they can be developed and operationalized without potentially threatening strategic stability.

Finally, the United States would also benefit from expanding confidence-building measures with both Russia and China. Increased dialogue and contact between middle- and top-level military officers, politicians, and diplomats will help both sides better understand one another's trends and technologies. Joint military exercises can give field commanders a more definite idea of what the U.S. military can (and cannot) do, while top-level military dialogue at forums such as U.S. Central Command's annual Chiefs of Defense Conference can help to guide policy and promote mutual understanding and, where possible, cooperation. Improving these mechanisms further will help the United States gradually acclimatize Russia and China to the trends in U.S. strategy. Moreover, establishing lines of communication now may help in the event of a crisis by limiting the possibility for misinterpretation and miscalculation. Programmatic engagement on these issues should continue to underpin U.S. bilateral relationships.

Conclusion

Prompt global strike programs, including DARPA's FALCON, should be terminated at the end of FY 2013. More attention should be focused on other key technologies that would better prepare and equip the U.S. military for future engagements, including those in anti-access/area-denial environments.

19. One case of immediate need is the oft-cited example of a high-level terrorist meeting in a remote location that will disperse before other conventional capabilities can be brought to bear.

20. Wade Boese, "Army Report Details Patriot Record in Iraq War," *Arms Control Today*, November 2003, http://www.armscontrol.org/act/2003_11/Patriotmissile.

Although nuclear weapons continue to underpin U.S. strategic deterrence, the United States has begun to rely more on the strength of its conventional forces to dissuade and deter potential foes. If this trend persists, the shift toward increased use of precision-guided munitions will continue in the near term. Therefore, at a time in which the U.S. military is being forced to operate within a contracting budgetary environment, military strategists and Congress will have to agree on designing and funding systems that will be more adaptable and more effective. An overly specialized or potentially destabilizing system such as the prompt global strike does not satisfy these requirements. Bilateral engagement with key regional actors is far less expensive and would do more to enhance global security and stability.

EXAMINING EXTENDED DETERRENCE PRACTICES ON THE KOREAN PENINSULA

David Slungaard[1]

As the United States moves to embrace its "pivot to Asia,"[2] continued insecurity on the Korean peninsula raises important questions about the ability of Washington to guarantee its extended deterrence commitments. Provocations by North Korea (Democratic People's Republic of Korea, DPRK), including the attack in 2010 on the ROKS *Cheonan* naval vessel, the 2010 shelling of South Korea's Yeonpyeong Island, and the controversial 2012 launch of the Unha-3 rocket, have forced policymakers to reexamine U.S. regional deterrence strategies for protecting and reassuring its ally South Korea (Republic of Korea, ROK).

Recent public debates within South Korea and the United States have scrutinized the extended role of U.S. nuclear forces—the nuclear umbrella—as a guarantor of security on the peninsula. With the introduction of an amendment to the fiscal year (FY) 2013 National Defense Authorization Act, the House Armed Services Committee signaled its intent to reopen discussions over the reinstallation of forward-deployed nuclear weapons in South Korea.[3] Although they are unlikely to gain support within either government, calls for reinstalling tactical nuclear weapons emphasize the growing tension between the need to reassure U.S. allies and the Obama administration's "vision of a world free of nuclear weapons."[4] In the case of South Korea, failure to reassure may

1. David Slungaard is a research analyst at the Elliott School of International Affairs, George Washington University.

2. White House Office of the Press Secretary, "Remarks by President Obama to the Australian Parliament," November 17, 2011. New strategies focused on a "pivot" of U.S. forces, including capabilities related to extended nuclear deterrence, may have serious implications for regional strategic stability and security arrangements with key allies dependent on the U.S. nuclear commitment. Official statements addressing a "rebalancing" of the current U.S. military and political orientation to the Asia-Pacific region are outlined in U.S. Department of Defense, "Sustaining Global Leadership: Priorities for 21st Century Defense," January 2012, http://www.defense.gov/news/Defense_Strategic_Guidance.pdf.

3. House Armed Services Committee, Amendment to H.R. 4310, 112th Cong., 2d sess., May 2, 2012, http://www.foreignpolicy.com/files/fp_uploaded_documents/120510_amd_report_DPRK_xml.pdf. The amendment requests "a report on deploying additional conventional and nuclear forces to the Western Pacific region . . . including a forward-deployed nuclear capability." Support for the redeployment of U.S. nuclear weapons has also found traction with several high-ranking South Korean officials concerned about an increasingly "provocative" North Korea. See Kim Young-jin, "Chung Calls for Nuke Redeployment," *Korea Times*, May 11, 2012, http://www.koreatimes.co.kr/www/news/nation/2012/05/116_110815.html.

4. White House Office of the Press Secretary, "Remarks by President Barack Obama" (speech, Prague, April 5, 2009), http://www.whitehouse.gov/the_press_office/Remarks-By-President-Barack-Obama-In-Prague-As-Delivered. This call to review extended deterrence practices highlights the assumed role of U.S. strategic systems in underwriting regional security commitments. Moreover, the discussion reveals a fundamental yet avoidable contradiction in the relationship between the United States and states dependent on U.S. extended deterrence commitments, particularly where long-term global strategies to reduce the role

compel Seoul to pursue an independent nuclear weapons capability—a development that could endanger strategic stability within the region, as well as undermine global nonproliferation norms.

Thus squaring this circle—strengthening extended deterrence commitments while reducing the salience of U.S. nuclear forces—will require Seoul and Washington to emphasize a broader spectrum of conventional and nonmilitary capabilities. This shift will necessitate moving traditional deterrence strategies away from Cold War–era models to more tailored approaches that build bilateral credibility around U.S. extended deterrence commitments. By reducing its reliance on explicitly nuclear capabilities, the United States can leverage the necessary political tools to ensure safety and security on the Korean peninsula, while moving toward lower numbers of nuclear weapons in the future.

Perceptions and Extended Deterrence

Extended deterrence involves "a confrontation in which the policymakers of one state . . . threaten the use of force against another state . . . in an attempt to prevent that state from using military force against an ally."[5] A critical component of this strategy rests on credibility—a twofold function that deters external aggression while, simultaneously, assuring allies. To that end, the aggregate functions of the extended deterrence provision rest on the perceptions of both the protected state and the potential aggressors, and demonstrate a relative relationship to the explicit capabilities of the protecting state.[6]

Linton Brooks observes:

> The potential aggressor must be sufficiently convinced that the United States has both the capability and the will to act so as to make aggression not worth the risk. Similarly, the target of assurance is the ally under the umbrella . . . [and] the state under the umbrella must be sufficiently convinced that the United States has both the capability and the will to act so as to (a) resist intimidation and (b) not seek nuclear capabilities of its own if it has the ability to do so.[7]

Although it is conceptually useful, some scholars have noted that a working definition of extended nuclear deterrence omits several factors critical to its applied practice. Particularly valuable cases have been junctures at which extended deterrence was perceived to fail to protect client states from aggression. Provocations by North Korea—low-level conventional violence, nuclear weapons development and testing, and ballistic missile production—provide several examples of instances in which the U.S. security guarantee fell short in protecting Seoul.[8] However, confirming

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and number of nuclear weapons may undermine the credibility of U.S. security guarantees to protect against external aggression. See Scott Snyder, "Finding a Balance between Assurances and Abolition," *Nonproliferation Review* (March 2011): 147.

5. Paul K. Huth, "Extended Deterrence and the Outbreak of War," *American Political Science Review* 82 (June 1988): 424.

6. Clark A. Murdock et al., *Exploring the Nuclear Posture Implications of Extended Deterrence and Assurance: Workshop Proceedings and Takeaways* (Washington, DC: Center for Strategic and International Studies, 2009), 10–11.

7. Ibid., 11.

8. For analyses of the perceived limitations of nuclear deterrence and U.S. extended nuclear deterrence, see Li Bin and He Yun, "Credible Limitations: US Extended Nuclear Deterrence and Stability in Northeast

the real efficacy of extended deterrence on the Korean peninsula remains difficult. U.S. and ROK officials place great importance on the role of U.S. nuclear forces in influencing Seoul's strategic behavior and security calculations.[9] As Andrew O'Neil observes, the U.S. nuclear umbrella exerts "a strong set of influences over states' strategic behaviour, both in negative terms (deterring adversaries) and positive terms (reassuring allies) . . . [and] plays a significant role in shaping states' security calculations in both negative and positive terms."[10] Indeed, state perceptions of the robustness of extended deterrence commitments have influenced decisions on major strategic policies, including the pursuit of indigenous nuclear weapons programs.[11]

Thus the total value of U.S. extended deterrence rests on the perceptions of the client state, as well as the capabilities assigned to the protecting mission. Rather than declining in strategic relevance as Washington reduces its reliance on nuclear weapons, U.S. extended deterrence commitments are likely to continue to play a major role in deterring aggression and reassuring key allies.[12] However, the degree and importance attached to the nuclear umbrella will depend on how the United States communicates its evolving strategic posture to its South Korean ally. Just as important for both governments is the ability to access existing political channels and capabilities without fundamentally altering their security alliance.

Extended Deterrence and the U.S.-ROK Alliance

One of several elements of the U.S.-ROK alliance, the provision of extended deterrence to South Korea, is a key pillar of the U.S. security commitment. The U.S. nuclear umbrella, combined with bilateral security agreements and the integrated operation of both militaries, plays a fundamental role in maintaining U.S. credibility and South Korea's confidence. Indeed, the governments of both states rely on official statements to confirm the essential role of U.S. nuclear forces in the U.S.-ROK partnership.[13] However, the true nature of the security relationship extends beyond strategic capabilities. Repeated requests from Seoul for bolstered assurances in the wake of North Korean provocations demonstrate that strong political commitments serve as the lynchpin of the security alliance.

Bilateral efforts to better coordinate defense policies are institutionalized in the annual Security Consultative Meetings (SMCs). Explicitly outlining the extension of the nuclear umbrella in

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Asia," in *Disarming Doubt,* ed. Rory Medcalf and Fiona Cunningham (Woollhara, Australia: Lowy Institute for International Policy, 2012); Brig. Gen. Kim Seung Taek, "Rethinking Extended Deterrence," Center for Strategic and International Studies, Washington, DC, July 2, 2010, http://csis.org/files/publication/100702_Rethinking_Extended_Deterrence-english.pdf; Ward Wilson, "The Myth of Nuclear Deterrence," *Nonproliferation Review* 15 (November 2008): 421–39.

9. Kim, "Rethinking," 1–2; Andrew O'Neil, "Extended Nuclear Deterrence in East Asia: Redundant or Resurgent?" *International Affairs* 87 (November 2011): 1448.

10. O'Neil, "Extended Nuclear Deterrence," 1448.

11. Persistent anxieties over the strength of the U.S. commitment to protect against aggression from Pyongyang was a strong determinant in the development of a clandestine nuclear weapons program. See Rebecca K. C. Hersman and Robert Peters, "Nuclear U-Turns: Learning from South Korean and Taiwanese Rollback," *Nonproliferation Review* 13 (November 2006): 540–43.

12. O'Neil, "Extended Nuclear Deterrence," 1455.

13. Michael H. Keifer, Kurt Guthe, and Thomas Scheber, "Assuring South Korea and Japan as the Role and Number of U.S. Nuclear Weapons Are Reduced," Defense Threat Reduction Agency, January 2011, 12–14, http://www.nipp.org/Publication/Downloads/Downloads%202012/2011%20003%20Assuring%20ROK%20and%20Japan.pdf.

1978,[14] the SMCs and related joint planning sessions have been the vehicle through which U.S. officials have confirmed the role of U.S. nuclear forces in underwriting the U.S. extended deterrent. Over time, meetings have continued to reiterate this commitment, especially during periods of instability on the peninsula. For example, North Korea's October 2006 nuclear test prompted South Korean officials to demand "a change in the formulation of the U.S. nuclear guarantee" as reflected in the communiqués of the SMCs.[15] The resulting language of the 2006 U.S.-ROK Security Consultative Meeting communiqué was thus revised to explicitly address the U.S. extended deterrence policy: "The United States reaffirms the firm commitment to the Republic of Korea, including continuation of the extended deterrence offered by the U.S. nuclear umbrella."[16]

Official reiterations of the U.S. nuclear guarantee were rolled out again after North Korea's second nuclear test in 2009 and later in 2011: "[The alliance] will maintain a robust defense posture, backed by allied capabilities which support . . . [the] continuing commitment of extended deterrence, including the U.S. nuclear umbrella."[17] Additional efforts to move the consultative process forward, including the U.S.-ROK Security Policy Initiative (SPI) and the ROK-U.S. Extended Deterrence Policy Committee (EDPC), have helped to optimize the formulation and implementation of extended deterrence practices.[18] Today, the U.S.-ROK strategic bilateral process continues to function as a principal channel in confirming the commitment of U.S. nuclear capabilities to the defense of South Korea.

Overall, Seoul's requests for assurance emphasize the critical role that U.S. political commitments play in the U.S.-ROK alliance. Although the nuclear capabilities for extended deterrence are significant, the credibility surrounding the strength of security commitments is central to the security relationship. The committed support of this robust bilateral security architecture offers promise for the prospects of positive reassurance should the United States reduce the size of its nuclear arsenal in the future.

Aligning Objectives, Assuring Commitments

The trends and key relationships developed through U.S. extended deterrence commitments provide important reassurances to regional allies. For South Korea, the elevated role of extended deterrence commitments illustrates the complex relationship between U.S. strategic capabilities and the credible assurance of security commitments. However, developing confidence-building measures to reinforce the credibility of the U.S. nuclear guarantee requires close policy coordination on short- and long-term engagement strategies.

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14. Joint Communiqué of the 38th ROK-U.S. Security Consultative Meeting, October 20, 2006, http://www.defense.gov/news/Oct2006/d20061020uskorea.pdf.

15. Keith Payne, Thomas Scheber, and Kurt Guthe, *U.S. Extended Deterrence and Assurance for Allies in Northeast Asia* (Fairfax, VA: National Institute Press, 2010), 7.

16. Joint Communiqué.

17. Barack Obama and Lee Myung-bak, "Joint Vision for the Alliance of the United States of America and the Republic of Korea," White House Office of the Press Secretary, June 16, 2009, http://www.whitehouse.gov/the_press_office/Joint-vision-for-the-alliance-of-the-United-States-of-America-and-the-Republic-of-Korea.

18. Choi He-suk, "S. Korea, US to Form Nuke Attack Contingency Plan," *Asian News Network*, April 30, 2012, http://www.asianewsnet.net/home/news.php?id=30067.

It is likely that shifts in U.S. strategic planning will have significant consequences for Seoul's security calculations. The administration's 2010 "Nuclear Posture Review Report" (NPR) outlines substantive changes to the current U.S. nuclear weapons policies, committing to reducing the role and number of nuclear forces, while pursuing a long-term "global zero" strategy.[19] A move away from nuclear forces would likely necessitate the development of conventional and nonkinetic platforms.[20] In addition, the 2010 NPR emphasizes the importance of niche capabilities such as the conventional prompt global strike (CPGS) and ballistic missile defense systems as part of the U.S. extended deterrence package.[21] This shift in the configuration of extended deterrence raises important concerns about whether new conventional capabilities can be tailored to assure allies such as South Korea.

In addressing these issues, the United States will need to assure South Korea of Washington's security commitments even as the number of its nuclear forces is being reduced and their role de-emphasized. The nonproliferation goals stated in the 2010 NPR are, however, not easily reconciled with the increasing importance Seoul has placed on U.S. nuclear capabilities. Changes to the current security environment on the Korean peninsula, through either another nuclear test or another ballistic missile test,[22] may further challenge the credibility of U.S. security commitments, particularly as further nuclear weapons reductions are realized.[23]

Optimizing Extended Deterrence Requirements

Answering the question of how conventional systems, bilateral assurances, and existing deployments supplement the credible provision of extended deterrence will be a critical next step for South Korea and the United States. The importance of the nuclear umbrella in reassuring Seoul of the extended U.S. security commitment cannot be diminished. Washington must assure South Korea that engagement tactics can continue to provide the necessary mix of capabilities to protect regional allies, while reducing the role of strategic weapons. Shifting deterrence strategies away from nuclear platforms must maintain U.S. credibility and continue to facilitate the high-level bilateral security exchanges that underpin the U.S.-ROK alliance. It is important to recognize that reassurance can be readily achieved through the existing bilateral forums to include conventional capabilities already outlined in the administration's 2010 NPR.

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19. U.S. Department of Defense, "Nuclear Posture Review Report," April 6, 2010, http://www.defense.gov/npr/docs/2010%20nuclear%20posture%20review%20report.pdf.

20. Hyun-Wook Kim, "US Extended Deterrence and the Korean Peninsula," in *Disarming Doubt*, ed. Rory Medcalf and Fiona Cunningham (Woollhara, Australia: Lowy Institute for International Policy, 2012) , 74.

21. Ibid., 24, 33.

22. North Korea's successful launch in 2012 of a weather satellite into orbit prompted international condemnation of Pyongyang's violation of a UN Security Council ban on the development of ballistic missile technology. Early official reactions from Seoul and Washington called for tightening existing sanctions, as well as enhancing a regional security presence to include "increased patrols in waters . . . along with military exercises with allies in the region." See David E. Sanger and William J. Broad, "After Rocket Launching, a Call for New Sanctions," *New York Times*, December 12, 2012, http://www.nytimes.com/2012/12/13/world/asia/north-korea-rocket-launching.html?pagewanted=all.

23. Richard C. Bush III, "The U.S. Policy of Extended Deterrence in East Asia: History, Current Views, and Implications," *Foreign Policy at Brookings Arms Control Series* 5 (February 2011): 8.

Closer policy cooperation can be accomplished through the channels already devoted to coordinating bilateral deterrence strategy. Both the SPI and the EDPC are positioned to assist policymakers in the design and implementation of tailored extended deterrence strategies. According to a ROK Defense Ministry official, the EDPC operates as "a permanent binational cooperative body . . . periodically evaluating the situation and establishing measures, formulating concrete plans to enhance the effectiveness of extended deterrence." [24] This specialized format allows officials and policymakers to address potential changes in the security environment, while collaborating on specific U.S.-led threat response scenarios. Semiannual consultations also enable the governments to discuss and forge understanding of changes to the U.S. strategic doctrine. These consultations will increase in importance as nuclear capabilities and their delivery systems are reduced or eliminated.

The U.S.-ROK strategic bilateral process is also ideally suited for integrating conventional platforms into the shared deterrence package. In line with the administration's 2010 NPR, "strengthening the non-nuclear elements of regional security architectures" remains a critical objective in the pursuit of "global zero."[25] Recent advances in conventional munitions have dramatically improved the strike capabilities available to the United States. Precision conventional weapons, including technologies such as the CPGS, may provide viable options to nuclear strikes, while holding hardened and widely dispersed targets at risk.[26] A shift in the configuration of extended deterrence to conventional weapons must balance regional perceptions and emphasize its importance as a nonnuclear alternative.

Conclusion

As both the secretary of defense and the secretary of state prepare reports on the feasibility of redeploying tactical nuclear weapons to the Korean peninsula, attention should be given to addressing extended deterrence relationships and perceptions. Jeffrey Lewis notes that the Senate might commission a broader study on how to strengthen extended deterrence commitments, with an emphasis on providing the maximum amount of reassurance from existing capabilities.[27] Such a study could also focus efforts to better leverage strategic bilateral forums with South Korea and its regional allies. In preparation for this change, the United States should emphasize the importance of its political commitment to the security of South Korea and downplay the significance of any particular weapons system (e.g., nuclear weapons) in affirming this commitment. This line of action would allow governments to perform need-based assessments for extended deterrence requirements, including options to optimize nonnuclear extended deterrence capabilities as part of the administration's goal to limit the role and number of U.S. nuclear weapons.

24. Kwon Hyuk-chul, "S. Korea–U.S. to Organize a Joint Nuclear Committee for Extending Nuclear Deterrence," *Hankyoreh*, October 9, 2010, http://english.hani.co.kr/arti/english_edition/e_northkorea/443035.html?utm_source=twitterfeed&utm_medium=twitter.

25. U.S. Department of Defense, "Nuclear Posture Review Report," 33–34.

26. Amy F. Woolf, "Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues," Congressional Research Service, July 6, 2012, http://www.fas.org/sgp/crs/nuke/R41464.pdf.

27. Jeffrey Lewis, "Extending Deterrence from the Triad," *Arms Control Wonk*, May 12, 2012, http://lewis.armscontrolwonk.com/archive/5224/extending-deterrence-from-the-triad.

REACHING AN AGREEMENT ON SOUTH KOREAN PYROPROCESSING

Sarah Weiner[1]

Since the 1950s, the United States and South Korea (Republic of Korea, ROK) have cooperated on the development of civilian nuclear power. South Korea's nuclear power program now supplies roughly one-third of the country's electricity and has grown large enough for the country to venture into the global nuclear export market.[2] However, as South Korea's nuclear power industry has grown, so has its desire for "peaceful nuclear sovereignty," including acquisition of domestic reprocessing abilities. The current U.S.-ROK nuclear sharing agreement limits the country's ability to reprocess U.S.-origin fuel. However, the upcoming expiration of the treaty in 2014 has sparked a series of heated negotiations over South Korea's desire to close the fuel cycle. The United States is apprehensive about a South Korean reprocessing capability, especially its proliferation potential and possible impact on negotiations with North Korea (Democratic People's Republic of Korea, DPRK). South Korea, on the other hand, desperately needs to find a solution to its nuclear waste problem and resents its exclusion from the U.S. short list of countries trusted with reprocessing capabilities. Bilateral discussions between the United States and the ROK paused in late September, in the run-up to the U.S. and South Korean presidential elections, without reaching a resolution on the reprocessing issue.[3] The tension between the U.S. and South Korean negotiating positions will only grow more pressing as expiration of the current pact nears.

The United States should grant South Korea permission to engage in pyroprocessing, a specialized reprocessing technique. To support this contention, this article begins by outlining the contours of the current nuclear sharing agreement between Washington and Seoul and then discusses each country's stake in the negotiations, as well as U.S. concerns and South Korea's motivations. It then argues that the United States' anxiety is largely misplaced. Granting South Korea the right to pyroprocess would not appreciably hurt nonproliferation efforts, as the United States fears. It would, however, give Washington an opportunity to placate a close ally, while reinforcing the access of U.S. nuclear power companies to the South Korean market.

1. Sarah Weiner is a research intern for the Project on Nuclear Issues at the Center for Strategic and International Studies.

2. World Nuclear Association, "Nuclear Power in South Korea," September 2012, http://www.world-nuclear.org/info/inf81.html.

3. Daniel Horner, "S. Korea, U.S. at Odds over Nuclear Pact," *Arms Control Today*, September 2012, http://armscontrol.org/act/2012_09/Sout-Korea-US-at-Odds-Over-Nuclear-Pact.

The Current Nuclear Deal

The United States began supporting South Korea's interest in nuclear power through President Dwight Eisenhower's Atoms for Peace program in the 1950s, but Seoul's program did not begin in earnest until the 1970s.[4] Under the authority of a 1972 nuclear sharing agreement with the United States, South Korea purchased a turnkey nuclear reactor from Westinghouse, and the American company completed construction of the ROK's first plant in 1978.[5] South Korea slowly began to indigenize nuclear power, taking over construction of power plants by its fourth facility, completed in 1985, and serving as a joint partner in reactor and generator supply by its tenth plant, completed in 1995.[6] Except for a few Canada deuterium uranium reactors, most reactors in South Korea's fleet are light water reactors based on a U.S. design.[7] Currently, 23 nuclear reactors are operating in South Korea, and nine more are planned or under construction.[8] The South Korean government hopes to provide almost 60 percent of this resource-poor nation's electricity from nuclear power by 2030.[9]

At the same time that foreign nationals were constructing South Korea's first reactor in the early 1970s, South Korean president Park Chung-hee was embarking on a program to acquire reprocessing capabilities and eventually nuclear weapons.[10] President Park's motivations were certainly complex, but many analysts, including Joseph Cirincione, have pointed out that Park's decision followed three major U.S. policy shifts: the announcement in 1969 of the Nixon Doctrine, outlining the U.S. position that its allies would need to become more responsible for their own security; the removal of a U.S. military division from the thirty-eighth parallel in 1971; and President Richard Nixon's visit to China in 1972. Making it clear that a South Korean nuclear weapons program was unacceptable to the United States, Washington threatened to withdraw U.S. security guarantees if South Korea did not quash its budding nuclear ambitions.[11] Relenting, South Korea signed a modified nuclear sharing agreement with the United States in 1974 and ratified the Nuclear Non-Proliferation Treaty (NPT) in 1975.[12] The United States and South Korea replayed the same drama in 1977 when President Jimmy Carter proposed removing U.S. ground troops from South Korea. President Park threatened to restart South Korea's nuclear weapons program and entered into talks with France to acquire a reprocessing facility, but President Carter intervened to stop the deal and promised to leave U.S. forces in South Korea.[13]

4. Nuclear Threat Initiative, "South Korea," August 2012, http://www.nti.org/country-profiles/south-korea/.

5. Mark Holt, "U.S. and South Korean Cooperation in the World Nuclear Energy Market: Major Policy Considerations," Congressional Research Service, January 21, 2010, 2–3, http://www.fas.org/sgp/crs/row/R41032.pdf.

6. Ibid., 3.

7. World Nuclear Association, "Nuclear Power in South Korea."

8. Ibid.

9. Ibid.

10. Chen Kane, Stephanie C. Lieggi, and Miles A. Pomper, "Time for Leadership: South Korea and Nuclear Nonproliferation," *Arms Control Today*, March 2011, http://www.armscontrol.org/act/2011_03/SouthKorea.

11. Ibid.

12. Ibid.

13. Ibid.

The 1974 ROK-U.S. Atomic Energy Agreement, crafted during these tense times, governed all U.S. nuclear sharing with South Korea during its subsequent boom in nuclear power production. The agreement is one of dozens of so-called 123 Agreements, named for the section of the U.S. Atomic Energy Act that mandates the formation of such pacts before the transfer of any nuclear technology from the United States to other countries.[14] These agreements are intended to create a market for the export of peaceful U.S. nuclear technology, while minimizing the probability that this technology will provide potential proliferators with the expertise or technology needed to develop a nuclear weapon.

Although the nonproliferation goals of 123 Agreements are universal, their content is not. One critical difference revolves around reprocessing—a class of techniques that separates fissionable material from waste products in spent nuclear fuel. The resultant plutonium or uranium can be fed back into a nuclear reactor or, if a country has more nefarious intentions, can be used as fuel for a nuclear bomb.[15] As a general rule, the United States bans countries from reprocessing U.S.-origin fuel, although Japan, India, and the member countries of the European Atomic Energy Community have received exemptions from this standard.[16]

The current South Korean reprocessing controversy centers on a technique called pyroprocessing. Pyroprocessing, like other reprocessing methods, could be used to turn waste from nuclear reactors into usable fuel. But unlike other reprocessing techniques, pyroprocessing does not produce pure plutonium; instead, the process leaves plutonium combined in a reactor-usable mixture with uranium and other transuranic elements.[17] South Korea has been discussing the pyroprocessing issue with the United States for several years, recently embarking on a shared decade-long study to investigate its proliferation risks and potential verification measures.[18] The United States, however, remains skeptical and has unequivocally stated that it considers pyroprocessing to be a form of reprocessing and therefore outside the bounds of the current U.S.-ROK agreement.[19] Technically, South Korea could pyroprocess non-U.S. origin material, but such a move without U.S. consent would significantly strain the bilateral relationship, especially considering existing accounting disagreements over precisely how much of South Korea's spent fuel originated in the United States.[20] Further complicating matters, the current cooperation agreement with South Korea was crafted before passage of the U.S. Nuclear Non-Proliferation Act (NNPA) in 1978. The NNPA expanded the scope of the United States' "right to consent" from U.S.-origin *material* to any material from a U.S.-origin *reactor*.[21] If South Korea is not given consent to pyroprocess in new negotiations, then this new definition of "U.S.-origin" nuclear material will prohibit reprocessing of the great majority of spent fuel in South Korea.

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14. Paul K. Kerr and Mary Beth Nikitin, "Nuclear Cooperation with Other Countries: A Primer," Congressional Research Service, June 19, 2012, 1–2, http://www.fas.org/sgp/crs/nuke/RS22937.pdf.

15. Choe Sang-Hun, "U.S. Wary of South Korea's Plan to Reuse Nuclear Fuel," *New York Times*, July 13, 2010, http://www.nytimes.com/2010/07/14/world/asia/14seoul.html.

16. Daniel Horner, "India, U.S. Agree on Terms for Reprocessing," *Arms Control Today*, May 2010, http://www.armscontrol.org/act/2010_05/US-IndiaReprocessing.

17. Kane, Lieggi, and Pomper, "Time for Leadership."

18. "South Korea, U.S. Plan 10-Year Reprocessing Study," *Global Security Newswire*, January 14, 2011, http://www.nti.org/gsn/article/south-korea-us-plan-10-year-reprocessing-study/.

19. "U.S. Sees Pyroprocessing as Nuclear Fuel Reprocessing: Official," *Global Security Newswire*, April 5, 2011, http://www.nti.org/gsn/article/us-sees-pyroprocessing-as-nuclear-fuel-reprocessing-official/.

20. Chen Kane, "Nonproliferation Issues in U.S.-ROK Nuclear Cooperation," Asia Foundation, San Francisco, January 20, 2010, 4–5, http://asiafoundation.org/resources/pdfs/ChenKane100120.pdf.

21. Seongho Sheen, "Nuclear Sovereignty versus Nuclear Security: Renewing the ROK-U.S. Atomic Energy Agreement," *Korean Journal of Defense Analysis* 23 (June 2011): 278.

U.S. Objections

The United States has long resisted calls from South Korean leaders for the right to reprocess. U.S. hesitation centers on the proliferation risks posed by reprocessing, although this objection has several layers. Three primary areas of concern have been raised about South Korean reprocessing: South Korean proliferation, North Korean denuclearization, and global nonproliferation norms.

South Korean proliferation. The most obvious proliferation risk posed by reprocessing lies in the fuel itself. Many in the United States worry that a South Korean pyroprocessing capability would give the country the material and technical know-how it needs to build a nuclear weapon. This fear is not groundless; South Korea has already twice displayed its willingness to begin—or at least threaten to begin—a nuclear weapons program. And Seoul's recent nonproliferation record is not spotless. In 2004 International Atomic Energy Agency (IAEA) inspectors discovered that South Korean scientists had engaged in several plutonium separation and uranium enrichment experiments.[22] The South Korean government stated that these scientists had acted without authorization from the government, and Seoul implemented a series of oversight reforms to correct the problem.[23] Still, many argue that this incident indicates that the South Korean nuclear establishment cannot yet be trusted with the temptation of reprocessing technology.

Further disagreement exists over the proliferation risk posed by the pyroprocessing technique itself. South Korean advocates have argued that pyroprocessing is much more proliferation-resistant than traditional reprocessing techniques because the resultant plutonium remains mixed with other materials.[24] Skeptics in the United States reply that pyroprocessing is different in degree but not kind; the technical skills acquired from pyroprocessing could easily be used in pursuit of weapons-grade fuel if scientists decided to take the process a step further.[25] Some even argue that pyroprocessing is *worse* than traditional reprocessing because it involves working with metallic plutonium, the same form used in nuclear weapons.[26]

North Korean denuclearization. The second proliferation concern raised by South Korean pyroprocessing is North Korea. South Korea and North Korea signed the Joint Declaration of South and North Korea on the Denuclearization of the Korean Peninsula in 1992, pledging to forgo reprocessing and enrichment capabilities.[27] Quite clearly, North Korea has violated the pact, but many in the United States hope to use the agreement as the basis for denuclearization negotiations with Pyongyang and the other members of the Six-Party Talks.[28] If a deal were to be struck with North Korea, Pyongyang's relinquishment of the right to reprocess may be a crucial step in producing a sustainable, verifiable bargain. North Korea is unlikely to agree to these terms, however, if South Korea retains the ability to reprocess its nuclear fuel.

Global nonproliferation norms. Finally, some argue that allowing South Korea to reprocess represents a backward step on the road to strict proliferation controls. Having established the gold standard for 123 Agreements with the United Arab Emirates (UAE), President Barack Obama may

22. Kane, Lieggi, and Pomper, "Time for Leadership."
23. Ibid.
24. Sheen, "Nuclear Sovereignty versus Nuclear Security," 280.
25. Kane, "Nonproliferation Issues," 4.
26. Ibid.
27. Kane, Lieggi, and Pomper, "Time for Leadership."
28. Sheen, "Nuclear Sovereignty versus Nuclear Security," 282.

have an opportunity to set a new national and international standard for nuclear sharing.[29] Allowing South Korea to reprocess its nuclear fuel, these observers argue, would undermine the potential new precedent.

South Korea's Motivations

Is South Korea pursuing pyroprocessing with an eye toward developing nascent breakout potential, or does it have other intentions? Three broad motivations could explain South Korea's request: the need to better manage nuclear waste disposal, the desire to count among the nuclear power elite, and, the least likely, the intention to develop the capabilities to build a bomb.

Better manage nuclear waste disposal. South Korea's logistical motivations are clear: it has too much nuclear waste and nowhere to put it. South Korea currently possesses over 10,000 tons of spent fuel.[30] And as the government attempts to ramp up nuclear power production, existing plants are finding it more and more difficult to dispose of their waste. Several plants have reported that their waste will exceed their storage capacity by the end of the decade, with the first facility projected to run out of room as early as 2016.[31] Worse yet, scientists say that a "geologic repository" is an unworkable solution for such a small and densely populated country.[32] Reprocessing spent fuel would allow South Korea to reduce the amount of nuclear waste requiring permanent storage.[33]

Count among the nuclear power elite. South Korea's second motivation is less tangible but perhaps no less important to some of South Korea's politicians and nuclear scientists. To many, U.S. reprocessing restrictions represent a fundamental inequality in the U.S.-ROK relationship. The United States creates restrictions, and South Korea is expected to follow them. Tired of accepting the unilateral dictates of U.S. nonproliferation policy, some in South Korea have begun advocating for the pursuit of "peaceful nuclear sovereignty" to improve domestic energy security and reduce reliance on the United States.[34] Adding insult to injury, South Koreans have not failed to notice inconsistencies in the U.S. policy that allow other close U.S. allies to reprocess their fuel. If the standard for receiving reprocessing rights is being a trusted and important U.S. ally, then South Koreans can only conclude that they are either unimportant or untrusted. Either way, many resent the insinuation that the nation is not yet responsible enough to reprocess nuclear fuel from its growing fleet of reactors.[35] Lee Byong-chul, senior fellow at the Institute for Peace and Cooperation in Seoul, wrote recently that the "[South Korean] mainstream is beginning to doubt whether the set of policies, institutions and norms recommended to South Korea is the agenda that was

29. April Yee, "UAE Presses the Case for Nuclear Gold Standard," *The National*, April 19, 2012, http://www.thenational.ae/business/energy/uae-presses-the-case-for-nuclear-gold-standard.

30. Dan Yurman, "Revisiting Reprocessing in South Korea," *ANS Nuclear Café*, August 2, 2012, http://ansnuclearcafe.org/2012/08/02/revisiting-reprocessing-in-south-korea/.

31. Frank N. von Hippel, "Korean Reprocessing: An Unnecessary Threat to the Nonproliferation Regime," *Arms Control Today*, March 2010, http://www.armscontrol.org/act/2010_03/VonHippel.

32. Yurman, "Revisiting Reprocessing in South Korea."

33. Sheen, "Nuclear Sovereignty versus Nuclear Security," 276.

34. Jong Kun Choi, "Domestic Debates and Assessment of Extended Deterrence in South Korea: A South Korean Perspective," April 10, 2012, http://www.posse.gatech.edu/outside-publications/domestic-debates-and-assessment-extended-deterrence-south-korea-south-korean-pe.

35. Sheen, "Nuclear Sovereignty versus Nuclear Security," 277–78.

universally applied to other countries."[36] These debates over U.S. "condescension," especially among the younger generation, reveal a new and growing point of contention in the U.S.-ROK alliance.[37]

Develop the capabilities to build a bomb. Finally, as many in the United States fear, South Korea's request for reprocessing rights could hypothetically be an intermediate step in the development of nuclear weapons. A signatory of the IAEA's Additional Protocol, South Korea could theoretically use pyroprocessing as a legitimate cover for acquiring the technology and skills needed to begin full-scale reprocessing of weapons-grade material down the road. According to this theory, South Korea may seek reprocessing rights to improve its nuclear capabilities and shorten the amount of time between unambiguous nuclear "breakout"—sure to spark tensions in the region—and acquisition of a functional bomb.[38]

Addressing U.S. Concerns

Each of the United States' proliferation concerns is fairly easily dismissed. First, although theoretically possible, a nuclear breakout from South Korea seems incredibly unlikely. The lesson that should be learned from previous South Korean attempts to reprocess is not that South Korea will use reprocessing to secure a nuclear weapon but that it will use the threat of reprocessing to secure U.S. defense commitments. South Korea threatened to acquire reprocessing technology in the 1970s in order to communicate to Washington that Seoul would have the technological means and geopolitical motivations to pursue a nuclear bomb absent U.S. security guarantees. Today, South Korea is well aware that the United States would not tolerate nuclear acquisition, and as the diplomatic rows in the 1970s evidenced, Washington could threaten to rescind its security guarantees.[39] These threats are likely to work. Although the U.S.-ROK military relationship is certainly different than it was in the 1970s when the United States stationed tactical nuclear weapons in the region, Seoul still seems exceedingly unlikely to sacrifice the nuclear and conventional protection of the United States. South Korea's request that the United States reaffirm its security guarantees following North Korea's nuclear tests is just the latest in a string of evidence showing the importance Seoul attaches to its military relationship with the United States.[40]

In addition, South Korea may be the only nation in the world more invested than the United States in denuclearizing the Korean peninsula. Although some observers have debated the relative stabilizing effect South Korean nuclear weapons could have on the South's tense relationship with North Korea,[41] the period of time from South Korean breakout to acquisition would be fraught

36. Lee Byong-chul, "Growing Seoul-Washington Tension on Nuclear Pact," *Asia Sentinel*, August 31, 2012, http://asiasentinel.com/index.php?option=com_content&task=view&id=4783&Itemid=189.

37. Lee Byong-chul, "South Korea Eschews Enrichment of Uranium, but Chafes at U.S. Effort to Restrict Its Options," *Japan Times*, October 8, 2012, http://www.japantimes.co.jp/text/eo20121008a4.html.

38. Kane, Lieggi, and Pomper, "Time for Leadership."

39. Mark Fitzpatrick, "Contrasting Nuclear Models on the Korean Peninsula" (presentation, 2012 Moscow Nonproliferation Conference, September 6–8, 2012), http://www.iiss.org/whats-new/iiss-experts-commentary/contrasting-nuclear-models-on-the-korean-peninsula/.

40. Hans M. Kristensen, "Nuclear Umbrella Reaffirmation Follows Nuclear Korean Nuclear Test," Nuclear Information Project, October 23, 2006, http://www.nukestrat.com/korea/umbrella.htm.

41. See Muthiah Alagappa, *The Long Shadow: Nuclear Weapons and Security in 21st Century Asia* (Stanford, CA: Stanford University Press, 2008); Stephen J. Cimbala, "Anticipatory Attacks: Nuclear Crisis Stability in Future Asia," *Comparative Strategy* 27, no. 2 (2008): 113–32.

with brinksmanship and miscalculation with an erratic North Korean regime. South Korean security would certainly be better served by the elimination of North Korea's weapons, not the acquisition of its own.

Because Seoul is highly unlikely to use pyroprocessing for weapons development, it is clear that the most pressing proliferation risk posed by South Korean reprocessing has very little to do with South Korea and much more to do with its neighbor to the north. Admittedly, South Korean reprocessing may make negotiations with North Korea more complicated, but this is by no means a reason to reject South Korean pyroprocessing outright. Granting South Korea pyroprocessing rights does not mean the country must maintain them in perpetuity. It is entirely possible that South Korea would be willing to relinquish domestic pyroprocessing capabilities in exchange for verifiable North Korean denuclearization, if negotiations ever get that far. Removing nuclear weapons from the peninsula would serve as a very large "carrot" for South Korea, which could investigate other options for dealing with its nuclear fuel, including outsourcing reprocessing to European countries or Japan. South Korea should openly advertise the negotiability of its pyroprocessing capability to quell the reservations that such technology might engender in other stakeholders in North Korean nuclear talks, especially China.

Objectors may argue that trading North Korean nuclear weapons for South Korean pyroprocessing seems like a bad deal for North Korea. This may very well be true, but that is a reason *current* negotiations, in which South Korea has less to barter, are even less likely to succeed. That is not to say that pyroprocessing gives South Korea a large bargaining chip; on the contrary, South Korea's clear intention to use the technology exclusively for nonmilitary purposes undercuts its utility in a tit-for-tat trade. But the point is that pyroprocessing will not *hinder* such talks. Others may argue that South Korean reprocessing will invite accusations by North Korea that Seoul is negotiating in bad faith. This is a difficult objection for Pyongyang to make with a straight face, however, if it continues its own nuclear program. If North Korea wants genuine dialogue, then the pyroprocessing issue can be dealt with; if Pyongyang is unwilling to negotiate away its nuclear program, however, then South Korean reprocessing cannot be blamed for Pyongyang's intransigence.

The third potential objection of the United States—that South Korean pyroprocessing may damage global nonproliferation norms—has very little connection to reality. Nonnuclear weapon states in Europe and Japan have the right to reprocess, along with nuclear-armed India, which is not a member of the NPT. The Obama administration passed on the opportunity to set a nuclear sharing standard, announcing after the UAE deal that domestic reprocessing and enrichment would be viewed on a "case by case" basis in future 123 negotiations.[42] Conversely, there may be nonproliferation benefits to South Korean pyroprocessing. Allowing Seoul to pursue the technologically novel process of pyroprocessing would allow the international community to see a valuable demonstration project. Because of U.S. and international reluctance to create an outright comprehensive ban on reprocessing, one can assume the process will be around for a while, and understanding how to implement a new technology such as pyroprocessing in a proliferation-resistant way will be important. If South Korean pyroprocessing could be successfully monitored and verified, then offering pyroprocessing to other countries may not be so threatening.

Finally, the United States should remember that South Korea is not irreversibly committed to importing U.S. nuclear material. South Korea has thus far abstained from pyroprocessing in the

42. "Shall We Call It the 'Bronze Standard'?" *International Herald Tribune*, February 5, 2012, http://www.nytimes.com/2012/02/06/opinion/shall-we-call-it-the-bronze-standard.html.

hope that it will receive the United States' blessing in the new nuclear sharing agreement. But if the pyroprocessing standoff cannot be resolved by 2014, South Korea may choose to purchase its enriched uranium and source new nuclear reactors from other countries such as Russia and France that do not impose such strict controls.[43] Such a development would present a major shift in South Korean reactor design, but the possibility cannot be ignored. Aside from doing real damage to the U.S. nuclear power industry, a shift in South Korean nuclear sourcing would reverberate across the world. The South Korean government, having successfully completed its first foreign export deal with the UAE in 2009, has set a goal of obtaining 20 percent of the global nuclear export market in the coming years. As long as South Korea uses U.S.-origin reactor designs, U.S. export controls will follow South Korean nuclear exports. If South Korea changes suppliers, however, U.S. companies—with their attendant restrictions—will lose out to those of foreign countries.[44]

For almost four decades, the United States and South Korea have been sharing nuclear material under the same cooperation agreement. South Korea's economic and geopolitical significance has evolved substantially over this time, and these changes should be reflected in the new nuclear sharing deal. Although the United States has some reasonable concerns about the regional and global proliferation potential of pyroprocessing, it also must recognize that South Korea has legitimate reasons to request the ability to use this new technology. Instead of stubbornly sticking to the past agreement, the United States should see the 2014 renegotiation as an opportunity to fulfill the request of a close ally at a very low nonproliferation cost.

43. Kane, "Nonproliferation Issues," 3–5.
44. Holt, "U.S. and South Korean Cooperation," 1.

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