Nuclear Scholars Initiative

A COLLECTION OF PAPERS FROM THE 2012 NUCLEAR SCHOLARS INITIATIVE
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PROJECT ON NUCLEAR ISSUES
Center for Strategic and International Studies
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Introduction and Acknowledgments

The 2012 Nuclear Scholars Initiative featured an outstanding class of 21 graduate students and young professionals from across the United States, as well as one from the United Kingdom. Together, they participated in six monthly workshops that covered various aspects of U.S. nuclear weapons policy. Sessions focused on the Nuclear Posture Reviews, deterrence and stability, nuclear modernization and arms control, nonproliferation and nuclear security, and nuclear targeting. The program culminated in a final meeting, at which the scholars presented their own research, the results of which are contained in this year’s journal.

The Project on Nuclear Issues (PONI) is deeply appreciative of the authors’ outstanding work as well as the contributions of many others. Special thanks are due to Clark Murdock, Douglas Shaw, Richard Wagner, and Amy Woolf, who provided feedback at the last session, as well as Kelley Saylor and the CSIS publications team for their help in editing and formatting the articles. We would also like to recognize the other members of the 2012 class who were unable to contribute an article to this journal but provided valuable contributions to meeting discussions: Maggie Sadowska and Zachary Thompson.

PONI would also like to thank Frank Miller, George Perkovich, and Walt Slocombe, who, along with PONI director Clark Murdock, each committed a substantial amount of their time to organizing and chairing one of the monthly meetings. Linton Brooks deserves special recognition for helping to organize and chair a number of the meetings and for sharing his invaluable knowledge throughout the program. Each year, the Nuclear Scholars Initiative depends entirely on the involvement of experts willing to take time out of their extraordinarily busy schedules. This year’s class is extremely grateful to Paul Bernstein, Elaine Bunn, Donald Cook, John Harvey, David Hoffman, Laura Holgate, Edward Ifft, Tim Morrison, Steven Pifer, Brad Roberts, Gary Samore, Thomas Scheber, Andrew Semmel, Baker Spring, and Richard Wagner for speaking to the group.

Last but not least, we would like to thank our partners at the Defense Threat Reduction Agency and the National Nuclear Security Administration for making this project possible through their consistent support.

John K. Warden
Project on Nuclear Issues
Examining the Broader Implications of the Ballistic Missile Industry’s Influence on Soviet and Russian Decisionmaking

Michael G. Albertson

This paper compares the influence of the ballistic missile industry on Soviet and post-Soviet Russian decisionmaking regarding the country’s strategic nuclear forces. This comparison is conducted in an effort to determine the broader political, economic, and international implications of this relationship for the Kremlin and for the United States. Using the bureaucratic politics model outlined by Graham Allison in Essence of Decision, the paper examines declassified intelligence reporting from the Cold War, interviews with former Kremlin officials just after the collapse of the Soviet Union, and analyses of current Russian force decisions by outside experts.

In 1995, a widely circulated report titled “Soviet Intentions 1965–1985” summarized a series of interviews with high-ranking Soviet defense officials, including Soviet military analysts, military-technical specialists, industrial managers, General Staff officers, and military and political staff members. This report was noteworthy because it was one of the first glimpses of what had been occurring within the Kremlin regarding Soviet nuclear decisionmaking during the Cold War. One of the key unforeseen findings of this study was the key role of the Soviet defense industry, in particular ballistic missile design bureaus, in driving the development and production of missile systems during the later stages of the Cold War. The report highlighted that “the volume of arms production in the USSR was conditioned by the internal dynamics and logic of the vast, civilian-dominated defense-industrial establishment.” The central question for this paper is whether a similar dynamic is now occurring—namely, that the Russian ballistic missile industry

1. Michael Albertson is an analyst at the U.S. Department of Defense. The views expressed in this paper are those of the author and do not necessarily reflect the views of the Department of Defense or the U.S. government.
3. Ibid., 59.
is a powerful yet overlooked player in current Kremlin decisionmaking and whether this has significant political, economic, and international implications for Russia.

There have been glimmers of this influence in the available literature. There is a wide body of Russian press articles from the post–Cold War period colored by advocacy for one strategic missile program or another, with authors touting their preferred systems’ capabilities while questioning the need for others. Some of these articles are written by professional defense analysts or academics, while others are more open advocacy pieces or interviews conducted with heads of design bureaus. The Nuclear Vertical, written by the chief designer of a major Russian ballistic missile design bureau, hints at the heavy lobbying campaigns going on behind the scenes. Long-serving think tank analysts are increasingly puzzled by decisionmaking concerning Russia’s strategic nuclear forces, especially by those decisions considered to be destabilizing, such as the development of heavy-liquid intercontinental ballistic missiles (ICBMs) equipped with multiple independently targeted reentry vehicles (MIRVs). One commentator noted: “Russia relies on exaggerated, unrealistic security goals to maintain the illusion of being a superpower.” These analysts increasingly question whether these force developments and acquisitions, which they see as both unnecessary and destabilizing, are the result of increased lobbying and influence by players within the defense industry.

There are two main sections to this paper. The first section is a discussion of two analytic frameworks drawn from international relations theory. The analytic frameworks for the research center on the unitary rational actor and the bureaucratic politics models as outlined by Graham Allison in his book Essence of Decision. The second section examines cases of Soviet and Russian decisionmaking using this structure. While there are certainly limitations regarding the bureaucratic politics model, there is sufficient available information to acknowledge that the ballistic missile industry has, not surprisingly, played a key bureaucratic role in both Soviet and Russian force structure and procurement decisions. This role is larger than outside observers would expect at first glance, given the seeming unitary nature of both the Soviet and Russian political regimes to the outside world.

The research shows that there are several reasons why the ballistic missile industry is a powerful player but is often overlooked when examining the issue of its influence on strategic forces decisionmaking. Some of these reasons result from the nature of the defense industry itself, as both its massive size and its technical complexity hinder political insight into its inner workings. Others originate in how the Soviet and Russian leadership use strategic ballistic missiles as symbols of their political strength. In conducting

this comparison of the Soviet and Russian cases, one sees that the partnership between the Kremlin and the ballistic missile industry has political, economic, and international consequences, which in turn have broader implications for the U.S.-Russian relationship.

The International Relations Theory Framework

Graham Allison’s book *Essence of Decision* provides one of the most useful analytic frameworks for attempting to understand the role of the Soviet and Russian ballistic missile industries in governmental decisionmaking. Allison outlined his overall argument as follows:

> When we are puzzled by a happening in foreign affairs, the source of our puzzle—our puzzlement—is typically a particular outcome. . . . In searching for an explanation, one typically puts himself in the place of a nation, or national government, confronting a problem of foreign affairs, and tries to figure out why he might have chosen the actions in question. . . . We are assuming government behavior can be most satisfactorily understood by analogy with the purposeful acts of individuals. In many cases this is a fruitful assumption. Treating national governments as if they were centrally coordinated, purposive individuals provides useful shorthand for understanding problems of policy. But this simplification—like all simplifications—obscures as well as reveals. In particular, it obscures the persistently neglected fact of bureaucracy: the “maker” of government policy is not one calculating decisionmaker but is rather a conglomerate of large organizations and political actors.  

This statement is instructive on several accounts. First, Allison argued that analysts use conceptual models to rationalize foreign policy events and that the simple act of using these frameworks has significant consequences for their thoughts. Models help decisionmakers to understand complex issues, for, as Robert K. Merton noted, they “make for the codification of methods of qualitative analysis in a manner approximating the logical, if not the empirical, rigor of quantitative analysis.” Second, of the frameworks available, Allison commented that the unitary rational actor model, which attempts to explain national decisions by recounting the aims and calculations of nations or governments, is the most commonly applied framework and is useful in simplifying a complex issue. Third, and finally, Allison concluded that the rational actor model had inherent limitations, namely, its inability to grasp the role of actors within the system. Alternative concepts, such as a bureaucratic politics model, could thus “provide a base for improved explanations and predictions,” if utilized appropriately.

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8. There is, of course, a huge body of international relations literature available that analyzes the various ways in which states make decisions. Allison’s models were chosen for their familiarity and the ease of comparing his various models against one another.

9. Ibid., 2–3; emphasis in the original.


The unitary rational actor model, which Allison simplified to the formula “monoliths perform large actions for large reasons,” explains international events through the actions of nations or governments. As Allison understood, most contemporary thought about foreign policy proceeds within the unitary actor model, due mainly to its ease in synthesizing large volumes of information to determine a single rational decision. The Soviet Union and its successor, the Russian Federation, are, at first glance, in many ways the epitome of a monolith as defined by Allison: a complex, centralized machine led by a single powerful figure in the form of the Soviet general secretary or Russian president. The national decision is seen as a rational decision by the single leader following discussion and deliberation with his inner circle.

While it is ultimately the general secretary’s or president’s decision that is observable to the public and analysts, the inputs and lobbying that shaped this decision are often opaque. Allison highlighted the importance of internal deliberations taking place behind the scenes: “(1) Monoliths are black boxes covering various gears and levers in a highly differentiated decisionmaking structure and (2) large acts result from innumerable and often conflicting smaller actions by individuals at various levels of bureaucratic organizations in the service of a variety of only partially compatible conceptions of national goals, organizational goals, and political objectives.” Allison cautions us that the unitary actor model has serious limitations, namely, the failure to understand the internal workings of the bureaucratic decisionmaking process.

A bureaucratic politics model, in which decisions result from games played between various powerful bureaucratic organizations within the system, can supply this additional information and hopefully provide more fidelity as to why a decision was made. The bureaucratic politics model views government as a “conglomerate of semifeudal, loosely allied organizations, each with a substantial life of its own.” Each organization has its own goals that drive its interests in the eventual outcome. Allison treated institutions as “players who act in terms of no consistent set of strategic objectives but rather according to various conceptions of national, organizational, and personal goals.” A hidden game takes place between these competing organizations and interests, with the end decision being the output of this process.

The use and efficacy of the bureaucratic politics model are limited, however, by several interlinked factors. First, this model is the hardest of the three frameworks outlined by Allison to process and understand: “[It] tells a fascinating story, but is enormously complex. The information requirements are often overwhelming, and many of the details of the bargaining may be superfluous.” Second, there is an existing bias by analysts in favor of the cleaner, neater unitary rational actor model. Allison explained that “the conception of national security policy as political resultant contradicts both public imagery

12. Ibid., 5–6.
13. Ibid., 10.
15. Ibid., 67.
16. Ibid., 144.
17. Ibid., 274.
and academic orthodoxy. Issues vital to national security are considered too important to be settled by political games.”

Because of this bias, the bureaucratic politics model is not as fully developed from a methodological standpoint. Third, bureaucratic politics is frequently under-reported in most of the foreign policy literature, outside occasional memoirs, anecdotes in historical accounts, and a few case studies. There is thus a cascade effect from the first issue, as the bias limits the amount of available information that analysts can utilize. Thus, due to a combination of the first two factors, the analyst often faces difficulties when assembling information needed to accurately reflect ongoing bureaucratic infighting. These challenges must be understood when trying to accurately examine what occurs within a complex bureaucracy.

Looking at Soviet and Russian Examples of Defense Industry Influence

During the Cold War, there was always a debate regarding Soviet military strategy between those who believed that strategy was set by the military leadership and those who asserted that it resulted from “pulling and hauling among competing bureaucracies with divergent interests.” This was true of both academics and analysts within the intelligence community. The Soviet Union’s decisionmaking regarding its strategic nuclear forces in many ways resembled the “monolith” or “black box” described by Allison, frustrating analysis of the bureaucratic infighting taking place behind the scenes. As Allison predicted, the rational actor model was a commonly used model in attempting to analyze decisionmaking. The size of the Soviet and Russian defense industrial establishment, the inherent secrecy of the Kremlin bureaucracy, and the lack of information regarding internal deliberations often compelled analysts to employ a rational actor model, because it was the easiest model for synthesizing information in such an opaque system. Thus the final decisions or outputs were often described as “the Soviet leadership seeks” or “Moscow desires” without a deeper look at the players operating within the system. While observers could see the end results of decisions, such as what missiles were selected for production, they were often unable to comprehend the complex internal discussions and deliberations driving the decision. In most cases this led analysts to the right conclusions, but as Allison predicted, the bureaucratic politics model could provide greater insight into why decisions were made.

18. Ibid., 146.
Throughout the Cold War, some U.S. policymakers and outside experts relied on the bureaucratic politics model in their analysis of the Soviet Union’s decisionmaking regarding its strategic forces. Thomas Schelling understood that the Soviet Union was likely dealing with the same bureaucratic infighting as the United States: “I see no reason to suppose that the Soviets react in a more rational, more coolly deliberate way, than the West. They surely suffer from budgetary inertia, interservice disputes, ideological touchstones, and the intellectual limitations of a political bureaucracy, as well as from plain bad information.”20 Similarly, Michael Howard understood that “the growth of the Soviet military power, however formidable, is the result of a whole complex of reasons, in part reactive to the external situation, in part driven by internal processes.”21 During the Cold War, however, observers outside the Soviet decisionmaking process were limited in that they could only guess at what was happening inside the Kremlin. As Lawrence Freedman explained, McNamara’s analysis on the offense/defense balance was influenced by his sobering recognition that “strategic assessments on which planning had to be based involved imperfect information, particularly with regard to the future capabilities of the other side, and so could be driven by institutionalized mistrust as much as rational analysis.”22 This was especially difficult when military procurement decisions did not track with Kremlin political rhetoric, making a Soviet unitary actor appear to be duplicitous or bipolar.

This conflict between Soviet words and actions was a particular problem during détente and likely resulted in the increasing validity of a bureaucratic politics approach. Referencing the Soviet ICBM buildup, Freedman noted that given the numbers being produced, outside analysts could only assume that the Soviet Union was seeking strategic superiority: “There had been an assumption that the buildup would stop at the magic figure of 1,000 ICBMs, which would mean equality with the United States. But the buildup continued to over 1,500 ICBMs. It was increasingly suggested that this could only be explained in terms of a drive for superiority.”23 One key example of how the bureaucratic politics model was applied within the intelligence community was the declassified National Intelligence Estimate (NIE) from 1973 titled “Soviet Strategic Arms Programs and Détente: What Are They Up To?”24 While other Cold War NIEs were often forced to take a unitary view of Soviet actions given the breadth of the subject, this NIE clearly indicated that the Soviet ballistic missile industry was likely driving many of the

20. Thomas C. Schelling, *Arms and Influence* (New Haven, Conn.: Yale University Press, 2008), 276. This statement was originally written by Schelling in 1966.
force decisions being made. The decisions to MIRV systems and develop new missiles were “probably influenced by very important institutional interests in the Soviet defense establishment. . . . The three major missile design entities presumably pressed the opportunity to engage themselves in follow-on programs.”

These interests were echoed later in the estimate: “In deciding on and implementing strategic force policy, Soviet leaders face a multitude of specific choices. Diverse pressures bear upon them, particularly pressures from military claimants and weapons producers.”

The information necessary to demonstrate the key role of the ballistic missile industry in driving decisions was only available years or even decades after the observed decision was made, when either key players involved could speak freely or when government archives opened to the public. The shocking revelation was just how large a role the defense industry had played in decisionmaking, and how little control the Soviet political leadership had over the system. Hines noted this important shift in analysis: “While it has been commonly assumed by Western observers that the military, as the consumer of defense-industrial products, was the senior partner in the relationship with industry, the opposite was true.”

The comments of Mikhail Gorbachev indicated that even the Soviet general secretary lacked information on what was happening within his own defense industrial system: “This Moloch was devouring everything that hard labor and strain produced. . . . What made matters worse was the fact that it was impossible to analyze the problem. All the figures related to the military-industrial complex were classified. Even Politburo members didn’t have access to them.”

Dmitri Volkogonov, former director of the Soviet Institute of Military History, wrote the following on how the increasing defense spending of the 1970s and 1980s bankrupted the Soviet economy:

> The stagnation was particularly marked by inordinate efforts in the military sphere. The achievement of strategic parity with the USA was regarded as an event of historic importance, but less was said of the fact that American economic power was twice that of the Soviet Union, or that America was not making a special effort to increase its military capability. Washington assessed the position correctly: to win a duel, one does not need a dozen pistols, as long as the one pistol is absolutely reliable. The USA exhausted the Soviet Union with the arms race which the Soviet Union entered mindlessly. They ostensibly reached the target of strategic superiority, but the cost determined the ultimate fate of the system.

What emerged in the aftermath of the Cold War through the observations of Soviet political participants and observers was that the decisions of its leadership and the self-

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25. Ibid., 303; emphasis in the original.
26. Ibid., 305.
promotions of its defense industry had led to a mindless and self-defeating arms race by spending money on systems that it did not need.

One of the most important sources of this information was Vitalii Katayev, the former senior adviser to the chairman of the Central Committee’s Defense Industry Department. It was Katayev who noted that there was a piaterka or five-person group—composed of the secretary of the General Committee, the minister of defense, the Central Committee secretary responsible for the defense industry, the head of the KGB, and the chairman of the Military-Industrial Commission—that was responsible for important political-military decisions. A similar decisionmaking structure was also noted in a 1988 U.S. government analysis: “The Politburo, in conjunction with the Defense Council, is responsible for all aspects of military and national security decisionmaking in the Soviet Union.” However, within this group, the critical new information confirmed by Hines in the mid-1990s was that the design bureaus had an inherent advantage in the bureaucratic system. Industrialists and designers were concentrated within the design bureaus, allowing these organizations to monopolize information and expertise on highly technical systems such as the ballistic missiles.

As David Hoffman noted in his conversations with Katayev, the ballistic missile industry had an agenda, not one which was rational to outside observers but one that served the interests of the most powerful players within the game: “The defense establishment was run in a way that was extremely random, ad hoc, and subjective. Katayev knew that Soviet central planning did not work. Weapons were not built because they were needed, but rather because of the power of vested interests of prominent designers, generals, and Politburo members. To meet the artificial benchmarks of progress, everything had to increase every year, so the military was often saturated with weapons it did not need.”

The stakes were political power and resources. Power involved gaining influence in the Kremlin decisionmaking system, whether within the piaterka structure mentioned by Katayev or between the various power ministries. Resources were also critical in the internal rivalries within the ballistic missile industry, as design bureaus jockeyed against one another for lucrative ballistic missile design contracts. In the Soviet era, the most heated rivalry was between the Yuzhnoye Design Bureau under M. K. Yangel and the Central Machine-Building Design Bureau under V. N. Chelomey.

Katayev noted that exaggerating the threat was an easy way for the defense industry to increase support from the politicians: “The defense industry never accepted simple solutions. Changes were made only in favor of the growth of the complex. All intelligence

30. Vitalii Katayev’s last name appears with two different spellings in the relevant research, “Kataev” in the Hines study and “Katayev” in the Hoffman book. I have used the latter spelling in this paper.
34. Hoffman, Dead Hand, 208.
assessments of the probable opponent were skewed in favor of the maximal threat when they were made available to the leadership. The principle was that it is better to overestimate than to underestimate the opponent.36 This overestimation of the threat produced a seeming irrationality, in terms of overall numbers and types of systems produced. In his history of the Soviet strategic nuclear forces, Pavel Podvig detailed that two “ICBMs of the lightweight class,” one from each of the competing design bureaus, were selected for procurement to replace a single retiring system.37 This duplication of effort, one that benefited both design bureaus, would appear to be an economically irrational decision to an outside observer and would certainly support Freedman’s point about the misinterpretation of motives.

There are many parallels in comparing interpretations of the ballistic missile industry’s influence on Soviet and Russian decisionmaking regarding its strategic nuclear forces. The first is the continuing difficulty for outside experts to effectively apply a bureaucratic politics model to this influence. Outside observers in the post–Cold War era have surmised that bureaucratic politics continue to play a role in Russian decisionmaking given the often-perplexing force decisions that have been made in the last 10 years. Alexei Arbatov and Vladimir Dvorkin, two senior nuclear policy experts at the Russian Institute of World Economy and International Relations, commented that multiple governmental players seem to have an interest in influencing the character of Moscow’s strategic forces modernization: “Powerful state, business, research, and political organizations are locked into sustaining nuclear confrontation in economic, technical, and mental respects, instead of addressing the more realistic and urgent needs of national and international security.”38

As during the Soviet period, outside analysts see irrationality in the decisions being made regarding the strategic nuclear forces. Some feel that Moscow is spending excessive amounts of money on ballistic missiles, money that could be better used in other areas such as domestic spending programs. Podvig, one of the most respected analysts of Russian strategic nuclear forces, noted in 2008 that the Kremlin was wasting its resources in an unnecessary field: “With a strong economy, Russia can certainly afford strategic forces that would be considered impressive by Cold War standards. But these standards are irrelevant today and the strategic forces designed to fight the Cold War are useless when it comes to the security threats that exist today. Therefore, this ‘grandiose resurgence’ will eventually prove unnecessary, expensive, and dangerous.”39 Podvig cited not only economic waste but also the potential arms race between the United States and Russia that this buildup causes.40

37. Podvig, Russian Strategic Nuclear Forces, 130.
40. Charles Glaser and others have written extensively on this particular phenomenon in international relations, noting the resulting action–reaction process of an arms race can leave a
Others see irrationality in terms of traditional concepts of strategic stability and nuclear deterrence. In particular, Russia’s pursuit of a new heavy-liquid-propellant, silo-based IBCM is seen as destabilizing, given the “use-or-lose” dilemma that these systems pose in a nuclear crisis. This decision—coupled with Russian development of new multiple-warhead, road-mobile ICBMs and a new submarine-launched ballistic missile (SLBM)—increases Moscow’s future dependence on multiple-warhead systems and goes against the last 20 years of arms control agreements stressing the downloading of strategic offensive arms. In words very reminiscent of the NIEs on Soviet politics and force decisions during détente, some criticize current Russian strategic force modernization plans with Moscow’s stated policy goals of nuclear arms control.\footnote{Podvig, “Russia’s New Arms Development.”}

Second, these debates regarding what is going on within Kremlin decisionmaking are exacerbated by the lack of available information. Arbatov and Dvorkin lament that this problem continues to hinder efforts to study why decisions are being made, despite the end of the Soviet state: “Access to military information, open discussion, and professional mobility for military and civilian specialists all increased, as did freedom of thought and expression. But in many respects the Soviet heritage has been kept alive to the present day—there is still inadequate access to information, and decisions on military matters are made completely behind the scenes.”\footnote{Arbatov and Dvorkin, 20.} This lack of information raises questions that are similar to those faced during the Soviet period: Who are the power players behind the scenes, how much control does the Russian president have over the defense industry, are strategic forces modernization and further nuclear reductions compatible, and why does Moscow invest in its strategic forces in seemingly “irrational ways,” whether in terms of size or systems?

Third, information from industry insiders is beginning to show that the ballistic missile industry continues to play a large role in Kremlin decisionmaking regarding the strategic nuclear forces. The recent self-authored memoirs of Yuriy Solomonov, for many years the chief designer of the Moscow Institute of Thermal Technology (MITT), serves in many respects the same role as Katayev’s interviews of 15 years earlier in providing an insider’s perspective into the defense industry’s role in strategic nuclear forces decisions.\footnote{The Moscow Institute of Thermal Technology is one of the two major ballistic missile design bureaus in Russia.} Solomonov corroborates Katayev’s earlier observations about the major role of the design bureaus in the Soviet system: “The insatiable hydra of the military-industrial lobby nourished the process with its own proposals, beyond which lay nothing but a struggle for power and influence in society, the siphoning of additional resources, and national exsanguination.”\footnote{Solomonov, Nuclear Vertical, 23.} He explained that the chief designer at a major ballistic missile design bureau has enormous power within the system, as they manage the relationships involving research institutes, design bureaus, and fabrication plants.\footnote{Ibid., 65.} Solomonov state less secure despite having more military assets. Charles L. Glaser, “The Security Dilemma Revisited,” \textit{World Politics}, vol. 50, no. 1 (October 1997): 175.

41. Podvig, “Russia’s New Arms Development.”
42. Arbatov and Dvorkin, 20.
43. The Moscow Institute of Thermal Technology is one of the two major ballistic missile design bureaus in Russia.
45. Ibid., 65.
also highlighted the competitive environment that existed between the various design bureaus in Russia as they lobbied for government contracts:

The competitive environment created by the enormous efforts of the state as applied to the ground-based systems led to the formation of several powerful design organizations who were constantly struggling to defend their place in the sun. Competition is the engine of progress, and while one can criticize what was created when the positive potential of competitiveness was exhausted, and the process of creating systems was transformed into a feeding trough, one cannot objectively deny that the struggle of design ideas was an extremely powerful motivation in the work.\(^\text{46}\)

More recently, there has been a competition between MITT under Solomonov and the Makayev Design Bureau under Vladimir Degtyar over ICBM and SLBM contracts. Heated contests between design bureaus over resources are common in the Soviet and Russian systems. This competition existed not only in times of relative funding deprivation, such as the lean years of the mid-1990s, but also surprisingly in times of economic plenty, such as the later Brezhnev years.

Fourth, this information from insiders nicely complements the questions outsiders are raising about why decisions are being made. One example of this can be found regarding the issue of threat inflation. Solomonov verified that this was indeed the case during the Soviet period: “Representatives of military science and various types of specialists, serving the interest of the military lobby and the country’s political leadership, were essentially performing one and the same task—analyzing the conditions in which the potential new threat to the country’s security could acquire real contours.”\(^\text{47}\) One expects that this role has continued throughout the post–Cold War era. Contemporary analysts such as Podvig are growing increasingly frustrated by what they see as a similar trend in Putin’s Russia: “Since the military-industrial complex can only build missiles, submarines, and bombers, it’s not surprising that Russia’s security threats are now defined to require missiles, submarines, and bombers. The result is that the discussion of security issues in Russia is dominated by paranoid scenarios.”\(^\text{48}\)

Conclusion

Graham Allison highlighted why the increased granularity of the bureaucratic politics model is necessary for getting to the root causes of issues: “To explain why a particular formal governmental decision was made, or why one pattern of governmental behavior emerged, it is necessary to identify the games and players, to display the coalitions, bargains, and compromises, and to convey some feel of the confusion.”\(^\text{49}\) In examining this paper’s comparison, however, it is not surprising that the ballistic missile industry would have a vested interest in encouraging the members of the Soviet and Russian leadership

\(^{46}\) Ibid., 92.

\(^{47}\) Ibid., 34.

\(^{48}\) Podvig, “Truth about Russia’s Military ‘Resurgence.’”

\(^{49}\) Allison, *Essence of Decision*, 146.
to invest in their companies and products. They are, after all, acting in their self-interest as players within the system. What is useful, however, are the broader implications that can be drawn from the comparison between the former Soviet and current Russian systems. Despite different political systems, players, and threat environments, one can see key similarities that allow one to draw a number of interesting conclusions from this study.

The first similarity is the political effects of the ballistic missile industry’s influence, the creation of a symbiotic relationship that existed in the Soviet system and exists today in the Russian system between the highest levels of the industrial leadership and the political leadership. The ballistic missile industry receives funding levels that, to an outside observer, do not always appear to be the most rational expenditures given the circumstances. Examples can be seen in the Soviet-era decision to produce both the SS-18 and SS-19 MIRVed ICBMs, rather than choose one system in the competition. Other examples would include more recent decisions such as giving the solid-propellant Bulava SLBM to a firm, MITT, that had previously produced only SLBMs, or giving the new liquid-propellant heavy ICBM to the Makayev firm, which had previously concentrated only on SLBMs.50 In return for its patronage, the Kremlin leadership receives a very visible sign of Soviet/Russian military strength in the form of launches of new missiles or the appearance of a new vaunted system in a television report or in the annual Victory Day Parade. Ballistic missiles provide demonstrable indications of Soviet and Russian military modernization when other sectors of the military are not progressing in their goals as scheduled and other sectors of the state, such as the economy or demographics, may be stagnating. This is particularly true of Russian conventional forces, which are currently undergoing a massive restructuring as part of Moscow’s “New Look” reforms but are still suffering from myriad problems, including salaries, housing, and contract soldier recruitment and retention.51

Podvig goes further in his analysis of this relationship, past the idea of symbiosis to a state of parasitism of the defense industry on the political system: “It’s a story of weak leadership, not one of strength. Instead of leading a resurgence, the current Russian leadership has given the military and defense industry a free hand in setting national security policy and uncritically accepted their narrow view of the world and its problems. Just like the Soviet Union during the Cold War, today’s Russia has little control over its military-industrial complex.”52 This highlights one of the potential problems for both sides in growing too dependent on the other for results. For the ballistic missile industry, a failure to provide the results in which the political leadership has invested a great deal of prestige can result in a fall from grace both for a firm and for an individual, as was seen when Solomonov was forced to resign and change positions in 2009 due to contin-

52. Podvig, “Truth about Russia’s Military ‘Resurgence’”; emphasis in the original.
ued problems with the Bulava SLBM. For President Vladimir Putin and the Kremlin leadership, staking too much political capital can lead to embarrassing results, as during the 2004 exercise where Putin watched, TV cameras rolling, during an SLBM’s launch failure.

The second similarity is the effect of the ballistic missile industry’s influence on priorities within defense spending as well as within the overall Soviet and Russian economy. This is not to say that the Soviet Union or Russia should be condemned for spending money on the replacement and modernization of its nuclear forces. However, due to a variety of factors, strategic nuclear forces are consistently the number one priority for defense spending programs, making progress when other lower-priority items such as the ground forces armaments continue to slip. At a time though when Russian forces will maintain rough numerical parity with the United States through New START, and when the decline of its nuclear arsenal has largely been arrested through the deployment of MIRVed systems such as the SS-27 Mod 2, there seems little reason for Russia to continue to funnel the majority of its defense spending into its nuclear forces. This is particularly true given the problems stated above with the conventional forces, along with larger social problems in Russia such as demographics, crumbling infrastructure, and rampant drug addiction.

The final key similarity is the international implications that the ballistic missile industry’s influence can have on a larger U.S.-Soviet or U.S.-Russian strategic relationship. Obviously, during the Cold War, the buildup of Soviet strategic systems sparked an increase in concern within Western policy circles, especially when put into a seemingly contrasting policy context of détente. Whatever the motivation for their creation, either driven by security needs or driven purely by economic self-interests, these systems represented a clear threat to the United States’ nuclear deterrent. As Lawrence Freedman noted: “The fears that the Soviet Union was bent on obtaining a decisive strategic advantage were given added force by the Soviet military buildup, covering all types of military capabilities, that began in earnest in the mid-1960s. The worrisome parts of Soviet doctrine had been present for some time. What made them more serious was the apparent convergence between doctrine and capabilities.” These views, complicated by the opacity of what was occurring within the Soviet bureaucratic monolith, had major ramifications for Cold War thinking, as circles within the U.S. policy and intelligence communities were quick to highlight the potential threats that these new offensive systems posed. This led to what Robert Jervis and others have termed a “spiral of misper-

ception” between the two sides during the Cold War, where interpretations of state decisions led to an action–reaction chain that left both sides less secure.57

The question for analysts now is whether Moscow can pull off a major modernization of its strategic nuclear forces, coupled with the implementation of an arms control reduction treaty, without creating a similar spiral of misperception. To do so requires an extremely delicate, nuanced external communications message, one that the Kremlin has not seemed capable of delivering. Instead, this rearmament, due to the above-mentioned relationships between the political and ballistic missile industry leaderships, has been trumpeted as a sign of Moscow’s military resurgence and strength, cheering domestic audiences at the cost of alarming outside observers. Given the long history of this relationship between the Kremlin and the ballistic missile industry, dating back to the heyday of the Soviet era, as well as the symbiotic nature of their partnership, it is unlikely that the problems inherent in this internal/external communication message will change, resulting in what Jervis depicted as a threat spiral. Only by examining in closer detail the heart of the problem—the issues that drive the relationship between the political and defense industry leaderships—will outside observers be able to identify and begin to consider the steps that need to be taken to address this potential spiral.

Nuclear Weapons Modernization in the Context of the CTBT and New START Debates

Michaela Bendikova

The United States last conducted an explosive test of a nuclear warhead almost two decades ago, while covert nuclear testing has apparently continued in Russia and China. India, Pakistan, and North Korea have overtly tested nuclear weapons. While the New Strategic Arms Reductions Treaty (New START) debate highlighted some of the issues that the U.S. nuclear weapons complex is facing, the U.S. government’s commitment to nuclear modernization appears to be unsubstantiated. President Obama’s proposed funding for nuclear weapons activities has been reduced in both the House and the Senate appropriations bills. Historical experience shows that neither the stockpile stewardship program advanced in conjunction with the Senate debate of the Comprehensive Nuclear Test Ban Treaty, before its rejection, nor the nuclear modernization promises made in concurrence with the New START debate were enough to gain political support for the long-term sustainment of the U.S. nuclear weapons complex. While issues associated with the vitality and resilience of the U.S. nuclear complex and future modernization plans have a significant technical component, policy is the most important factor in successfully addressing these issues.

During his 2009 Prague speech, President Obama committed to work toward a world free of nuclear weapons. He said: “So today, I state clearly and with conviction America’s commitment to seek the peace and security of a world without nuclear weapons.” As long as other states have nuclear weapons, President Obama also pledged that the United States “will maintain a safe, secure, and effective arsenal.” This paper seeks to analyze the tensions stemming from these different visions. While funding for nuclear weapons activities is relatively modest compared with other parts of the federal budget, nuclear modernization will require billions of dollars in investments in the nuclear complex and delivery systems in the years to come. This paper also outlines the lessons learned from the consideration of the Comprehensive Nuclear Test Ban Treaty (CTBT)

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and the New Strategic Arms Reductions Treaty (New START)—a major arms control agreement between the United States and the Russian Federation.

The CTBT is considered by the Obama administration as a step on the road to fulfilling the vision of a world without nuclear weapons. According to the U.S. understanding, the treaty would ban all nuclear weapons experiments and tests that would produce a nuclear yield. The Obama administration has been very vocal in its desire to bring the CTBT, previously rejected in the U.S. Senate in 1999, back to the Senate floor.

As in the CTBT debate in the 1990s, one of the central questions in any future ratification deliberation will most likely be whether it is possible to sustain the U.S. nuclear weapons stockpile absent of any yield-producing nuclear weapons experiments. This paper seeks to offer a contribution to that discussion. While the substance of this question is technical, policy decisions are what ultimately set the course on whether and under what circumstance the United States will conduct nuclear weapons experiments producing yield. This is because the debate about the CTBT and nuclear weapons experiments producing yield has significant political and policy implications. There are many arguments being made to support the current policy not to conduct experiments producing nuclear weapons yield. There is very little discussion, however, about the benefits that would stem from resuming nuclear weapons explosive testing or other nuclear yield-producing experiments.

This paper also seeks to underscore the importance of resilience within the U.S. nuclear weapons complex. In the past, the United States found itself surprised by new international developments (e.g., after the Soviets launched the Sputnik satellite in 1957 or the Indians tested a nuclear device in 1974 and again in 1998). In a post–Cold War environment that is proliferated and increasingly uncertain, it is essential for the United States to be able to develop a new nuclear weapon in a timely manner if the strategic environment were to dramatically change or a new military mission that its current conventional or nuclear weapons cannot fulfill were to be identified. This resilience is also important because the United States provides nuclear security guarantees to over 30 countries around the world. If these states do not feel assured, they might develop their own nuclear weapons. The scope of this paper is limited to strategic nuclear weapons, although many of the lessons learned apply to tactical nuclear weapons as well.

3. Ibid.
4. The treaty does not actually define what constitutes a nuclear weapons test. Critics argue that this is one of the weakest points of the treaty.
5. The distinction between a “test” and “yield-producing nuclear experiment” is that “tests” demonstrate that nuclear weapons perform as intended whereas “experiments” observe and measure “physical phenomena that occur in nuclear explosions” to “improve and/or validate the computer codes used to design and assess weapons.”
7. Tactical nuclear weapons continue to play a significant political role in the U.S. nuclear posture, especially in the context of the North Atlantic Treaty Organization. Their current deployment does not have any military utility.
The New START debate revived the discussion about important issues pertaining to the U.S. nuclear weapons complex, such as preserving the institutional knowledge of nuclear weapons designers and engineers as well as addressing current deficiencies within its structure.

**CTBT: A Close Look**

From the 1960s through 1994, bilateral negotiations on a test ban treaty failed to produce an agreement. From the U.S. perspective, the basic problems then and now were the difficulty of effectively verifying compliance and maintaining the effectiveness and safety of the U.S. nuclear deterrent without testing.

Negotiations on the CTBT began in 1994 and were finalized in 1996. In 1995, in order to secure the Senate’s advice and consent, President Bill Clinton proposed safeguards to ensure the effectiveness of the U.S. nuclear weapons arsenal without conducting nuclear weapons tests and yield-producing nuclear weapons experiments. Those safeguards were to conduct a Science-Based Stockpile Stewardship Program to ensure a high level of confidence in the safety and reliability of the nuclear weapons in the active stockpile; to maintain modern nuclear laboratory facilities and programs; to maintain the basic capability to resume nuclear test activities prohibited by the CTBT; to conduct a comprehensive research and development program to improve U.S. treaty monitoring; to conduct intelligence programs that would gather information on worldwide nuclear arsenals, nuclear weapons development programs, and related nuclear programs; and to establish an understanding that there is an option for the president, in consultation with Congress, to withdraw from the treaty if the secretaries of defense and energy determine that a type of nuclear weapon critical to U.S. national security can no longer be certified. The safeguard program, however, envisioned the resumption of testing when the safety and reliability of weapons in the stockpile could not be certified. It did not take into account the military effectiveness of U.S. nuclear weapons or the need to respond in the event that a new military mission is identified.

Science-based stockpile stewardship is more of a political slogan than a policy because it rejects the essence of science—testing. As Ambassador Paul Robinson noted in 1999, “to forgo that validation through testing is, in short, to live with uncertainty.” The techniques of “stockpile stewardship” are not new. Before the Clinton administration, they were never regarded as a substitute for yield-producing nuclear weapons experiments or testing. It is reasonable to assume that these safeguards should have been in place regardless of whether the CTBT passed, since the United States has not conducted a yield-producing nuclear weapons experiment since 1992. Safeguards were deemed


essential for maintaining the effectiveness of the active weapons in the stockpile absent any underground nuclear weapons tests or yield-producing experiments. In 2008, Secretary of Defense Robert Gates stated, “To be blunt, there is absolutely no way we can maintain a credible deterrent and reduce the number of weapons in our stockpile without either resorting to testing our stockpile or pursuing a modernization program.” Still, successive administrations failed to secure political support and funding for executing the full scope of the safeguard programs.12

The U.S. Senate rejected the CTBT by a majority vote after a full floor debate in 1999, and, while President Clinton signed the treaty, it has never entered into force. Since the United States generally follows the Vienna Convention although it is not a party to the treaty, it should not take any actions contrary to the purpose and the object of the treaty. Unless the president asks the Senate to return the treaty to the executive branch and announces that he has no intention of ratifying the CTBT, the United States, under its own practices, should not take actions contrary to the object and purpose of the treaty and therefore conduct a yield-producing nuclear weapons experiment.13

The CTBT Ratification Debate

The treaty’s objective, stated in its preamble, is to achieve nuclear disarmament through cessation of nuclear explosions.14 The 1990s the debate during the treaty ratification process mostly focused on the political benefits associated with the United States becoming a party to the CTBT. That debate also considered the ability of the national nuclear laboratories to maintain safe, secure, and effective nuclear weapons absent their testing or conducting yield-producing experiments.15 While the Senate refused to give its advice and consent to the ratification of the CTBT, the discussion at that time provides an important source of information regarding the state of U.S. nuclear weapons and the complex that is responsible for their maintenance.

U.S. Nuclear Warheads

Since the end of the Cold War, the U.S. government has decided to dismantle many types of nuclear warheads. During the Cold War, the diversity of the stockpile mattered tremendously. Designers usually preferred higher yield-to-weight ratios, and the designs of the weapons were complicated by the most stringent safety standards in the world. If a flaw were found with one type of warhead and significant numbers of that type of

warhead had to be taken offline, the United States could rely on other types of warheads for the ability to continually fulfill the mission.

That is why the United States developed diverse designs and types of nuclear weapons. Since the 1950s, nuclear weapons testing was considered essential to prove the effectiveness of new or rebuilt weapons. This diversity has been largely lost since the end of the Cold War; the current warhead stockpile comprises seven types of nuclear weapons, and the number is declining. The United States produced its last new nuclear warheads in 1989. These warheads are based on 1970s technologies. President George H. W. Bush signed the appropriations bill containing a provision that imposed a moratorium on U.S. yield-producing experiments. His administration, however, rejected the notion that the U.S. nuclear deterrent could be maintained without nuclear testing. He says: “Specifically, Section 507 of H.R. 5373, which concerns nuclear testing, is highly objectionable. It may prevent the United States from conducting underground nuclear tests that are necessary to maintain a safe and reliable nuclear deterrent. This provision unwisely restricts the number and purpose of U.S. nuclear tests and will make future U.S. nuclear testing dependent on actions by another country, rather than on our own national security requirements.”

Since 1993, the National Nuclear Laboratories have been required to maintain a certain level of test-readiness at the Nevada test site (the last remaining U.S. test site). The law stipulates that the United States must be able to conduct a test within two or three years if directed by the president to do so, in the event that a circumstance arises when it will be necessary for the United States to test its nuclear weapons. While the National Nuclear Security Administration requested funding to be prepared to conduct a nuclear test within 18 months of such a presidential notice, Congress refused in fiscal year (FY) 2006 to fund the request and lengthened the response time frame to 24 months. Since then, budgetary pressures have led to the further deterioration of U.S. test preparedness.

In concurrence with past nuclear weapons-testing arms control debates (Threshold Test Ban Treaty, Sea Bed Test Ban Treaty, Limited Test Ban Treaty, CTBT), scientists and engineers in the nuclear weapons complex have developed tools to monitor and refurbish nuclear warheads and to keep them safe, secure, reliable, and effective. The United States has never solely relied on explosive testing to assess the state of its stockpile. To achieve the goal of maintaining a safe, secure, and militarily effective arsenal, the United States has maintained impressive computational tools and developed other advanced mechanisms to reduce the margins of uncertainty when assessing the weapons


19. Ibid.
in the stockpile. Today, not surprisingly, the most powerful computer in the world is housed at the Lawrence Livermore National Laboratory.\textsuperscript{20}

Even the most sophisticated computational devices, however, do not guarantee that nuclear weapons will perform as expected. This is because data inputs are derived from previous nuclear weapons tests and experiments producing yield. They are limited by measuring technologies that existed at the time of the nuclear test.\textsuperscript{21} In addition, we cannot check our computer codes against any yield-producing experiments. This is a problem at a time of cyberpenetration. How do we know that somebody has not penetrated the network and manipulated data? As we make changes to our weapons, for example as a result of Life Extension Programs, we are departing further from the designs from which we have derived our codes. In the past, nuclear weapons scientists and engineers were frequently surprised by the results of nuclear weapons tests and experiments. As David Sharp points out, “As weapons depart further from the tested envelope, models and simulations become increasingly problematic, and as test experience in the weapons science community diminishes, its scientific judgment also becomes problematic.”\textsuperscript{22}

The 1958–1961 Nuclear Weapons Testing Precedent

The 1958–1961 nuclear testing moratorium that occurred in the United States demonstrated that confidence in the performance of weapons could not be determined without testing or conducting experiments producing yield. Due to the stockpiling of untested weapons, “4 of the 24 weapon designs in the 1961 stockpile had problems that could be resolved only by additional nuclear tests.”\textsuperscript{23} One of these was the W-47 warhead on a Polaris submarine-launched ballistic missile. The United States had fielded nuclear weapons that were found not to work properly under various conditions and found out about it only because of nuclear weapons testing and experiments.\textsuperscript{24}

Experience from this moratorium is not encouraging.\textsuperscript{25} Subsequent nuclear weapons testing and experimenting revealed serious undetected stockpile problems. While technology and diagnostic tools have advanced significantly since then, it is still likely that

\textsuperscript{21} However, nothing prevents us from analyzing previously gathered data with today’s technologies.
\textsuperscript{23} This is the case with a caveat that 1 design of the 18 weapon designs in 1958 stockpile had been retired and 7 new designs were added. See G. Miller, P. Brown, and C. Alonso, “Report to Congress on Stockpile Reliability, Weapon Remanufacture, and the Role of Nuclear Testing,” October 1987, Lawrence Livermore National Laboratory, 16.
\textsuperscript{25} It is also worth mentioning that the moratorium ended when the Soviet Union violated it with a series of nuclear weapons explosions prepared during the moratorium. The United States was caught by a complete surprise. While it was able to detonate nuclear weapons, it took about two years to prepare meaningful nuclear weapons experiment.
U.S. scientists would be surprised in some ways should the country decide to conduct a nuclear weapons test or yield-producing experiment today.

There are also serious human resources problems associated with the lack of nuclear weapons testing, conducting experiments producing yield, and designing new nuclear weapons (even for training purposes). The absence of U.S. testing between 1958 and 1961 led to serious deterioration of personnel skills and infrastructure. According to an insider’s account of the efforts to resume nuclear weapons testing in response to Soviet violations, “the experience for America’s testing community was technically agonizing, operationally painful, and economically very costly. The atmospheric component of test resumption had especially high political obstacles and costs.”

Today, the United States is facing a more serious challenge. In a few short years, for the first time since the dawn of nuclear age, the next generation of U.S. nuclear weapons scientists and engineers will be trained by people with no actual testing experience and who have never designed a nuclear weapon. These scientists will eventually be relied upon to make judgments about changes in U.S. nuclear weapons. These changes will introduce more and more uncertainty regarding the functionality of weapons in U.S. stockpile. According to the 1987 Lawrence Livermore National Laboratory Report to Congress, “This is a script for failure.”

Nuclear weapon testing and experimenting was deemed essential for maintaining a healthy stockpile and necessary to validate new nuclear weapons designs. One of the many lessons U.S. engineers and scientists have learned from nuclear testing is that nothing is ever certain when it comes to nuclear weapons. They are made up of thousands of parts that must work with split-second precision and under extreme temperatures and pressures. Even molecular differences in different material batches can change an outcome of a test or an experiment in unexpected ways.

During the Cold War, the United States was able to produce the best and the safest nuclear warheads in the world due to nuclear testing and experimenting. This led to designs with lower margins between nominal functioning and catastrophic failure than those of China or Russia, and therefore a greater reliance on nuclear testing. Scientists


30. This is also why the exact replication of nuclear weapons is impossible. Ibid., 3.
have been surprised by the performance of nuclear weapons and the results of nuclear tests in the past.

The United States now has the oldest nuclear arsenal in its history. The average age of its nuclear warheads is getting close to 28 years. With aging, we have detected many potential problems that have had to be fixed without nuclear testing or yield-producing experiments. We do not know whether or not the fixes have had an impact on the reliability of the weapons. Without testing or conducting yield-producing experiments, the assessments of the reliability of the weapons are nothing better than educated opinions. Life Extension Programs are introducing additional changes in the weapons that are moving them further and further from the originally tested designs.

Today, very few nuclear weapons scientists and engineers have participated in the process of designing a new nuclear warhead. Yet, maintaining such a skill-set is essential should the United States ever find itself geopolitically and strategically surprised, and determine that it needs a nuclear weapon with new characteristics. Resilience is critical. The United States cannot find itself in a situation where it would take 10 years to respond to new geopolitical developments. Ten years is about the time it would take to develop a new nuclear weapon.

New parts from the new materials used during the refurbishment of nuclear weapons can cause design problems that were not anticipated during the time when the original weapons were assembled. While a materially modified warhead could be certified without a nuclear test, such a certification would be a theory-based statement rather than an experimental one. The question is whether the United States, its allies, and any adversaries will know for sure that it actually works or not until it is too late.

New START Ratification Debate

The state of the U.S. nuclear weapons complex attracted considerable attention during the New START ratification debate. As the number of nuclear warheads goes down, it is essential to ensure that the reliability and effectiveness of the remaining nuclear warheads are maintained. Additional resources for the nuclear weapons complex were supposed to achieve this goal. To secure the Senate’s advice and consent, the administra-


33. Sometimes it is not possible to remanufacture the original material (e.g., due to environmental restrictions preventing the usage of the original material or contractors going out of business).

tion promised to request more than $85 billion for the nuclear weapons complex over the next 10 years.\(^{35}\) President Obama also committed to requesting the funds necessary to ensure completion of the Uranium Processing Facility and Chemical and Metallurgy Research Replacement Facility (CMRR).\(^{36}\)

The Senate’s advice and consent to ratification of New START is contingent upon the president’s certification: “I intend to (a) accelerate, to the extent possible, the design and engineering phase of the Chemistry and Metallurgy Research and Replacement (CMRR) building and the Uranium Processing Facility (UPF); and (b) request full funding, including on a multi-year basis as appropriate, for the CMRR building and the UPF upon completion of the design and engineering phase for such facilities.”\(^{37}\) At the time, critics of the treaty pointed out that the president cannot guarantee funding because Congress provides for the nuclear security complex through the annual appropriations process. In FY 2012, Congress cut the president’s funding request by $400 million. The administration did very little to prevent cuts to the nuclear modernization budget in FY2012 and reneged on its commitments relating to nuclear weapons funding in its proposed FY2013 budget.

After about a year since New START entered into force, President Obama decided to abandon his own certification. The FY 2013 budget request defers the construction of the CMRR facility by at least five years and cuts the funding by 83 percent (compared with the FY 2012 enacted level).\(^{38}\) While, in 2010, President Obama pledged to provide the National Nuclear Security Administration with $7.9 billion for weapons activities in FY 2013, his actual FY 2013 budget request provides only $7.6 billion for these accounts.\(^{39}\)

Some of these cuts are driven by the Budget Control Act of 2011 passed by the Congress. As a result of the caps established in the law, about $483 billion will be cut from the defense portion of the budget over the next nine years (this varies depending on which baseline is used). Unless the law is changed, another process called sequestration will result in the reduction of about another half trillion dollars from the defense budget alone; other mandatory spending will be cut further. Such a reduction would have significant effects on the U.S. defense industrial base, nuclear weapons complex, and the nuclear triad itself. In his November 2011 letter, Secretary of Defense Leon Panetta states that the sequestration process would cause a termination in the bomber program,

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36. Ibid.


a delay in the strategic submarine program, elimination of the intercontinental ballistic missile (ICBM) leg of the triad, as well as other programmatic cancellations.\textsuperscript{40}

The examples of CTBT and New START show that consensus on the funding levels for the modernization of the nuclear infrastructure and delivery vehicles cannot be driven by arms control objectives. While the Senate seems to recognize the importance of adequate funding levels during its treaty consideration, experience shows that such a consensus does not last very long after the Senate gives its advice and consent to ratification of a treaty. Policy positions and fiscal considerations are more important than consensus building driven by arms control when deciding how much the country will spend on its nuclear modernization programs.

Since the United States stopped its nuclear weapons testing and yield-producing experiments, the country has not developed any new long-range delivery systems. When planning for follow-on submarine-launched ballistic missiles and ICBMs, the United States will need to understand the effects of mounting “old” U.S. nuclear warheads on new systems. Do new delivery vehicles have to be limited in design to fit these warheads? Will military planners be limited in the requirements they can place on a new delivery system if those new systems are not constrained by “old” nuclear warheads? In the past, each type of delivery vehicle was mated to its specific nuclear warhead in order to survive extreme conditions unique to the delivery vehicle and targeting requirements.\textsuperscript{41} These questions are beyond the scope of this paper, but they will be analyzed if the United States follows its nuclear modernization plan. Resilience is essential as the United States faces an increasingly uncertain strategic environment while providing nuclear security guarantees to some 30 nations in the world.

Conclusion

Given that more than 30 countries all around the world rely on U.S. nuclear security guarantees, it is essential that U.S. leadership fully consider the implications of CTBT as well as other arms control treaties. The New START experience demonstrated a lack of political support for the effort to modernize the nuclear complex, even if that effort was linked to arms control agreements. The safeguard program that was agreed to before the Senate rejected the CTBT should have been in place, because the United States has not conducted a nuclear test or yield-producing experiment since then. The program, however, has not even been fully funded. U.S. experiences do not offer much hope when it comes to linking arms control and nuclear modernization funding.

In the absence of nuclear weapons testing or yield-producing experiments, the credibility of the U.S. nuclear arsenal will be questioned at some point in the future. According to William Ogle’s account of the nuclear testing moratorium of 1958–1961, “No one


\textsuperscript{41} Miller, Brown, and Alonso, “Report to Congress on Stockpile Reliability,” 29.
can predict when the nation may face a similar set of conditions in attempting to balance political imperatives against the harsh truths of science, or the constraint which must accompany diplomatic negotiations against the urgent need to be ready to move swiftly should negotiation fail.”

Proponents of “nuclear zero” believe that disarmament will somehow increase other nations’ willingness to reduce their own nuclear stockpiles. Yet there is no demonstrated link between nuclear proliferation, U.S. nuclear weapons testing, and the extent of the funding devoted to the nuclear enterprise. In fact, South Africa and Argentina gave up their respective nuclear weapons programs while the United States tested its nuclear warheads. North Korea, India, and Pakistan conducted their nuclear weapons tests after the United States stopped testing and conducting yield-producing experiments. While issues associated with maintaining the U.S. stockpile or preserving the nuclear weapons infrastructure and knowledge base are technical in nature, policy plays an essential role in directing the activities of U.S. nuclear scientists and engineers. This is because policy establishes the political and military purpose of nuclear weapons and therefore dictates the military requirements for them.

The strategic choices that the United States makes today will have an impact on national security for decades to come. The New START debate has revived the interest in the U.S. nuclear weapons complex. That debate has brought to the attention of decision-makers the consequences of years of underfunding. As a result of the discussion about the treaty in the Senate, the Obama administration promised to increase funding for the U.S. nuclear weapons enterprise. Those promises have not survived the first anniversary of New START’s entry into force. Furthermore, the modernization plans for strategic delivery vehicles and the existence of the nuclear triad itself are threatened by the Budget Control Act of 2011. President Obama also stated that he would veto any legislation that would prevent sequestration. Experience shows that agreements on the importance of nuclear weapons funding forged during arms control debates do not guarantee follow-through regardless of whether the president certifies to the Senate.

Both the capability of the nuclear weapons complex to produce new warheads and the capability of industry to produce delivery systems to meet new security requirements and fulfill new military missions have atrophied as a result of years of neglect and the refocusing on sustainment and Life Extension Programs rather than designing new weapons. As the Minuteman III ICBMs and Trident II submarine-launched ballistic missiles are retired, the United States will have to develop new delivery vehicles or move to a dyad or monad.

Historical experiences have shown that neither the safeguard program from the 1990s nor the nuclear modernization promises made in concurrence with the New START debate were able to gain enough political support for their long-term sustainment. The United States must make relatively modest investments in its nuclear weapons infrastructure to preserve its own strategic security as well as that of the more than 30 countries around the world that depend on U.S. extended deterrence.

Goodbye Geneva?
Options for Negotiating the Fissile Material Cut-Off Treaty
Andrea Berger¹

As of 2012, the Conference on Disarmament (CD) will have been deadlocked for more than half its existence. Designed as a negotiating forum for treaties on practically all multilateral arms control and disarmament issues, the consensus-based CD is struggling to maintain its relevance amid a persistent stalemate. As a result, a coalition of nonnuclear countries, led by Canada, is on a quest to free the Fissile Material Cut-Off Treaty (FMCT)—a CD agenda item since early 1994. Last year, it succeeded in convincing a majority of UN member states that, should the CD fail to agree to its own program of work in 2012, the General Assembly bears special responsibility to evaluate options to negotiate the FMCT elsewhere. With no breakthrough in Geneva, that subject is poised to become the center of heated debates in the UN General Assembly in late 2012.

Before delving into the present state of the debate, this paper considers the history of the FMCT with a view to outlining the central disagreements that have emerged between CD member states. In fact, no consensus exist on what the central obligation of an FMCT should be. Compounding this divide, Pakistan’s fresh objections to perceived double standards in the Nuclear Non-Proliferation Treaty (NPT) regime highlight South Asia as a region that will demand particular, focused attention in any negotiation setting. To resolve some of these difficulties, international political trade-offs such as a Nuclear Suppliers Group waiver for Pakistan may have to be debated.

Getting the FMCT to a place where key players can exchange views and information on sensitive issues, without fear of international public reprimand, will be essential to moving the initiative further forward. Four possible negotiating approaches outside the CD will be assessed in this context. Each has been the subject of some discussion in advance of the UN General Assembly’s First Committee debates this fall:² Begin

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² The United Nations First Committee is a Main Committee of the UN General Assembly that deals with disarmament and international security issues. It provides recommendations to the General Assembly and Member States in the form of resolutions. Unlike the CD, they are not explicitly charged with negotiating treaties, and their decisions are taken by majority vote.
negotiations in the General Assembly; follow the model selected for the Arms Trade Treaty; pursue an FMCT through an ad hoc, extra-UN process similar to the Ottawa Convention on antipersonnel land mines; and begin discussions in a parallel “P-5 plus” process. (The “P-5 plus” includes Britain, China, France, Russia, the United States, and Germany.)

While these forums have their clear merits, most run head-first into vocal objections by nuclear-armed states. However, a “P-5 plus” process offers the General Assembly First Committee a pragmatic way forward, improving chances that deep divides between key states can be overcome in the long term.

The FMCT: 16 Years Not in the Making

The FMCT’s origins, historical hurdles, and the solutions deployed in attempt to resolve those differences all have important implications for the present debate over negotiating options. The concept of regulating highly enriched uranium (HEU) and plutonium used in nuclear weapons has a history nearly as long as the atomic age itself. The 1946 Baruch Plan called for “complete managerial control of the production of fissionable materials.” Then as now, nuclear weapons states held the key to crafting any effective agreement to control weapons-useable fissile material. During the Cold War, their participation in such initiatives was precluded by the centrality of nuclear weapons in their strategic doctrine and security calculations. The Baruch Plan floundered in the face of arms race enmities.

Proposals for fissile material regulation were genuinely revived in 1993, when U.S. president Bill Clinton warned against the danger of nuclear terrorism posed by HEU and plutonium and called for the negotiation of an international agreement to end their production. Shortly thereafter, the General Assembly requested an international body to negotiate a nondiscriminatory multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices. As this would be a treaty-drafting initiative, the CD was the logical choice for FMCT negotiations.

Ambassador Shannon: Mandate and Legacy

NPT signatories met in 1995 to discuss whether that treaty should be indefinitely extended. As part of the agreement for extension, states outlined 13 practical steps to disarmament—one of which was the FMCT. As a result, Ambassador Gerald Shannon of Canada was appointed as special coordinator in the CD, and he was charged with canvassing


3. This paper draws on a number of personal discussions with government officials and subject experts from Non-Proliferation and Disarmament Initiative countries, nuclear weapon states, and nuclear-armed states. I am extremely grateful for their time and assistance with this research project.

the views of members on the scope and way ahead for such a treaty. This development is of great importance for the current state of FMCT discussions for two reasons. First, Shannon’s discussions illuminated the fact that member states do not agree on the central obligation of an FMCT. Pakistan and several others argue that a treaty should go beyond the simple obligation of a future cut-off in fissile material production for nuclear weapons purposes and perceive the FMCT as a long-term mechanism for disarmament. This vision also leads Pakistan to advocate for the inclusion of existing stockpiles of fissile material within the scope of the treaty, with a view to their reduction and elimination.

Conversely, most other nuclear weapon states (NWS) and India object firmly to anything that goes beyond the scope of a cut-off. For them, an FMCT is an immediate cap on military fissile material production, allowing them to convert existing military stocks into weapons, but manufacture no more weapons than its strategic-designated stockpile at the time of treaty ratification allows. Most countries have now come around to the fact that its relative popularity among nuclear-armed states renders it the only “negotiable” way forward. Nevertheless, disagreement over the aim of an FMCT persists today as one of the primary hurdles that negotiations must overcome. Shannon’s compromise was to recommend the creation of an Ad Hoc Committee on an FMCT that left the question of core obligations and existing stocks to be ironed out in discussions.

Second, Ambassador Shannon’s appointment cemented the FMCT as a legacy issue for Canada. As one of the world’s largest suppliers of uranium and reactor technology, Canada has long felt a sense of responsibility in promoting the development of robust regulation. This has particularly been the case since India diverted plutonium from a Canadian-built reactor for its first nuclear test in 1974; Canadian prime minister Pierre Trudeau proposed increasing transparency and reducing strategic nuclear material stocks shortly thereafter.5

Despite its broad approach, the Shannon Mandate failed to create momentum. Non-Aligned Movement states demanded that FMCT negotiations be explicitly linked to demonstrable progress toward the elimination of nuclear weapons. China made its support contingent on simultaneous progress on the Prevention of an Arms Race in Outer Space (PAROS). A draft Program of Work prepared by the CD president aimed to resolve this by creating four substantive Working Groups: one addressing a ban on fissile materials; one on broader steps toward nuclear disarmament; one on the provision of Negative Security Assurances (NSA); and one on PAROS. This framework has been the starting point for the vast majority of efforts to revitalize the CD, and it features in some of the contemporary suggestions for negotiating avenues outside the CD.

In 2004, the Bush administration in the United States concluded that it could no longer agree to pursue an FMCT on the basis of the Shannon Mandate, because such a treaty could not be “effectively verifiable.” In 2009, the Obama administration repealed


this stance, and a number of states compromised on their positions regarding PAROS and NSAs, accepting that a Program of Work need not have a negotiating mandate for either. The Conference was therefore able to pass a Program of Work.

The Pakistan Problem

Breakthrough on a Program of Work was fleeting, as no consensus on how to operationalize it could be found. A period of reflection led Pakistan to again demand that the mandate clearly mention existing stocks. An FMCT that capped future production without including stockpiles would “freeze” a country’s weapons usable material—and therefore, the number of new weapons it could manufacture—at the time of ratification. From Islamabad’s standpoint, “a wide disparity in fissile material stockpiles of India and Pakistan could erode the stability of nuclear deterrence.” Pakistan has continued to ramp up its fissile material production since it issued this statement. According to the International Panel on Fissile Materials, it now possesses approximately 2.89 metric tons of HEU and plutonium, compared with India’s 6.96 metric tons. Despite Pakistan’s accelerated production, the gap remains wide.

A common misconception is that Pakistan’s primary objection still rests on the exclusion of “existing stocks.” This is patently not the case, as it has continued to elaborate upon its position since 2009. By now, Islamabad has had time to formulate its view on the 2008 United States–India nuclear deal, which detailed full bilateral cooperation on civilian nuclear energy. From a Pakistani viewpoint, the agreement frees up its rival neighbor’s indigenously produced fissile material for nuclear weapons, using facilities excluded from the deal, thereby exacerbating Pakistan’s stockpile inferiority. Moreover, Islamabad rejects outright the broader trend toward discrimination promoted by the United States–India nuclear deal: “Selective and discriminatory measures that perpetuate regional instability . . . derogate from the objectives of nuclear disarmament and non-proliferation. . . . Pakistan will not support any approach or measure that is prejudicial to its legitimate national security interests.” Pakistan’s ambassador to the CD has stated plainly that he would acquiesce to negotiations only when Islamabad too had a nuclear commerce arrangement and Nuclear Suppliers Group (NSG) waiver in hand.

Support within the NSG to cater to Pakistani demands seems virtually nonexistent. Taking Pakistan’s position at face value, NSG flexibility may be required for an FMCT that includes Islamabad to be realizable. However, a waiver is presently unacceptable

to most Western governments, which have a strong memory of the proliferative activity of the A. Q. Khan network. Change in this stance seems implausible without a broader thawing of the currently tense relations between Washington and Islamabad, as well as increased confidence by the international community in Pakistan’s ability to act as a responsible nuclear user.

Other situations wherein Pakistan agreed to a cut-off without an NSG waiver are foreseeable—namely, if it reached what it thought to be rough stockpile parity with India. But betting on this would truly be a gamble—not least one that relies on vertical proliferation as the key to future arms control.

As Pakistan’s concerns over the exclusion of existing stocks and fears of nonproliferation regime discrimination imply, the FMCT may not be ripe for formal negotiations. Instead, it is now in desperate need of a forum that involves nuclear-armed states and could treat some of these and other highly politicized issues, including verification and fissile material production for naval reactors. These discussions should take place without being an explicit prelude to negotiations. Ultimately, it is this combination that holds the potential of bridging the divide between certain CD member states.

National Positions in the Debate over Parallel Negotiations

For now, Pakistan’s persistent opposition in a consensus-based forum creates little hope that the CD will break free from its paralysis in the near term—a challenge that the FMCT’s long-standing proponents have recognized. Convincing Pakistan to reverse its position on an issue that is essentially one of national security and of perceived NPT regime bias, is beyond the abilities of the CD. Against this backdrop, a coalition of non-nuclear CD members is adamant that the FMCT is too important to let die in the CD. They argue that it is time to consider other parallel forums to take FMCT discussions further forward. 12

At the helm of this initiative is Canada. As mentioned above, Ottawa sees the FMCT as a legacy issue, given its role in the Shannon Mandate. Its enthusiasm for rescuing it from CD imprisonment, however, can be attributed to Canada’s leadership of “successful” Ottawa Convention negotiations regulating antipersonnel land mines—a process entirely outside the UN system. These factors together have led Canada to nominate itself as chief prosecutor in the CD’s trial. Most significantly, the Canadian delegation drafted and sponsored UN General Assembly Resolution 66/44 (2011) on the FMCT. Rather than the previous resolutions that condemned the impasse, implored adoption of a Program of Work, and called upon efforts to “revitalize” the CD, Resolution 66/44 resolved to

consider options for the negotiation of a treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices at its sixty-seventh

12. This position is represented by New Zealand, among others. A/C.1/66/PV.4 General Assembly official records, 66th session, 1st Committee, 4th meeting, New York, Tuesday, October 4, 2011, 18.
session should the Conference on Disarmament fail to agree on and implement a comprehensive Programme of Work by the end of its 2012 session.\textsuperscript{13}

The resolution was adopted with 158 in favor, 2 against, and 21 abstentions.\textsuperscript{14} With the CD still moribund after the conclusion of its 2012 session, the General Assembly will, as agreed, discuss negotiating options for the FMCT in the coming months.

**Supporting the Motion**

Resolution 66/44’s voting record is a useful starting point for analyzing the current split over the broad question of whether or not the UN General Assembly should seek a new home for the FMCT. It should be noted that the suggestion is not to abandon the CD per se; the CD could continue attempting to build the political will necessary to pass a Program of Work. But the FMCT could progress in a parallel forum, independent of the CD’s efforts.

Avidly supporting the resolution, and the broader initiative to pursue parallel negotiations, is the Non-Proliferation and Disarmament Initiative (NPDI), and many other nonnuclear UN members such as Austria and Mexico. The NPDI is a relatively new, increasingly vocal grouping of 10 like-minded countries,\textsuperscript{15} which are adamant that the CD’s stalemate should not bridle the FMCT. As Australian foreign minister Kevin Rudd warned in 2011, “if the Conference on Disarmament [does] not get down to the business of negotiating, it [will] be washed away by history. And so it should be.”\textsuperscript{16}

The five NWS and India voted in favor of Resolution 66/44, perhaps cautiously viewing it as another opportunity to exert pressure on Pakistan. However, debate in the First Committee demonstrated that they are less enthusiastic about the prospect of the FMCT’s forceful removal from the CD than their NPDI counterparts. They reiterated a number of concerns: namely, that another forum would be unable to ensure “key states” were active participants, and that a nonconsensus voting system could have repercussions for their ability to direct the content of, and get buy-in to, an eventual treaty.

Washington’s stance has been confused in academic literature for genuine eagerness to see the FMCT negotiated elsewhere.\textsuperscript{17} In 2011, both the secretary of state, Hillary Clinton, and the assistant secretary of state for arms control, verification, and implementation, Rose Gottemoeller, warned the CD that the United States would explore other op-

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\textsuperscript{14} Meeting Record of the 71st Plenary, A/66/PV.71, General Assembly of the United Nations, New York, December 2, 2011.

\textsuperscript{15} The NPDI is composed of Australia, Canada, Chile, Germany, Japan, Mexico, the Netherlands, Poland, Turkey, and the United Arab Emirates.

\textsuperscript{16} A/C.1/66/PV.4 General Assembly official records, 66th session, 1st Committee, 4th meeting, New York, Tuesday, October 4, 2011, 10.

tions if deadlock persists. More recent statements retreating from these threats suggest that the United States was attempting to use their words as a last resort to exert pressure on Pakistan.

According to Russia and China, the CD should not be supplanted as the negotiating forum for any fissile material treaty though their on-the-record comments do not attack sideline discussions. That being said, China has not participated in the 2011 and 2012 Geneva-based, but not CD-housed, technical expert meetings. Its abstention is a repeated reminder that its active participation should in no way be taken as given.

For India, formal negotiation outside of the CD would come with the risk that it too would lose its de facto veto over the progression of talks. At present, Pakistan’s fissile material stockpile is inferior to India’s, and there remains a critical mass of CD member states opposed to inclusion of existing stocks in any proposed treaty. For now, however, New Delhi seems an enthusiastic but quietly cautious participant in any initiative that involves repeated, high-level naming and shaming of its nuclear neighbor. However, negotiating dynamics and the strategic environment in South Asia may change. This is particularly plausible if the FMCT initiative continues to advance at its presently lethargic pace for some time into the future.

The array of support for General Assembly Resolution 66/44 illustrates that there is broad receptiveness to evaluating options for parallel discussions, but not necessarily to commencing official negotiations. But, as consideration of a “P-5 plus” process will later show, should a forum offer sufficient control over the FMCT’s content, most nuclear-armed states may also be willing to actively pursue the initiative outside Geneva.

Against the Motion

In large part, the Middle East proved more hesitant than NWS. Many members of the Arab League and Iran abstained on Canada’s resolution out of preference for the control and predictability afforded by the CD. For countries with changing and unfavorable regional nuclear dynamics, CD membership and voting rules mean they can be assured that an FMCT will not progress without Israel—and perhaps of future concern, Iran—alongside it.

Israel is itself an interesting FMCT case study. It has vowed not to hold up the start of negotiations, contently removing itself from most FMCT discussions. Tel Aviv clarified its position on abandoning the CD: “The rules of procedure, and in particular the rule of consensus, reflect the necessity to protect vital security interests and provide negotiating

21. The 2011 meetings were hosted by Australia and Japan, and the 2012 iterations by Germany and the Netherlands (the latter is scheduled for August 2012).
States with the comfort levels required for dealing with such critical issues. In principle, Israel does not support taking [the FMCT] outside the Conference on Disarmament.”

Like China, its active participation should not be counted on, and there is widespread doubt that Israel would risk or abandon its nuclear opacity for an FMCT anyways.

Pakistan and North Korea are firmly opposed to the Canadian initiative. Should the NPGD or any other coalition succeed in convincing the UN General Assembly that the FMCT should be negotiated outside the CD, these two countries have made it clear that they will not be at the table. Islamabad’s apparent “compromise” is that it will not oppose technical- or expert-level talks in a CD-associated process. Its apparent openness, however, has not involved willingness to actually participate in those meetings.

The “Key State” Requirement

Careful consideration of the options for negotiation illuminates the prospects that any particular forum will be able to address the primary concerns of nuclear-armed states. As mentioned above, predictability in outcome is one preference held by many CD member states. An equally prominent issue relates to the assertion by nuclear-armed nations that a forum’s design should ensure “key states” are at the table, and increase the likelihood that any resulting treaty will secure their buy-in.

The term “key state” is generally used to mean countries with military nuclear programs, specifically the P-5, India, and Pakistan. North Korea is intentionally excluded by other nuclear-armed states, which seem to be in agreement that North Korea’s nuclear weapons program should not be legitimised with an invitation to FMCT discussions parallel to the CD. Israel is also deprioritized, as it is widely held that they are extremely unlikely to partake in any treaty that would jeopardize their nuclear opacity. Instead, nuclear-armed states appear happy with Israel’s current pledge not to obstruct the commencement of substantive FMCT discussions.

The FMCT would affect some nuclear-armed states more substantially than others. France, Russia, the United Kingdom, and the United States already have voluntary moratoria on fissile material production in place, have large stockpiles, and therefore have no security need for resuming production. The greater challenge is therefore to secure the participation of fissile material manufacturers still producing HEU or plutonium (India and Pakistan), or without a voluntary moratorium on fissile material production for use in nuclear weapons (China). Without agreement to an FMCT by any of these countries,

26. Yet, securing buy-in from even these states is not easy. As experience with the Comprehensive Test Ban Treaty suggests, a split or Republican-controlled Congress in the United States may very well obstruct ratification of an FMCT, preferring to keep the option of resuming fissile material production open for some unknown future threat. It is also generally assumed by diplomats in the P-5 that Israel will not join an FMCT, despite presumably having acquired enough fissile material for foreseeable weapons requirements.
the treaty would add little to the nonproliferation regime. In fact, a weak treaty that does not involve one or more of China, India, and Pakistan may be more problematic than not having a treaty in the near to middle term at all. Should a treaty be negotiated and opened for signature without confidence that buy-in from one of China, India, and Pakistan (as well as the rest of the P-5) could be won, the result would be that a weak text is cemented in international law. Finding future agreement on an amendment is normatively and procedurally more difficult when dozens of states have already signed a text. Getting it right, rather than getting it now, should therefore be the approach. The NWS seem to agree.

Options for Parallel Forums

Keeping this demand in mind, there are, as noted above, four possible courses of action that could catalyze substantive FMCT discussions: Begin negotiations in a General Assembly plenary; follow the model selected for the Arms Trade Treaty; pursue an FMCT through an ad hoc, extra-UN process similar to the Ottawa Convention on antipersonnel land mines; and begin discussions in a parallel “P-5 plus” process.

General Assembly Negotiations

A common assumption in much of the literature on the Canadian initiative is that the likely alternate forum for FMCT negotiations will be a General Assembly plenary or ad hoc committee. Experience with the Comprehensive Nuclear Test Ban Treaty (CTBT) demonstrated that the General Assembly can, in dire circumstances, be a foster home for arms control initiatives plagued by the CD’s consensus rule. In June 1996, after two years of negotiations in the CD, India blocked the draft CTBT. Without a consensus, the CTBT could not be transmitted to the General Assembly for ratification. Australia sought to circumnavigate New Delhi’s roadblock by submitting the identical text to the General Assembly for adoption. In September 1996, the General Assembly adopted that resolution, which requested the secretary-general to open the CTBT for signature at the earliest possible date. CD abandonment is therefore directly responsible for the CTBT’s existence as a treaty, albeit one not yet in force.

The UN General Assembly is again being talked of as a means to surmount CD deadlock. Some see its majority voting procedure as an opportunity to free the FMCT; functionality, they say, should be prioritized over forum. For nuclear-armed states, however, the General Assembly’s procedures mean that non–nuclear weapon states (NNWS) alone could determine the text of an eventual treaty, with key players getting lost in the mix. The control afforded to them in the CD would be forsaken. In practice this would

likely result in a negotiating process that avoids, rather than meaningfully confronts, existing or emerging objections.

Broad membership is also a double-edged sword for the FMCT. On the one hand, all nuclear-armed states and non-NPT members will be present for discussions or negotiations, by virtue of the UN’s composition. On the other hand, it could be argued that the involvement of 193 states in the debate, compared with the CD’s 65, would be an unnecessary procedural complication likely to retard timely progress. This is particularly so considering the FMCT would be negotiated essentially from scratch in the General Assembly. Aversion to this arrangement flows from the conviction that NNWS are not particularly significant for this treaty, and are therefore dispensable to the process. Not producing fissile material themselves, NNWS under the NPT would not be subject to any new obligations under an FMCT. However, for a NNWS’s adherence to a possible FMCT to be verified, rather than redesigning verification procedures for an NNWS, the treaty could very possibly mandate that the state implement a Safeguards Agreement and an Additional Protocol. Widespread NNWS ratification of an FMCT and the Additional Protocol would create a remarkable degree of regulatory harmony in the international verification regime. Indeed, one of the few ideas that has attained consensus in the CD is that an FMCT should be a tool for both disarmament and non-proliferation.

Recognition of the importance of eventual NNWS ratification does not necessarily demand that those countries be integrally involved in the discussion process from the start. By dealing with the fissile material production of states with nuclear weapons programs, a verifiable FMCT will have to confront serious technical challenges subject to national security concerns. A total of 185 other delegations in the room for debates may make nuclear weapon- and nuclear-armed states extremely hesitant to iron out how the FMCT would, for instance, treat sensitive issues such as conversion of former military facilities, verification of hybrid civil–military facilities, or mechanisms to ensure that fuel for naval reactors is not diverted to weapons.30

Offering some counterbalance to the numerous disadvantages of a General Assembly process are a number of more favorable traits. As a UN body, the General Assembly offers increased legitimacy compared with an ad hoc approach such as the Ottawa Process. In the same vein, it is also relatively transparent, and movement on the FMCT within the General Assembly could be used by NWS to substantiate progress toward meeting their commitments under the 2010 NPT Review Conference Action Plan. Similarly, the General Assembly is more open to expert and nongovernmental organization (NGO) participation than other forums such as the P-5. However, transparent dialogue that explicitly ties progress to the Action Plan may make NWS retreat rather than raise and address sensitive political and technical topics.

Ultimately, the General Assembly’s downsides for an FMCT outweigh its merits. Nuclear-armed states have made it clear that majority voting for the FMCT, and to a

30. Fissile material for naval nuclear propulsion programs is widely accepted as being exempted from an FMCT. However, states do not agree on how diversion of this fuel to weapons can best be guarded against. This will be particularly significant in the South Asian context, where India has a new and active nuclear submarine program.
lesser degree, extremely broad membership to potential negotiations, are unsuitable for an arms control treaty of this kind. And, though NNWS opinions are important for the added regulatory harmony that their eventual participation could offer, finding an informal forum with key players that is able to address the most salient issues should take priority. The General Assembly should therefore not be the first port of call for the FMCT.

**Arms Trade Treaty- Style**

Another possibility also benefiting from UN legitimacy is to pursue a process similar for the Arms Trade Treaty (ATT). The ATT, which would regulate trade in certain categories of conventional arms, began with a Governmental Group of Experts (GGE). Ordinarily composed of representatives selected on a regional basis, GGEs are designed to identify and discuss major areas of convergence and divergence between states, and report on them to the General Assembly. Following its 2008 report to the General Assembly on the feasibility, scope, and parameters of a potential ATT, the group was replaced by an Open-Ended Working Group (OEWG). OEWGs are called “open-ended” because all UN member and observer states and accredited NGOs are free to attend their meetings. At the same time, however, the model does not guarantee any state’s participation. For the ATT, the OEWG was asked to further discuss the issues raised earlier by governmental experts. Many crucial questions, such as which types of weapons or ammunition would be regulated, were not resolved at this stage.

In 2009, the United States removed its opposition to the ATT and announced that it would support a General Assembly resolution calling for a formal negotiating conference. Of particular importance, Washington made its support conditional on the implementation of consensus rule for any adopted text. The three-week-long July conference commenced with swathes of disagreements raised in earlier stages, but still unsorted. A total of 150 participating nations unsurprisingly failed to reach a consensus on a final text. The conference disbanded, and the way forward has not yet been laid out.

Experience with proposals for alternate FMCT forums put forth in 2011 highlight why it is improbable that an ATT process will be chosen to start negotiations for an FMCT, but might be chosen to end them. Canada’s original draft of Resolution 66/44 included the GGE. The clause was ultimately dropped because of opposition from the members of the Non-Aligned Movement, which clearly expressed their opposition to any process too far-removed from the CD. This left the resolution with the pledge that the General Assembly shall investigate options for pursuing an FMCT at its next session.

Adding to the concerns voiced by the Non-Aligned Movement, the GGE is simply not the antidote for the problem. Identifying and reporting disagreements is work that has already been done by General Shannon and countless CD presidents since. In itself,
it would do little to resolve rifts in opinion over verification or existing stocks, or to address Pakistan’s security concerns and perception of Indian favoritism in the non-proliferation regime. Though selection of the GGE would undoubtedly have prioritized nuclear-armed states, those adamant that they would not be involved in an extra-CD process could again have abstained. The GGE’s final product—a report and recommendation to the General Assembly—is not sufficiently determinative of an FMCT’s content to put outlier states at risk of being left without say.

The second step of an ATT—OEWGs—also met with opposition when they were proposed by Norway, Austria, and Mexico at the 66th session of the General Assembly. They asserted that if the CD did not pass its own program of work, then two OEWGs should be established. The first would deal with “nuclear disarmament,” and the other with “PAROS”—the latter presumably having been insisted upon by China. Furthermore, the proposal outlined that the disarmament group would “consider all relevant views and proposals, past, present, and future”—CD language used to signal that the existing stocks question is open to debate. However, their suggested mandate went further than draft CD programs of Work, stating that it would be within working group purview to initiate formal negotiations on any of the subjects under discussion, “as deemed appropriate.”

This proposal troubled important constituencies for several reasons. First, it explicitly put FMCT discussions, and possibly even negotiations, under the wider heading of nuclear disarmament. Linkage in this way made NATO members extremely nervous. Signing up to FMCT discussions that were directly framed as a means of getting to zero was thought to put tension on the NATO commitment to remain a nuclear alliance so long as other states possess nuclear weapons.

Second, the members of the Non-Aligned Movement feared that creating a set of working groups in Geneva, with a remit to discuss a wide range of topics under the disarmament and PAROS headings, edged too close to their own proposal for a fourth Special Session on Disarmament (SSOD). An “SSOD IV,” which would bring high-level government officials together to discuss ways of eliminating global armaments, has long been championed by the Non-Aligned Movement. If the OEWGs proposal by Norway, Austria, and Mexico succeeded, it might drain political will to convene an SSOD IV covering many of the same issues. Facing significant pushback, the three sponsors of the draft resolution chose to withdraw it rather than allowing opposition to be “locked in” by a formal vote.

34. Ibid.
36. This draft is unlikely to reappear again in the sixty-seventh session without amendment to its substantive framework. “New NAM” seems unenthusiastic about reinvesting the effort to secure agreement to a modified draft, shifting its political focus to promoting a 2013 Oslo conference on the humanitarian consequences of nuclear weapons.
Failure of both the GGE and OEWG proposals suggest that FMCT negotiations are unlikely to begin in the same way that the ATT did. Should FMCT discussions proceed elsewhere in the first instance, however, a treaty conference framework would be plausible. Vocal attachment to the CD and a fear of majority voting by some delegations suggest that if an ATT-style process was eventually favored, consensus decisionmaking might be insisted upon. Effectively, the result would be a negotiating environment like the CD, with up to three times the number of participants. With a significant investment in political capital at earlier stages and in the right environment, or movement toward an NSG waiver, there is a chance that Pakistan and other hesitant stakeholders could be convinced that a verifiable FMCT is indeed in their interests. Only then might the challenge of consensus decisionmaking be overcome.

The ATT has also proven that its final negotiating stage can be useful in compelling “key players” to stay at the table. Once granted its consensus caveat, the United States seemed to recognize that having a say in the negotiations was preferable to being left behind. Even politically charged issues like the status of Palestine, which held up the conference for days, did not change the U.S. calculus that staying in the conference was most in its interest.\(^{37}\) Owing to this realization, any ATT will now have to incorporate U.S. concerns to avoid a Washington veto. A similar principle could be extended to Pakistan’s, India’s, and China’s roles in a negotiating body that had the potential and mandate to produce an FMCT text.

**The Ottawa Convention**

With Canada at the helm of this debate, it should come as no surprise that there has been mention of an ad hoc process outside the UN system similar to the Ottawa Convention. In 1996, 50 states met in Ottawa to discuss the prospect of a treaty regulating antipersonnel land mines. At the end of the meeting, then–Canadian foreign minister Lloyd Axworthy issued a challenge to states to conclude the treaty by December 1997. Nearly twice as many states subsequently met in Vienna to formulate an initial text. Austria took drafting leadership throughout what became known as the Ottawa Process. At a follow-up meeting in June 1997, approximately 100 states agreed to ban antipersonnel land mines by the Canadian foreign minister’s stated deadline. A final convention was negotiated over three weeks in Oslo in September, and was opened for signature in Ottawa in December.

The key features of an “Ottawa Process” relevant to an FMCT are leadership by a group of concerned and like-minded states, an ad hoc meeting framework outside the UN, and a final (majority voting) drafting conference. On the first point, the NPDI has already demonstrated that there is a coalition willing to lead FMCT negotiations. An ad hoc meeting framework, drafting conference, and majority voting system leave the “key states’” concern unaddressed, however. Hesitant nuclear-armed states would have little incentive to join the early stages of an ad hoc process. Furthermore, majority voting in

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the final stages removes the carrot of control over a final treaty text that an ATT process uses to entice holdout states to participate.

Additionally, the utility of overlaying the Ottawa Convention experience on the FMCT’s predicament erodes when the two are compared: The former was primarily a normative humanitarian initiative without emphasis on verification, whereas the latter is an arms control exercise in which verification plays a crucial role. Overcoming primary differences such as existing stocks and technical questions relating to verification would verge on impossible if the Ottawa Process was applied to the FMCT. An ad hoc process without sustained engagement between key players does not cater to the significant political, technical, and security challenges involved in verifying moratoriums on military fissile material production. This basic difference also undermines the traditionally cited merit of an Ottawa Process: It can produce a treaty in mere months. Truly, the complex issues involved in an FMCT cannot be rapidly untangled, no matter how removed from the UN system the process is. In light of this, advantages of pursuing an Ottawa Process for the FMCT are few.

A “P-5 Plus” Process

A final parallel option that could be evaluated is the P-5, which is composed of the five recognized NWS. Having gained notable momentum since its 2009 London meeting, this forum could be used to catalyze discussions (rather than negotiations per se) on an FMCT in a closed setting. Admittedly, categorization of the P-5 as an “untried option” is inaccurate. Though details are sparse, it seems that the P-5 are already making an effort to prioritize the FMCT as an agenda item for their meetings. Their 2011 joint statement noted that “in order to sustain the potential of negotiations in the CD, the P-5 will . . . renew their efforts with other relevant parties to promote such negotiations.” More recent statements confirm that cooperation between the NWS on this front is ongoing.

One advantage of the P-5 process is that it carries the possibility of being selectively expanded out to other nuclear-armed states. India, Pakistan, and possibly Israel would likely be the targets of any enlargement into a “P-5 plus” process. It is rumored that invitations to these states have already been extended, with collaboration with India moving forward. Fortunately for prospects of “key state” participation, the “P-5 plus” represents a prestigious de facto nuclear club. In fact, it confers more than prestige on its members, offering opacity as a door behind which sensitive issues can be treated. Slowed progress resulting from tricky discussions cannot be held against any country. Together, these qualities may in the near term make the “P-5 plus” forum sufficiently attractive to traditional outliers—namely, Pakistan.

Moreover, China is already at the table in a P-5 forum—a point that should not be understated. Though Pakistan is commonly focused upon as the CD’s sole roadblock, Islamabad may merely be the convenient cover behind which other dissenters are hiding. Judging by China’s past reservations on the FMCT in the CD with regard to PAROS issue linkage, it is reasonable to suggest they may be one. Encouraging China to expand its cooperation on advancing an FMCT would be valuable in itself.

There is a flip side of P-5 opacity; NNWS may feel that inadequate progress is being made against the 2010 NPT Review Conference Action Plan’s commitment to work toward an FMCT. Nevertheless, NNWS pressure has proven ineffective over 17 years of CD deadlock. Truly, if nuclear-armed states’ political and technical concerns cannot be adequately addressed in this forum, there is little hope of it being achieved elsewhere.

Conclusion

Despite the NPO’s enthusiasm, it is clear that many of the new processes mentioned above hold little hope of resolving major issues of international politics, such as the question of existing stocks and a possible NSG waiver for Pakistan. An informal UN General Assembly plenary, ATT approach, or ad hoc Ottawa Process may succeed in getting formal negotiations started sooner rather than later, offering immediate gratification for those campaigning to free the FMCT. However, the beginning stages of each of those frameworks would undermine the prospect that nuclear-armed states will ratify an eventual cut-off. Active discussion with nuclear-armed states should not be compromised, as their involvement is crucial to ensuring that sensitive issues are addressed.

Increasing confidence in Pakistan’s ability to be a “responsible nuclear user,” possibly extending an NSG waiver to Islamabad, and verifying specific types of facilities or material (including the nondiversion of material earmarked for naval reactors) are all extremely complex and politically sensitive issues that must be tackled. Indeed, it is in the FMCT’s long-term interest to treat them now, rather than leave them to a negotiating conference as was done for the ATT. Without any one of the three countries Pakistan, India, or China on board, it is difficult to see the others agreeing.

In essence, the FMCT is not yet ready for formal negotiations. In the first instance, closed, selective, and less rigid discussions parallel to the CD should be prioritized. While NNWS involvement in an FMCT is certainly valuable in creating a high degree of regulatory harmony, it should be deferred to accommodate a process that focuses on nuclear-armed states. A P-5 or “P-5 plus” forum is well suited to this job. Because of the exclusivity and opacity it offers, the P-5 forum may be most likely to compel Pakistan to partake in FMCT talks. Of particular importance, they also guarantee participation by China—the only NWS yet to declare a voluntary moratorium on fissile material production. If the “P-5 plus” could overcome the stumbling blocks outlined over nearly two decades and agree to a model verification protocol, FMCT discussions could then be expanded to other processes and parties.
It is at that point that the CD may again become integral to the FMCT’s progression. Judging by the hesitation of NWS and nuclear-armed states to outright CD abandonment, their insistence on participation by key states, and their overt objection to majority voting procedures for parallel FMCT discussions, consensus decisionmaking is likely to feature at some point. At a minimum, it will probably be insisted upon at the final negotiating stage. If divisions are effectively addressed earlier in the process, consensus on a draft text may be achievable. Of the available consensus-based forums, returning the FMCT to sender would be the least bad option. With 65 member states—relatively few compared with the ATT conference, for instance—the CD involves dozens fewer potential vetoes.

Ultimately, the unattractiveness of options outside the CD makes it doubtful that the First Committee will opt for drastic measures at its 67th session. Doing so would cause a wholesale loss of interest in the CD, with a corresponding drain of expertise from Geneva. Self-inflicted or not, the death of the CD would be an unfortunate outcome, as long-term pragmatism illuminates the CD’s potential utility in the FMCT’s future. Instead of ignoring the concerns of nuclear-armed states and risking complete erosion of the CD’s legitimacy, the First Committee will likely call for the CD to be “revitalized,” as it has done so many times before. Canada’s initiative, manifested as Resolution 66/44, will have nevertheless had a positive impact on the prospects for the FMCT’s advancement; it pushed the P-5 to assume leadership. Upon reflection, the P-5 discussions may be the most progressive development in the FMCT’s seventeen-year-long imprisonment. That is a matter with which NNWS should remain patiently seized, but satisfied.
Security Interests in the Middle East: U.S. Nonproliferation Policy

Sarah Bilson

In the Middle East, energy diversification plans that allow for improved access to key natural resources are critical to the region’s stability, determining whether governments will be able to realize an acceptable quality of life for the region’s nearly 400 million inhabitants. Nuclear power has emerged as a suitable option for meeting the region’s growing energy and resource needs, with the United Arab Emirates launching a full-scale nuclear power plan while neighboring Saudi Arabia and Jordan continue to entertain the idea. The United States has maintained a policy of promoting regional access to peaceful nuclear energy while minimizing the threat of proliferation. A policy question of great debate is whether to achieve this objective by insisting on including restrictions on states’ rights to enrichment and reprocessing (ENR) within Civil Nuclear Cooperation Agreements (123 Agreements), in an effort to prevent the transfer of sensitive technologies and as included for the first time in the United Arab Emirates’ “gold standard” agreement. This paper contends that it is unlikely that Middle East states will be willing to permanently forgo rights to ENR. To promote U.S. nonproliferation objectives in the region, the United States should employ other tools and requirements within 123 Agreements with Jordan and Saudi Arabia that reduce proliferation concerns but do not eliminate the likelihood of the agreements being acceptable to those countries. Doing so will enhance U.S. leadership on nuclear energy and nonproliferation in the region and serve to avoid a discriminatory policy principled on excluding states’ rights.

Background

Nuclear Energy in the Middle East

Several countries in the Middle East are now placing the introduction of nuclear power at the core of their economic growth and development strategies. The United Arab Emirates (UAE) is the first and only to have initiated construction of a reactor so far; Jordan

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and Saudi Arabia appear intent on moving forward, while Egypt and other countries that belong to the Gulf Cooperation Council (GCC) continue to entertain the idea.

The interest in nuclear power is justifiable. While the growth in electricity demand in advanced economies is nominal and matched by diverse, sustainable sources, Middle Eastern states depend almost entirely on oil and natural gas to fulfill their rising energy needs. Although the region is host to more than 55 and 40 percent of global oil and natural gas reserves, respectively, individual countries need improved and diversified sources of energy for domestic use for many reasons. The major oil producers in the Gulf, facing rising oil prices and rising demand, have an interest in seeking alternative energy sources in order to make the oil and gas currently used in electricity generation available for exporting. Other nearby countries—including Egypt, Turkey, and Jordan—are highly dependent on foreign oil and gas for electricity generation. Their rationale for reducing the use of these increasingly expensive fuels and diversifying their electricity portfolios is evident. Most are pursuing efforts in solar and wind power, but they are more enthusiastically turning to nuclear power as a proven emission-free, scalable, and reliable base load source of electricity generation.

The need for improved energy sources could not be more pressing. Access to key natural resources is essential to achieving an acceptable quality of life for the region’s nearly 400 million inhabitants. The ever-growing population has aggravated issues of water scarcity and access to arable land, as well as heightened the demand for electricity, which itself is challenged by the increasing economic and environmental costs of using fossil fuel for power generation. Insufficient and imbalanced access to key resources perpetuates many of the socioeconomic problems of the region. The past year’s domestic uprisings only make addressing issues of social stability all the more important, as improved access to key resources, specifically water and electricity, will be a critical component of appeasing civil and regional discord by enabling governments to meet their populations’ demands and improve the standard of living.

Jordan is a prime example. The country’s economy is under great strain from its need to import more than 95 percent of its electricity-generating energy sources—oil and natural gas—costing the country over 20 percent of its gross domestic product. Moreover, its significant uranium deposits (up to 25,000 metric tons of yellowcake) could be mined and used to power its nuclear energy program. And though the mining

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5. Finlay, Bergenas, and Tessler, “Beyond Boundaries.”


of lower-grade uranium was formerly believed to be economically unviable due to the cost of uranium mining, rising energy costs and improved extraction technology have now made this mining more attractive. Nuclear power has become a key goal in Jordan’s development and economic security agenda, potentially able to turn it from an energy importer into an exporter. Doing so would revitalize the economy, provide opportunities for a domestic job market, and lead the way toward alleviating one of the country’s most pressing socioeconomic issues: water scarcity.

**Concerns about Nuclear Power in the Middle East**

*Fundamentally, a major expansion of nuclear power need not pose greater proliferation risks if two basic principles are applied: there should be no growth in the amount of direct, weapons-usable fissile material nor in purely national enrichment capabilities. The implication is that civil reprocessing of spent fuel should be curtailed rather than expanded.—Sharon Squassoni*8

The stability of the Middle East—which is home to some of the world’s most complex challenges and valuable global goods—is extremely sensitive. The introduction of civil nuclear energy programs, feared by many to be the first step on a path toward a clandestine nuclear weapons program, raises alarm in a region of such sensitivity. Any tentative balance of power that exists would be shattered by the overwhelming supremacy that would accompany a state’s acquisition of a nuclear weapon, and the radical shift in the balance of power that this capability would cause. Iran’s alleged clandestine nuclear weapon program,9 Saudi Arabia’s supposed ties to Pakistan’s weapons program,10 and Syria’s pursuit of advanced nuclear technologies underline the proliferation threat in the Middle East.11 The sensitive regional balance of power has also led to a prevailing fear both inside and outside government circles that the region is extremely susceptible to a spiraling nuclear arms race—a fear acknowledged by President Obama in a speech earlier this year.12 This fear, in turn, is perpetuated by the potential for the Middle East to be the region where proliferation and extremist terrorism meet.13 As such, many hesitate to support the introduction of nuclear energy to the region, believing that it may be nothing more than a cover for power-hungry states to gain the technology, material, and expertise to launch a nuclear weapons program.

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However, the spread of peaceful nuclear energy does not necessarily pose a proliferation threat. If the countries that are interested in developing nuclear power choose to purchase standard nuclear reactors, which run on low-enriched uranium (LEU), and to not develop other fuel cycle capabilities such as enrichment and reprocessing, the spread of nuclear power into the Middle East and beyond would be far less a cause for concern from a proliferation perspective.

Nuclear weapons are made with either highly enriched uranium (HEU) or plutonium. Most nuclear power reactors operate predominantly on LEU fuel that cannot be used in a nuclear bomb without further enrichment. Once the LEU fuel has been used in a reactor, it is considered “spent” or “used” fuel, and contains a small amount of non-weapons-grade plutonium—approximately 1 percent by weight of the fuel assembly\(^{14}\)—as a result of the fission process that takes place while the fuel is in the reactor. The small amount of plutonium in the spent fuel is also mixed with a number of other extremely dangerous chemical elements, which makes the plutonium very difficult and dangerous to extract. Reprocessing is a chemical process that separates plutonium from the other chemical elements in spent fuel. The resulting plutonium could be used as fuel in certain types of reactors, or mixed with uranium (to produce mixed oxide fuel) and used as fuel for other types of reactors.

Because states do not need to produce their own LEU fuel for reactors given the open international market for LEU fuel, enrichment and reprocessing (ENR) capabilities are not a necessary component of a peaceful nuclear program. Many states opt instead for geologic repositories or the storage of spent fuel at reactor sites instead of developing reprocessing to address spent fuel management issues. International fuel banks may soon provide an additional source of nuclear reactor fuel, further allaying the need for states to reprocess.

Though non–nuclear weapons states (NNWS) are afforded the right to enrich and reprocess material under the Nuclear Non-Proliferation Treaty (NPT), the spread of this capability presents numerous threats to the nonproliferation regime. Primarily, the facilities are very difficult and costly for the International Atomic Energy Agency (IAEA) to safeguard and inspect.\(^{15}\) A state with ENR capabilities could feasibly decide to enrich material, and then invoke Article 10—withdrawing, claiming that the treaty is no longer responding to its needs, and giving 90 days’ notice to all members of the NPT, the United Nations Security Council, and other members of the IAEA. The NPT does not include a provision for dealing with a country that withdraws, paving the way for a state to legally enrich and produce bomb-grade material, then exit the NPT to build a bomb, without ever having broken any rules or commitments and without inspectors being any the wiser. An additional concern is that even if a state has purely peaceful intentions, a large


amount of bomb-grade material makes the facility a perfect target for a terrorist looking to build an improvised nuclear device.16

Since 1974, when India “peacefully” exploded a nuclear device that had been made using plutonium extracted from spent fuel using reprocessing technology provided by the United States,17 the United States has sought to restrict the spread of reprocessing technologies. Having itself abandoned its reprocessing facilities nearly three decades ago,18 it has remained opposed to the development of ENR capabilities in NNWS. The founding in the late 1970s of the Nuclear Suppliers Group (NSG), which was intended to develop a common set of guidelines to restrain the supply of sensitive nuclear technologies, was a landmark achievement, and has largely succeeded in limiting the spread of these technologies.19 Recent crises, however—such as the discovery of the transfers from the Pakistani A. Q. Khan network to North Korea, Libya, and Iran—have raised serious concerns.20 Accordingly, fortifying efforts to restrict the spread of ENR technologies remains a central component of the United States’ nuclear policy, allowing it to support the peaceful use of nuclear energy without spreading the risks of nuclear proliferation.

**U.S. Civil Nuclear Cooperation Agreements**

The United States, as a principal nuclear supplier, the upholder of the world’s strongest nonproliferation standards, and the global leader in the safe and efficient operation of nuclear power plants, has an important role to play in supporting new states’ access to peaceful nuclear energy while ensuring that such programs do not lead to the spread of enrichment and reprocessing technologies.

Section 123 of the U.S. Atomic Energy Act (AEA) requires an accord for cooperation as a prerequisite for nuclear trade between the United States and other nations. What are known as “123 Agreements” thus establish the legal framework for significant nuclear cooperation between the United States and other countries, along with other nonproliferation tools such as the NPT.21 These 123 Agreements contain valuable nonproliferation controls and commitments, in the form of U.S. consent rights, access, and other opportunities to positively influence the nuclear energy programs and nuclear fuel cycles of partner countries. And the 123 Agreements also make possible other forms of cooperation, including technical exchanges, scientific research, joint training, and safeguards discussions.

Section 123 of the AEA requires that all 123 Agreements meet nine nonproliferation criteria. The seventh criterion mandates that nations cannot chemically separate uranium and plutonium without U.S. approval. The 123 Agreements’ requirement of prior U.S. approval is a cornerstone of nonproliferation efforts. The NSG, established in 1974, represents an international effort to control the trade in sensitive nuclear technologies, including reprocessing.

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16. Ibid., 1.
18. Ibid.
20. Ibid.
consent if a country is to enrich or reprocess United States–origin material is a significant safeguard against the potential misuse of nuclear material. This is not required for cooperation agreements with any other supplier nation.

In an effort to further prevent the spread of ENR capabilities, in 2009 for the first time the total forswearing of rights to ENR was included in the U.S.-UAE 123 Agreement, whereby the UAE agreed to give up all rights to fuel cycle activities and instead “to conclude long-term arrangements . . . for the secure supply of nuclear fuel, as well as the safe and secure transportation and, if available, the disposal of spent fuel via fuel leasing or other emerging fuel supply arrangements.”

This 123 Agreement is now heralded as the “gold standard,” offering “total compliance with the pillars of U.S. nuclear policy.” The Obama administration and the U.S. Congress are now considering insisting that all future 123 Agreements include this provision. This possible course of action has obvious benefits but also has risks, and thus raises concerns about the overall course of U.S. nonproliferation policy.

U.S. Nonproliferation Policy and ENR Restrictions

While the willingness of the UAE to forgo rights to ENR is a laudable landmark in efforts to prevent the spread of ENR technologies and capabilities, insisting that all future 123 Agreements include similarly stringent restrictions is risky, and may lead to the collapse of U.S. influence in the nonproliferation regime instead of the extension of U.S. nonproliferation standards.

The Benefits of Including ENR Restrictions

Ensuring that standards for nonproliferation, safety, and security are not compromised is an important goal for the United States, the strictest nuclear supplier and the leader in setting the highest bar for ENR restrictions. Given the precedent set by the U.S.-UAE 123 Agreement, it is reasonable that the United States would want to raise the bar to meet this standard in all future agreements. Not only would this serve to promote better norms, but if the United States backtracks on this standard, it risks compromising the benefits of the U.S.-UAE 123 Agreement, which could be renegotiated if the United States were to negotiate a 123 Agreement in the Middle East with less strict terms.

If the United States were to permit Iran, for example, to enrich uranium, the UAE might feel emboldened to claim enrichment as a right—mooting the 123 Agreement and making it even more difficult for the United States to quell the nuclear ambitions of Iran and

References:

prevent nuclear breakout in the Middle East,” observes Ambassador Thomas Pickering.\textsuperscript{25} Instead, upholding the highest standards could make clear that the United States will only support nuclear commerce when it poses no proliferation threat. U.S. engagement with other supplier nations may allow it to bring other suppliers on board with these higher standards, which would significantly strengthen the global nonproliferation regime.

Meeting this standard in all future 123 Agreements in the Middle East could also create a strong diplomatic push against Iran. If Iran’s neighbors make explicit efforts to prove the peaceful nature of their programs, Iran’s uncooperative behavior with IAEA inspectors and clandestine approach to its program will stand in harsh contrast.

The United States may be able to insist on ENR restrictions because of the extent to which partner nations want an agreement with Washington. To run a safe and economically feasible program, a nuclear cooperation agreement with Washington is considered extremely beneficial. U.S. reactors are considered by some to be the best quality and best performing, with the top 3 best-performing nuclear reactors in the world, 7 of the top 10, and 16 of the top 20.\textsuperscript{26} Safety and security are not the sole factors. “Any nuclear cooperation agreement with the United States is about why the country needs or wants the U.S. blessing or cooperation for its nuclear energy program,” says Chen Kane.\textsuperscript{27} The United States may be able to use this competitive advantage to promote its industry and advance its nonproliferation goals, by weighing the degree to which countries value U.S. cooperation over cooperation with other supplier countries and by setting the nonproliferation standards they require as high as possible. Not doing so would be a lost opportunity for advancing nonproliferation standards.

\textbf{The Risks of Insisting on ENR Restrictions}

\begin{quote}
Pressing countries to forswear what they regard as their sovereign rights as states and their rights as enshrined in the NPT, or banning transfers of enrichment and technology except to existing technology holders, stiffens the resolve of states to resist such demands and leads to discord and acrimony, hardly a recipe for building a consensus on strengthening the nonproliferation regime.
—Fred McGoldrick\textsuperscript{28}
\end{quote}

Insisting that states give up rights to which they are entitled by an international treaty poses serious risks to the United States’ nuclear cooperation relations with its foreign

\begin{itemize}
\item \textsuperscript{25} Pickering, “UAE 123 Agreement.”
\end{itemize}
partners, possibly substantially depressing U.S. nuclear trade, and thus also diminishing the extension of U.S. nonproliferation benefits in a region that is highly vulnerable to the threat of proliferation. Moreover, it does not address the primary proliferation concerns of the region, namely, the purchasing of a Pakistani weapon by Saudi Arabia, or Syrian arms deals with North Korea.29

The primary and most plausible risk is that Middle Eastern states will refuse to agree to this strict requirement, and instead will turn to other supplier countries to launch and advance new nuclear energy programs. Jordanian officials have publicly declared that Amman will not forfeit its right to enrich uranium. Instead, Amman has signed nuclear cooperation agreements with nine countries—Japan, France, Spain, China, South Korea, Canada, Russia, the United Kingdom, and Argentina—and is considering three partners for the construction of its nuclear power plants: Rosatom, the Canada Deuterium Uranium (CANDU) reactor, and France’s AREVA.30 Saudi Arabia’s position is not yet clear, but its initiation of cooperation with China, South Korea, and France could lead one to conclude that it may pursue a nuclear program without U.S. support.31

Foreign competitors of the United States, which are increasingly becoming the chosen option for new countries looking to enter the nuclear market, do not impose as harsh ENR conditions in their nuclear cooperation agreements. U.S. involvement could ensure that much higher standards for nonproliferation, security, and safety are met, due to the important consent rights over United States–obligated fuel included in 123 Agreements, which allow the United States to shape the fuel cycle developments of its partners. If the United States fails to negotiate 123 Agreements that are acceptable to partner nations, it will lose the inherent nonproliferation, safety, and security benefits that accompany U.S. nuclear trade with foreign partners.

A second risk is a further degradation of the view of the United States in the Middle East. The Obama administration announced that it would negotiate agreements on a “case-by-case basis,” indicating that it would insist on ENR restrictions for some and not for others. Khaled Toukan, chairman of the Jordan Atomic Energy Commission, made clear that he disapproves of the discriminatory approach of a case-by-case basis: “We believe in the universality of the NPT. We do not agree on applying conditions and restrictions outside of the NPT on a regional basis or a country-by-country basis.”32 If Arab and Muslim states feel as though they are being singled out, the widely held view of the United States as anti-Islamic is sure to intensify. This would be a troubling development that could impede U.S. foreign policy objectives and existing nonproliferation cooperation in the region. Alienating close allies whose cooperation is essential for strengthening the global nonproliferation regime would be an enormous loss.

31. Ibid., 5.
A third and related risk is a degradation of efforts to diplomatically isolate Iran. Initiating peaceful nuclear cooperation with countries in the region can send a powerful signal to Iran that the benefits of cooperation with the United States and the international community are numerous and greatly outweigh global isolation. The Obama administration has made Jordan a key potential partner in its global program to promote peaceful nuclear energy, as part of a broader plan to push for transparency in other nuclear programs in the region. Cooperation with Saudi Arabia could provide similar benefits—as a powerful axis in the region, its adherence to nonproliferation norms and receipt of benefits from the United States could demonstrate to Iran the benefits of cooperation and compliance. As mentioned above, insisting on standards that the United States does not require with other countries could seriously risk alienating these partners, and reduce its ability to employ these partnerships in efforts to marshal diplomatic pressure against Iran.

The fourth loss would be for the U.S. nuclear industry. This industry is already in decline, but it could risk disappearing if, as the Middle East goes nuclear, the United States has no stake in one of the world’s most energy-seeking regions. As it loses its ability to compete in the international market, its strengths are likely to only further decline.

**The Reasons for Compromise**

Maintaining security in the Middle East is not solely a question of dispelling armed conflict or an arms race; it is also dependent on governments’ abilities to provide for the resource needs of their populations. Many of the region’s greatest sources of conflict are perpetuated by critical needs for key resources, namely, water and electricity. Border disputes, large domestic wealth gaps, levels of gross domestic product that differ vastly between neighboring countries, and power struggles among religious and ethnic groups are all aggravated by insufficient and uneven access to these resources. Last year, long-held dictatorships fell and opened the door to young, transitioning governments; the success of these new governments will depend in part on their ability to provide for the energy needs of their populations.

Stability in the region is in the best interests of the United States for numerous reasons, not least because of the Middle East’s critical role in the global economy, given that it holds more than half the world’s oil reserves and over a third of its natural gas. The United States can play a supportive and cooperative role in energy security in the Middle East by helping states meet their energy and resource needs while ensuring the highest possible standards in nonproliferation.

While the UAE willingly gave up its rights to ENR, asking other countries to do so while other major suppliers do not include such restrictions will likely only lead new countries to forgo U.S. cooperation, turning to other suppliers to fill their needs. Richard Stratford, director of the Office of Nuclear Energy, Safety, and Security at the Department of State, explained, “A very large part of the Non-Aligned Movement and those who might proceed into nuclear are not people who are going to sign away their ‘inalien-
able’ Article IV rights to nuclear cooperation.”34 Though states value the conclusion of an agreement with the United States as a validation of their nonproliferation credentials, an agreement with the United States does not appear to be an absolute must. When push comes to shove, Middle Eastern states look as though they will opt for choosing other suppliers over forfeiting their rights under the NPT for the benefits of a U.S. 123 Agreement. Countries will not choose to forgo nuclear energy; rather, they will simply look elsewhere for nuclear energy support if the U.S. terms are too rigid.

“While we have many ways to promote nonproliferation objectives, one important nonproliferation tool that we cannot afford to lose is our ability to enter into peaceful nuclear cooperation agreements with other countries,” asserted Fred McGoldrick, an expert on international nuclear cooperation. “This capability, among others, has allowed the United States to promote widespread acceptance of nonproliferation norms and restraints, including international safeguards and physical protection measures and the NPT.”35 Even without the total ENR restriction, the United States’ civil nuclear cooperation agreements include the most stringent nonproliferation controls of all suppliers, specifically through consent rights on the reprocessing, enrichment, and storage of weapons-usable materials subject to its agreements.36 They lay the groundwork for extensive collaboration in other areas of nonproliferation, helping the United States to realize its nonproliferation goals.

If the United States fails to negotiate agreements with Jordan and Saudi Arabia by insisting on standards to which they refuse to adhere, it will miss an opportunity to gain insight and connections into nuclear programs that will be implemented regardless of U.S. support.37 Moreover, alienating Jordan and Saudi Arabia, two of the United States’ closest and most stable allies in a tumultuous and globally important region, will significantly reduce U.S. clout in furthering a global and regional nonproliferation regime. This is particularly risky given the alleged Iranian program—maintaining a cooperative relationship on regional nuclear issues will be absolutely vital to marshaling diplomatic pressure against Iran. While insisting on a hard line of no ENR has its merits, it will bear no real fruits in advancing nonproliferation standards if the 123 Agreements do not succeed.

Rather, if the United States succeeds in negotiating 123 Agreements and has U.S. domestic companies at the forefront of constructing foreign facilities and providing vital services, it will be in a better position to shape the fuel cycle decisions in the region. The United States must devise alternatives to ENR restrictions that can be included in 123 Agreements and can work with existing nonproliferation tools in order to best prevent the spread of ENR capabilities.

36. Ibid., 9.
Alternatives to Restrictions

While 123 Agreements are an important U.S. nonproliferation tool, they are not the only ones available. U.S. nonproliferation policy and bilateral and multilateral initiatives are also a key part of U.S. influence on global nonproliferation norms and actions. U.S. nonproliferation influence is also derived from its leadership role over the last 50 years in making nonproliferation a significant foreign policy objective.—Jodi Lieberman

To best prevent the spread of ENR capabilities, the United States should pursue alternatives to ENR restrictions in its 123 Agreements. There are mechanisms that can be included in 123 Agreements that can better enhance the nonproliferation qualities of the agreements as well other tools outside 123 Agreements that can promote U.S. nonproliferation goals. The 123 Agreements will not be successful on their own, after all—they will have the greatest impact if they are used along with other complementary approaches. Pursuing these alternatives will allow the United States to support the energy and economic diversification plans of the Middle East while reducing the threat of proliferation. These other approaches include the following:

- **Enhanced multilateral nuclear fuel assurances.** Providing states enhanced nuclear fuel assurances, as an attractive alternative to enrichment and reprocessing, could serve as an incentive to not embark on the costly path of ENR to fulfill fuel supply needs. An international fuel bank, specifically, is a transparent and secure means of fulfilling enrichment and reprocessing needs. Saudi Arabia has previously made proposals for a multinational enrichment facility, to be located outside the Middle East but available for regional use. To date, this idea has not been pursued. However, given the broad international support for international fuel banks and the ability of these fuel supply systems to displace needs for ENR, this option should be seriously considered. Other fuel assurance programs, such as “cradle to grave” services, should also be offered.

- **Multilateral controls on ENR facilities.** States that currently have ENR facilities, or new states seeking to develop ENR facilities, should be pressured to place these facilities under multilateral controls. This approach does not deny states’ rights to ENR, but rather encourages a collaborative, transparent framework for reprocessing. A global push by nuclear weapons states to place their sensitive nuclear fuel cycle activities under multinational controls would be a powerful start.

- **Strengthen ENR rules within the Nuclear Suppliers Group (NSG).** The NSG should adopt new guidelines that offer greater specificity in the rules governing transfers of enrichment and reprocessing. Members should also register their com-

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mitments to promote access to nuclear energy to those states that are in compliance with their NPT obligations.

- **The Additional Protocol (AP) as a U.S. legal condition of supply.** While the AP is a condition of supply in U.S. policy, it is not yet cemented in U.S. law. Despite the recent NSG decision to not make the AP a universal condition of supply, the United States will only be able to garner support to move toward this goal if it is first secured in U.S. law. This would simply require amending Section 123 (b) of the AEA.

- **Sustained diplomatic effort to discourage the development or transfer of ENR capabilities in the region.** As McGoldrick notes, diplomatic interventions and interdictions have been effective in stopping the spread of ENR in the past. Middle Eastern countries’ fear of the development of an Iranian nuclear weapon, and alliance with the United States against Iran, could lead U.S. diplomatic initiatives to discourage ENR to be highly successful. While states may not be willing to rescind their NPT rights, they are unlikely to make choices that they believe would hurt the international case against Iran.

**Conclusion**

Middle Eastern states are embarking on nuclear energy programs in an effort to diversify their energy and economic portfolios. Initiatives that will provide improved electricity and water for the region could considerably help address the socioeconomic issues that continue to fuel political conflicts, serving to appease civil and regional discords and bring stability. A stable Middle East is in the best interests of the United States, and playing an integral role in the region’s forthcoming nuclear energy programs is part of this. U.S. nuclear trade with new countries will best allow the United States to help shape the path these programs take and advance U.S. nonproliferation objectives. However, the United States will not be able to do so if it does not develop nuclear cooperation agreements that are acceptable to partner nations. The United States will struggle to uphold the precedent it set with the UAE of no fuel cycle activities, and other suppliers will likely not rise to match these standards. As such, if the United States insists that states forego rights that are considered inalienable under the NPT, it is likely to forfeit its ability to shape the fuel cycle development plans in the region, and appear discriminatory in its approach toward nuclear trade, thus alienating its close allies. Therefore, the United States should look for other mechanisms to restrict the transfer of sensitive nuclear technologies that do not rely on denying states technologies that they will in any case otherwise acquire. Doing so will allow the United States to advance U.S. nonproliferation interests and U.S. nuclear trade, while playing a cooperative and supportive role in the region’s energy security.

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Domestic Constraints and Drivers of U.S. Nuclear Policy
Alexander K. Bollfrass

An examination of the George W. Bush and Barack Obama administrations’ nuclear weapons policymaking toward Russia and Iran finds evidence of the influence of domestic factors on policy outcomes. In the cases examined, an administration’s ability to carry out its preferred policy was correlated with two variables. First, if the coalition of interest groups favoring the policy was more influential than those opposing it, the odds that the nuclear policy would be implemented improved. Second, if the country subject to the policy had a benign government in U.S. eyes, these odds also rose. Policies that have been elevated by the opposition for a high-profile political critique were difficult for an administration to execute. Contrary to common academic and practitioner predictions, public opinion, bureaucratic politics, and opposition control of Congress did not consistently constrain or drive nuclear policy.

American political culture is suffused with the “strong and widely held view . . . that it is immoral to let domestic political considerations influence decisions that may affect war and peace.” The norm favoring bipartisan foreign policy can even lead participants to misunderstand their own motivations: “This belief is so strongly held that senior officials frequently deny them in public—and even apparently to themselves—that they take domestic politics into account in making national security decisions.” Although Senator Vandenberg’s notion that “politics stops at the water’s edge” appears unduly rosy to even casual observers of the political process, the scholarly analysis of foreign policy decisions primarily casts the analytical eye beyond the borders of the United States. This paper is an effort to evaluate whether this focus misses other determining factors.

In academic discussions about nuclear weapons, domestic politics is rarely mentioned. Instead, nuclear decisions—from the initial choice to acquire them to later force

1. The author is a doctoral student in security studies at Princeton University’s Woodrow Wilson School of Public and International Affairs.
3. Ibid.
sizing decisions—are typically presented as responses to international factors. How can this be reconciled with the fierce domestic debates about nuclear-related issues like missile defense and Iran’s nuclear program?

To begin an investigation of the subject with a manageable set of cases and to be relevant to future policymaking, this paper surveys the domestic factors affecting the George W. Bush and Barack Obama administrations in their decisionmaking on the Iranian nuclear proliferation challenge and in making arms control decisions with Russia. While both cases have nuclear weapons at their center, the policy substance and political circumstances differ. However, as the case study narrative given below shows, the domestic dimensions of these policies are similar in the tools available to presidents, as well as in the limits administrations face. Contrasting how presidents of opposing parties have fared in dealing with similar problems can make partisan effects more visible.

Interviews with policymakers suggest that most domestic concerns, including an administration’s desire for reelection, are reflected and channeled in Congress. The combination of constitutional and legislative limits on presidential nuclear decisionmaking also suggests that domestic factors can be seen most clearly through an examination of executive–congressional interactions. Therefore, the analysis below emphasizes congressional efforts to drive or restrain presidential policy implementation.

Congress and the Presidency: Realpolitik and Real Politics

The Constitution endowed Congress with four formal levers over the president’s conduct of foreign affairs. First, Congress can use its legislative power to legally bind the executive branch into conducting or refraining from certain activities. Second, the Senate must confirm high-ranking presidential appointments in the federal bureaucracy, including to positions necessary for the execution of nuclear policies. Third, all treaties must be approved by a two-thirds majority in the Senate. Finally, Congress controls the budget, an authority that can be used to starve presidential foreign policy initiatives of the necessary funding.

In the nuclear policy realm, an example of the power of the budget authority is the 1994 Agreed Framework signed by President Clinton with North Korea. Throughout its


5. Much of the information used is taken from interviews and research conducted for the author’s separate projects. In exchange for candor, most conversations with current and former government officials were conducted off the record or on background. However, all information attributed to anonymous sources has been verified with at least one other source.
troubled existence, the agreement suffered in part from congressional underfunding that resulted in the United States reneging on its side of the bargain.⁶

Congress also has several informal, nonlegislative means of influencing foreign policy. Like the president, members of Congress enjoy the power of the bully pulpit. They hold hearings, pass nonbinding legislation, and speak to the press.⁷ If they are members of the opposition, in particular, the media and public look to them for informed critiques of an administration’s policies. Senators and representatives can also engage with foreign governments on their own in fulfillment of their legislative work.

Nuclear Decisions from 2001 to the Present: Eight Variables

The following eight variables are examined in the following case studies. They are included on the basis of suggestions in the political science literature and by practitioners, or because they offer a plausible explanation of the outcome:

- **Interest groups**: The influence of organized interests is frequently cited in studies of domestic policy outcomes. Interest groups with international agendas or economic stakeholders also seek to shape government decisions. Like their domestically oriented counterparts, they exercise influence through direct lobbying of Congress or the executive branch, citizen mobilization, and the media.

- **Public opinion**: With the exception of occasional high-profile decisions, foreign policy is not a high priority for voters in the United States. Public opinion, however, has been described as a “trump card” in the “struggle between the President and Congress over foreign policy.”⁸ The respective popularity of the president and Congress may also be relevant.

- **Elite opinion**: Governments are influenced by the expertise and prescriptions offered by policy elites, which include academics, think tank analysts, editorial writers and journalists, retired government officials, and so forth. Elite opinion is often reflected in the news media and can shape public opinion as well as persuade the government’s policymakers directly.⁹

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- **Bureaucracy:** All actors in the federal government, from departments to individual officials, face the incentives of bureaucratic politics. They seek to maximize their resources and standing, and may support, oppose, ignore, or sabotage the president’s policies accordingly.

- **Perception of country’s regime:** The forms of nuclear statecraft described in this paper require the cooperation of other governments, some of which may be founded on very different ideological principles. If U.S. policymakers and the public were indeed influenced by the long tradition of American liberal thought, the other country’s regime type would be expected to influence the process.

- **Institutional control:** Politicians and policymakers affiliated with different parties can be expected to exhibit differing policy preferences. If lawmakers of the president’s party control the houses of Congress, the executive branch is more likely to receive support than if the opposition controls them. Even if the president’s foreign policies were not substantively objectionable, aiding presidential achievement would be inimical to the opposition’s electoral goals.

- **Other domestic factors:** Policy on a given issue rarely appears in a political vacuum. Additional domestic factors that do not fall into the above categories may be at play. This could take the form of competing policy questions distracting from the nuclear issue at hand or greater trends in political culture, such as moments of national unity or acrimony.

- **Other international factors:** In international relations, one would expect to find explanations for foreign policy decisions in the international environment. This paper is an effort to isolate domestic factors, but that can only be accomplished if they are contrasted with broader developments in the international system or in the nature of the relationship with the other country.

**Cold War, Revisited: Arms Control with Russia**

Arms control has a long history in the bilateral relationship between the United States and Russia, the heir to the Soviet Union’s nuclear arsenal. Integral to President Nixon’s détente with the Soviet Union was his willingness to negotiate mutual limits to land- and sea-based ballistic missiles, as well as restrictions on missile defense systems, in the Strategic Arms Limitations Talks (SALT). A second SALT round was negotiated, but not submitted to the Senate for ratification in response to the Soviet invasion of Afghanistan.

As the Cold War wound down, both sides returned to the principle of nuclear parity and agreed to reduce their arsenals under the 1991 Strategic Arms Reduction Treaty (START). The subsequent START II, which would have required further strategic arms reductions, never entered into force. Although the Senate agreed to ratify the treaty it-

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self, Russia insisted on a strengthening of the Anti–Ballistic Missile (ABM) Treaty for START II to take effect, which the Senate refused.\textsuperscript{11}

With the exception of the unilateral Presidential Nuclear Initiatives—in which President George H. W. Bush withdrew the bulk of tactical nuclear weapons from Europe, a move that was reciprocated by a crumbling Soviet Union’s Mikhail Gorbachev—all bilateral arms control agreements have taken the form of treaties. Under the U.S. Constitution, treaties require the Senate’s “advice and consent.”\textsuperscript{12} Instead of the typical simple majority vote required for domestic legislation, a two-thirds majority is necessary for approval of treaties.

Throughout the Cold War and its aftermath in the early 1990s, this high hurdle was not difficult for presidents to clear, as their vote counts demonstrate: The SALT I limits were approved by 88 to 2, START I with 93 in favor and 6 opposed, and START II with 87 yeas and 4 nays. The exception was the Senate’s refusal to ratify the missile defense protocol to START II.

The bilateral arms control process was driven by Republican administrations, which negotiated all treaties that eventually entered into force. Democratic-majority Senates, however, approved both SALT I and START I. The Senate refused to ratify President Carter’s SALT II agreement, despite a Democratic majority. With START II, a Democratic president submitted a Republican-negotiated treaty to a Republican Senate.

\textit{George W. Bush: The Best Defense Is a Good Defense}

The Bush administration was more skeptical of nuclear arms control’s benefits with Russia in a post–Cold War environment. The administration reorganized the State Department’s arms control bureau, not anticipating any future treaty-based arms reductions.\textsuperscript{13} With regard to Russia, the Bush administration believed that negotiating limits to weapons was appropriate for rivals, not countries cooperating on counterterrorism and other matters of mutual interest. With a growing missile and nuclear proliferation threat from rogue states, there was also little point in purposefully leaving the U.S. mainland exposed to missile attack for the sake of strategic stability with Russia. Therefore, in January 2002, the Bush administration withdrew from the ABM Treaty.

Russia reacted negatively. Vladimir Putin urged the Bush administration for an offensive limitations treaty, which eventually led to the signing of SORT, a four-page pledge to limit deployed weapons on the last day of 2012. Signed in May 2002, the agreement, also known as the Moscow Treaty, breezed through the Republican-controlled Senate in a 95 to 0 vote in March of 2003. A high-ranking State Department official in the Bush administration later expressed his surprise that Senate Democrats did not “ask hard questions” about the treaty.\textsuperscript{14}

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{11} Ibid.
\item \textsuperscript{12} U.S. Senate, “Advice & Consent: Treaties,” http://www.senate.gov/general/Features/Treaties_display.htm/.
\item \textsuperscript{13} Confidential interview with State Department official, July 8, 2011.
\item \textsuperscript{14} Confidential phone interview with former State Department official, July 15, 2011.
\end{itemize}
\end{footnotesize}
Free from the restraints of the ABM Treaty, the Bush administration secured the Czech and Polish governments’ permission to install a radar and up to 10 interceptors, respectively. This missile defense system was aimed at a potential future ballistic missile threat from Iran or other Middle Eastern nations and would not have diminished Russia’s ability to deliver intercontinental ballistic missiles to the United States. Nevertheless, Russia protested vehemently and refused to engage in negotiations for a replacement to START I, which was due to expire in December 2009.

Barack Obama: The First Democratic Arms Control Treaty

The Obama administration came into office with very different nuclear priorities than its predecessor. Rejecting the preceding administration’s focus on missile defense, the incoming president directed the cancellation of the Central European system. Instead, Barack Obama personally committed himself to advancing the multilateral and diplomatic approach to arms control and nonproliferation, articulating as his end goal the “peace and security of a world without nuclear weapons,” allowing that, “this goal will not be reached quickly—perhaps not in my lifetime.”

Although the Obama administration has publicly rejected the interpretation that its abandonment of the Polish and Czech missile defense system was connected to the irritation it had caused Russia, the cancellation opened the way for negotiations for a follow-on treaty to START I. Talks were initially slowed by bureaucratic efforts to reorganize the State Department for such negotiations and by delayed Senate confirmations of necessary staff. Furthermore, although the record has not been released, some observers of the negotiations believe they took longer than necessary because of Russian insistence on missile defense limitations in the treaty, which the Obama administration knew would never be approved by the Senate. A completed treaty, named New START, was signed in April 2010.

The Obama administration did not expect the same blithe authorization that SORT had received in 2003. It did not perceive the successful record of ratification for past bilateral arms reductions treaty to be the relevant precedent, but worried about a repetition of the Senate’s 1999 rejection of the Comprehensive Nuclear Test Ban Treaty (CTBT). The CTBT’s failure had surprised the Clinton administration, which many ascribe to its ignorance of a behind-the-scenes campaign by Senator Jon Kyl, a Republican representing Arizona, to defeat the treaty.

For New START, the administration recognized at the outset that it would need to either win over or neutralize Kyl, who had risen in influence among his caucus at the expense of the longtime pro–arms control Richard Lugar of Indiana. Kyl was courted even

16. Confidential interview with State Department official, July 8, 2011.
18. Confidential conversation with former staff to Senator Jon Kyl, November 2011.
during the negotiation process, when a Senate Democrat used her private plane to fly him to observe negotiations in Geneva. After months of legislative maneuvers, Kyl succeeded in negotiating an $84 billion, 10-year plan for the modernization of the nuclear weapons complex.\(^{19}\) Having met Kyl’s demands, the administration risked a floor vote it was not entirely confident it would win.\(^{20}\) In the December 2010 lame duck session, the treaty garnered 71 votes, only 4 more than necessary, with 26 opposing.

This narrow victory was pyrrhic. New START had initially been viewed by the administration and outside observers as a stopgap measure to assure the continued verification of the Russian nuclear arsenal, which had been lost with START I’s expiration. The nuclear infrastructure investments the administration committed had been planned as the currency with which to secure ratification of the CTBT.\(^{21}\) After the bitter and costly ratification battle, the administration has no actionable plans for a follow-on treaty with Russia as a real step toward the president’s goal of nuclear disarmament. Russia also has no interest in negotiating such an agreement, unless it addresses missile defenses, which would have minute odds of securing Senate agreement. In sum, the Obama administration achieved the narrow objective of ratifying the treaty, but at great cost to the remainder of its nuclear agenda (table 1).

The successful ratifications of SORT and New START bore many similarities in the relevant factors. In both instances, the Senate was controlled by the president’s party, and the treaty enjoyed broad support among the public and elite, as well as within the bureaucracy. Both floor votes were accompanied by other major events: the lead-up to the Iraq war during SORT and a disputed lame duck session, which Democrats used to pass a series of contested legislation.\(^{22}\) Presumably, the former may have been helpful and the latter harmful. Another significant difference was Russia’s softer image during the SORT ratification, which had degraded by the time of New START.

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21. This is the view of the pro–arms control lobby and is not necessarily indicative of White House planning. Interview with Daryl Kimball, executive director of the Arms Control Association, July 19, 2011.

22. Senator John McCain’s surprising vote against New START is generally attributed to his displeasure with the repeal of the Don’t Ask, Don’t Tell policy for homosexuals in the military. See Kimball interview.
<table>
<thead>
<tr>
<th>Variable</th>
<th>SORT, Bush (R)</th>
<th>New START, Obama (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest groups¹</td>
<td>Broad support from nongovernmental organizations (NGOs), little opposition</td>
<td>Active support from NGOs, little opposition²</td>
</tr>
<tr>
<td>Public opinion</td>
<td>Strong support¹</td>
<td>Strong support⁴</td>
</tr>
<tr>
<td>Elite opinion</td>
<td>Support</td>
<td>Support³</td>
</tr>
<tr>
<td>Budgetary/economic impact</td>
<td>Reductions would bring savings⁶</td>
<td>Approximately neutral</td>
</tr>
<tr>
<td>Bureaucracy</td>
<td>Supported by weapons laboratories, military, and intelligence community</td>
<td>Supported by weapons laboratories, military, and intelligence community</td>
</tr>
<tr>
<td>Perception of country’s regime</td>
<td>Illiberal democratic⁷</td>
<td>Authoritarian⁸</td>
</tr>
<tr>
<td>Institutional control</td>
<td>Republican presidency and Senate</td>
<td>Democratic presidency and Senate</td>
</tr>
<tr>
<td>Other domestic factors</td>
<td>Vote held two weeks before start of Operation Iraqi Freedom</td>
<td>Vote held during acrimonious lame duck session after heavy Democratic losses</td>
</tr>
<tr>
<td>Other international factors</td>
<td>High point of post–Cold War U.S. power</td>
<td>Russian threats to withdraw from treaty if the United States fielded missile defenses</td>
</tr>
<tr>
<td>Implementation of preferred policy</td>
<td>Success</td>
<td>Strongly qualified success</td>
</tr>
</tbody>
</table>

¹ Methodological note: Unless otherwise noted, these variables were determined by conversations with participants in the debate, personal observations, and an extensive literature review and scored subjectively by the author.

² NGOs favoring arms control enlisted faith-based and left-leaning organizations to organize grassroots campaigns in the states of pivotal senators in the lead-up to the ratification vote. Other than the Heritage Foundation, very few conservative organizations organized in opposition to the treaty.


⁵ The tenor of the mainstream policy elite’s discussions of the treaty was strongly favorable, with more opinion pieces appearing in favor than opposed. One notable opponent was the current Republican presidential candidate, Mitt Romney. See Mitt Romney, “Stop START,” Boston Globe, December 3, 2010, http://www.boston.com/bostonglobe/editorial_opinion/oped/articles/2010/12/03/stop_start/.


⁷ Although doubts were surfacing about the democratic health of the Russian political system, Russia was still broadly perceived to be on a democratic trajectory. For example, it was still rated as “free” by Freedom House. See Freedom House, “Russia: 2003,” http://www.freedomhouse.org/report/freedom-world/2003/russia/.

⁸ The treaty was negotiated with the newly elected President Medvedev, but the image of Russian democracy had been degraded since SORT. The nation was branded “not free.” Freedom House, “Russia: 2009,” http://www.freedomhouse.org/report/freedom-world/2009/russia/. New START opponents made frequent references to Russian untrustworthiness on the basis of their domestic regime type.
From Sanctions to Negotiations and Back Again: Iran’s Nuclear Program

Following the Iranian Revolution in 1979, diplomatic relations between the United States and the Islamic Republic were cut. In subsequent years, relations grew more hostile because of Iran’s support for assorted militants and terrorists and concerns over Iranian weapons of mass destruction programs. The United States responded with embargoes and sanctions against the regime. These coercive diplomatic measures were mostly imposed by executive order. However, Congress also formalized them in legislation, culminating in the 1996 Iran Sanctions Act (ISA). 23

Revelation and Negotiation: The Bush Administration and Iran

The routine of mutual malign neglect was disrupted by an Iranian opposition group’s revelation in August 2002 that Iran was constructing a clandestine uranium enrichment facility near Natanz. In response to the alarm this created in the West, Iran is reported to have used a Swiss channel in May 2003 to offer full nuclear transparency, as well as to address many other key issues on the U.S. list of grievances. The Bush administration denied having received such a comprehensive offer and opted for a policy of greater pressure on Iran. 24

The Bush administration did not oppose European-led negotiations with Iran, which achieved a temporary Iranian suspension of uranium enrichment, but it finally broke down in August 2005. In June 2006, the United States joined in the negotiations alongside China and Russia, but this new negotiating format achieved little by the time George W. Bush left office in January 2009.

In building pressure on Iran, the Bush administration did not work closely with Congress. Members complained that ISA was not being applied to punish international companies still engaged in business with Iran. ISA vests the authority to determine violations with the executive branch. Members of Congress worked toward legislation that would remove this presidential discretion to waive sanctions, but it never became law. 25 To secure three UN Security Council sanctions against Iran, the Bush administration was cautious not to antagonize China or Russia, whose companies would have qualified for ISA sanctions. As additional unilateral measures, the Treasury Department led an unprecedented campaign of financial measures against Iranian banks and companies. 26

Dual Track: Pressure and Engagement under President Obama

The Bush administration received criticism in Congress and the press for the preconditions it placed upon negotiations with Iran, but was mostly free of domestic constraints

25. E.g., the September 2007 H.R. 1400 would have achieved this if it had become law. See Katzman, “Iran Sanctions,” 7.
to pursue its preferred policies. President Obama has had a very different experience, which began during his pursuit of the party nomination, disagreeing with his main rival Hillary Clinton over the prudence of engaging Iran. During the nomination process for the 2012 Republican presidential candidacy, Obama’s Iran policy was described as his “greatest failing.”

The Obama administration began its efforts to diminish the Iranian nuclear threat by acting on its promise of engagement with messages to the Iranian people and government. When Iran’s disputed 2009 presidential election gave rise to the Green Movement, the administration restrained itself from the kinds of antiregime rhetoric some Republican members of Congress were advocating, fearing that they might imperil the efforts at engagement.

Iran did not unclench its fist, and the Obama administration shifted emphasis toward the other half of its dual-track strategy: pressure. In June 2010, the UN Security Council agreed to U.S. insistence on a fourth round of sanctions against Iran, and, in November 2011, Obama signed an executive order to pursue further financial punitive measures. However, even to lawmakers of his own party, President Obama has not been aggressive enough. After the administration requested delays and less stringency from its Democratic sponsors over half a year, Congress passed an update to ISA in July 2010, although the administration has not made much use of provisions in the new Comprehensive Iran Sanction, Accountability, and Divestment Act (CISADA).

Then came the most significant congressional impingement on the administration’s freedom of action: the sanctions levied against Iran’s central bank as part of the 2012 National Defense Authorization Act. The administration “strongly opposed” this measure, and the president issued a signing statement that he would treat any provisions that he believed would “interfere with [his] constitutional authority to conduct foreign relations” as “non-binding.”

The above narrative might suggest that the Obama administration has repelled congressional attempts to shape its Iran policy, but that would miss the president’s self-restraining political deference. Some inside the administration have advocated for greater risk taking in engaging Iran, perhaps through unilateral gestures of good will. This view has been quashed over concerns of the electoral harm such initiatives might cause. Thus, the political constraints imposed by Congress and the opposition amount to a failure of President Obama to retain full control over the administration’s policy toward Iran (table 2).


**Table 2. Iran’s Nuclear Program during the Bush and Obama Presidencies**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pressure—Bush (R)</th>
<th>Dual Track—Obama (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest groups¹</td>
<td>Supportive groups more powerful than those advocating for negotiations.</td>
<td>General support for pressure track, criticism of engagement track from pro-Israel groups.</td>
</tr>
<tr>
<td>Public opinion</td>
<td>Divided</td>
<td>Support²</td>
</tr>
<tr>
<td>Elite opinion</td>
<td>Divided</td>
<td>Divided</td>
</tr>
<tr>
<td>Budgetary/economic impact</td>
<td>Sanctions affected a few U.S. companies</td>
<td>Sanctions affect a few U.S. companies</td>
</tr>
<tr>
<td>Bureaucracy</td>
<td>Interagency supportive, but 2007 National Intelligence Estimate politically unhelpful³</td>
<td>Dissatisfaction with White House at State Department</td>
</tr>
<tr>
<td>Perception of country’s regime</td>
<td>Repressive theocracy—enemy of the United States⁴</td>
<td>Repressive theocracy—enemy of the United States, with new human rights abuses and electoral fraud</td>
</tr>
<tr>
<td>Institutional control</td>
<td>Mixed D and R control of House and Senate</td>
<td>D Senate throughout, House went to R in 2011</td>
</tr>
<tr>
<td>Other domestic factors</td>
<td>Post–September 11th concerns over weapons of mass destruction</td>
<td>Iran is a Republican campaign issue⁵</td>
</tr>
<tr>
<td>Other international factors</td>
<td>Iraq and Afghanistan wars drew public and policymakers’ attention</td>
<td>Green movement repression and Arab Spring make accommodation with regime unpalatable; Israeli desire for prompt resolution⁶</td>
</tr>
<tr>
<td>Implementation of preferred policy</td>
<td>Success</td>
<td>Qualified failure</td>
</tr>
</tbody>
</table>

¹. Unless otherwise cited, the description and classification of variables are based on personal judgments informed by conversations with relevant policy process participants.


⁴. A recent poll found that 83 percent of the U.S. public views Iran negatively, with half of all respondents characterizing the Islamic Republic as an enemy of the United States. This negative perception increased by roughly 10 percentage points with the revelation of Iran’s clandestine nuclear program and has been steadily inching up since. See CNN Opinion Research Poll, May 31, 2011, 2, http://i2.cdn.turner.com/cnn/2011/images/05/31/re9e.pdf/. In both periods, Iran was rated “not free.” Freedom House, “Freedom in the World: 2003,” http://www.freedomhouse.org/report/freedom-world/2009/iran/.


Over the past decade, Iran has gotten significantly closer to a nuclear weapons capability. Although the problem has gotten worse, the Obama and Bush administrations have faced very similar circumstances at home. However, Obama has not succeeded in executing his preferred dual-track policy of simultaneous engagement and pressure. His administration has emphasized the latter even as it has devoted its energies to assuring that congressional pressure would not undermine its efforts to build an international
coalition against Iran. By many of its top officials’ admission, the administration has not fully exhausted opportunities for diplomatic engagement for reasons of domestic politics, in spite of evidence of majority public support for Obama’s diplomacy-first approach.

Three clear differences emerge in the variables under consideration. First is the political salience that the Iran issue assumed during the Obama presidency and the Republicans’ selection of it as a major 2012 presidential campaign theme. Israel’s publicly vocal insistence on an end to Iran’s program is the second. The third is the wave of protests washing over the region, beginning with the failed Iranian Green Movement. The Obama administration may fear the domestic political consequences of striking a diplomatic bargain with a repressive regime. Further, any agreement struck by Obama would need to favor the West’s priorities more than one concluded by Bush. This further narrows the possible zone of agreement between the United States and Iran.

Limitations to Presidential Nuclear Statecraft

Both the Bush and Obama administrations have faced similar domestic hurdles to implementing their nuclear weapons–related policies, but the Republican seems to have enjoyed greater success. A partisan interpretation may be that Bush may simply have had better policies or was a more effective president. A Democratic retort might be that his policies were less ambitious and therefore easier to achieve. With respect to each variable:

- **Interest groups:** In all four examined instances, the configuration of interest groups is correlated with the outcomes. A more powerful constellation of advocacy groups backed arms control with Russia than opposed it. Similarly, greater influence supported pressure on Iran rather than engagement.

- **Public opinion:** Public opinion was aligned with the Russian outcomes, but the public’s support for diplomacy does not appear to have aided President Obama’s failure to fully pursue his preferred engagement strategy.

- **Elite opinion:** It is difficult to ascertain the influence of policy elites on the Iran question because they are very divided. With arms control, the predominant view was supportive of the eventual outcome.

- **Bureaucracy:** Both administrations were united on the Russian treaties. The Obama administration has suffered from greater internal divisions over its Iran policy than was apparent in the Bush administration, which may be evidence for the influence of bureaucratic politics.

- **Perception of country’s regime:** Both nations’ images degraded in line with presidential ability to pursue bargains with them.

- **Institutional control:** Contrary to expectations, the outcomes were not affected by whether the president’s own party controlled the houses of Congress.
- **Other domestic factors:** Unlike the Bush administration, the Obama presidency found itself confronting an opposition that elevated its Iran and Russia policies to major political and electoral issues.

- **Other international factors:** With the caveat that this paper has not included a full survey of international variables, foreign factors do not appear available as major determinants.

Contrary to some practitioners’ protestations, these nuclear statecraft cases demonstrate that domestic politics influences the shaping of foreign policy. It appears that on nuclear policies, the president has his hands on the steering wheel, but Congress—like a driver’s education instructor—has a second accelerator and brake pedal.

Congress appears to do the most damage to a president’s nuclear agenda not with its formal authorities but through its ability to raise the political cost of acting against its wishes. That is how, in the absence of legal restraints in determining U.S. policy toward Iran’s nuclear program, Congress demonstrably holds an informal veto against the Obama administration. Congressional opposition can be overcome, but at a very high political cost that the president is unlikely to incur for a high-risk and low-payoff initiative with Iran, which is unlikely to respond in kind.
The Impact of Emerging Technology on the U.S. Nuclear Triad

Jeffrey C. Boulware

Treaty agreements limit the development of new weapon systems in the nuclear triad and their carrier vehicles; however, this does not prohibit the United States from integrating new technology into its post–Cold War nuclear mission. Research into nuclear forensics, enrichment, and modeling and simulation has garnered much attention, but the bounds of science and technology are far more vast. The intent of this project is to examine various aspects of emerging technology, what their role could be in the nuclear triad, and their impact on political, fiscal, and strategic concerns.

Research into technological advances within the U.S. nuclear triad must focus on different aspects than those pursued during the height of the Cold War. Arms reduction treaties, such as the Strategic Arms Reduction Treaty (START) and its successors, have restricted the types of weapons systems that can be developed; however, this does not necessarily limit the impact that emerging technology can have on military strategy. In previous decades, heavy investments were made to increase yield, reduce weight, and improve carrier vehicles. With the fall of the Soviet Union, the U.S. nuclear mission has shifted its research to ensure a safe, secure, cost-effective, and enduring stockpile while maintaining its primary role as a global deterrent. Bodies like the International Atomic Energy Agency now require investments into areas like nuclear forensics, enrichment techniques, and nuclear modeling and simulation, and while these areas will aid the U.S. mission, other, less-explored areas of technology should also be considered for their impact. The intent of this paper is to review certain types of emerging technologies for the roles they could play in the U.S. nuclear triad and the potential impact they could have on political, fiscal, and strategic concerns.

1. Jeffrey C. Boulware is a civilian engineer with the U.S. Air Force. The views expressed herein are those of the author and do not necessarily reflect the views of the Air Force or the U.S. government. Due to the potential sensitivity of discussing military technology, it is critically important to note that the author has not consulted with any member of the military or federal government and acknowledges that the ideas expressed herein are his and his alone. The potential applications described are purely theoretical and conceptual and do not in any way represent any actual work being performed by the U.S. government or private industry.
Military and Domestic Technology

Inarguably, technology plays a critical role in warfare. Some of the most notable examples are the Mongols’ use of mounted archers to expand through Central Asia, the conquistadors’ use of firearms to control indigenous American tribes, and Hitler’s blitzkrieg invasions early in World War II. Each of these examples and countless others throughout history are conflicts in which the successor overpowered its opponent through advanced weaponry and tactics. The battlefield technological advantage, however, does not always guarantee success. Infamously, the U.S. pullout in Vietnam and Custer’s Last Stand at the Little Bighorn River represent instances where technology was trumped by other factors. Furthermore, battlefield technology is only made possible due to a strong domestic base. For example, although his technological capabilities were near that of the Allied Powers, Hitler’s demise near the end of World War II can be attributed to his lack of resources and other infrastructural failures.

Through these lessons, history has shown that reduced research, development, test, and evaluation (RDT&E) investments in weapon systems do not necessarily limit the effectiveness of the overarching U.S. nuclear posture. The 2010 Nuclear Posture Review indicates investments into areas that indirectly improve U.S. military might, such as life extension programs, command and control, modernization of the national laboratories, and stockpile stewardship including nuclear forensics, surety, and modeling and simulation (M&S) as a replacement for testing. None of these research areas affect the capability or quantity of nuclear weapons that the United States possesses; hence, they are acceptable by treaty. But, unquestionably they augment the cost-effectiveness, flexibility, and confidence in the United States’ nuclear posturing. Internationally, the reaction to these investments is relatively silent when compared with the reaction garnered from discussions on more sensitive areas, such as ballistic missile defense. Nonetheless, investments into support infrastructure lead to a question that may have a serious influence in future negotiations with the United States’ nuclear partners and foes. That is, at what point does the U.S. war machine become so cost-efficient that other countries will want to limit not only U.S. military capabilities by treaty but also U.S. domestic capabilities? Fortunately, this is not an immediate threat, and it is doubtful that the United States would allow others to have such a deep impact on its domestic industrial base. But when discussing emerging technology, it is a relevant question if the technology is a serious game-changer. For example, if the United States were to develop a revolutionary technology that somehow reduced operational costs by 90 percent, it would have a significant advantage over its rivals. Or if the U.S. alternative energy industry made significant strides in solar cells for environmental purposes, a foreign country could argue that it was dual-use technology that, when applied to an unmanned aerial vehicle (UAV), would give the United States an unfair advantage by enabling the capability for a permanent airborne platform for reconnaissance or communication. Thus, the question regarding war machine effectiveness will be considered when reviewing emerging technology.

Readiness Assessment

Integrating new technology in the nuclear triad requires cooperation from congressional and defense research bodies. The RDT&E work itself may be performed by agencies such as the Defense Advanced Research Projects Agency, Air Force Research Laboratory, the Department of Energy’s laboratories, or other private groups, but allocation of the funding would be controlled by bodies such as the White House Office of Science and Technology, the Senate Committee on Commerce, Science, and Transportation, or the House Committee on Science, Space, and Technology. And although funding is the literal bottom line of decisionmaking, economic requirements for RDT&E are difficult to ascertain and cannot be addressed with high confidence. Instead, an assessment of the technology readiness level (TRL) is used to estimate maturity simply because the actual cost for procurement ranges widely on the application. Likewise, the manufacturing readiness level (MRL) is often used alongside the TRL to ascertain when the technology can be put into practice. Like the TRL, the MRL is dependent on application; thus, both readiness levels will be concurrently estimated simply as low, medium, or high. While this may seem indefinite compared with the actual TRL/MRL scales used by various agencies, the intent of this paper is to give a top-level review of emerging technologies, and a deeper discussion would require a much more focused analysis than the scope of this paper allows.

As with cost, the time to development is largely dependent on national needs. An inexperienced program manager may point to the Manhattan Project, Hoover Dam, or Apollo program as examples of magnificent projects being accomplished in a relatively short amount of time. And any scientist studying a particular area will state that his or her research could be put into practice within just a few years if the necessary funding were available. Unfortunately, when the national need is low, grand projects can take several decades, if they can be completed at all. Some point to an overly bureaucratic acquisition process as the reason for lengthy procurements; however, the relatively quick procurement of the Predator UAV system in the mid-1990s shows that national need can influence the time to deployment. National needs are ever changing and, again, due to this variance, the TRL/MRL assessment can only be put into vague terms such as low, medium, or high.

The undetermined cost and time required for deployment also leads to subjectivity on what is considered an “emerging” technology. This study attempts to limit its scope to technologies that could be deployed within approximately 10 years, assuming national need is high. This restriction eliminates far-out concepts such as antimatter propulsion engines or plasma artillery since these ideas still verge more on science fiction than anything else. However, some concepts seem far-out, such as carbon nanotubes or cloaking devices, but have actually made significant progress recently and could become feasible within a decade if national interest were high. These concepts are addressed here, even though the depth of analysis is limited by publicly available knowledge.
Analytical Parameters

To determine the impact a particular technology may have, the facets of an effective military beyond the battleground must be identified. Millet and his colleagues point out 19 areas that are necessary for a successful military organization, but for the purpose of discussion, these areas can be summarized into five pillars as sort of a pentagon for the Pentagon. These five pillars are categorized as military fundamentals, technological prowess, funding profile, domestic support, and foreign support.

For the purpose of this study, military fundamentals are considered as the components typically associated with a winning military campaign. These include, but are not limited to, strong leadership, a well-defined organizational structure, experienced soldiers and strategists, proficient intelligence, surveillance, and reconnaissance (IS&R) capabilities, and well-guarded vulnerabilities. These military fundamentals enable tactics and are historically critical to the battlefield.

As mentioned in the previous examples listed, a significant technological advantage typically leads to victory. Since the confrontation is not always guns versus arrows, these technological advantages tend to affect the battlefield in less obvious ways. The advent of nuclear technology also happened to coincide with the development of the turbojet engine, ushering in the age of modern fighter jets. The nuclear arms race may have dominated headlines during the time, but discoveries and innovations regarding advanced metal alloys, avionics, and supersonic aerodynamics led to increased ranges, speeds, and firepower of American and Soviet forces. The fall of the Soviet Union left the United States as the only remaining superpower, largely due to the technological prowess of its nuclear and conventional forces developed over decades.

The fall of the Soviet Union also illustrates another critical pillar to an effective military: a strong funding profile. Considering the previous two pillars, military fundamentals and technological prowess, the Soviet Union and the United States were relatively even and stood above all other nations. The Soviet Union’s fall can be attributed to basic arguments concerning capitalism versus communism, arguments that are strengthened by the fall of nearly every other communist nation on the planet. The economic failure crippled the Soviet Union to the point of its demise, but the question of funding lies in more than just the magnitude of wealth. Stability and the appropriate distribution of investments are also key factors. The success of the U.S. National Aeronautics and Space Administration (NASA) during the Apollo program contrasts to its recent struggles with high-level missions because of changes in goals during administration turnovers. Although it is well funded, the lack of a consistent goal causes program cancellations, thereby wasting millions or billions of taxpayer dollars.

An entire nation backing the military mission can have a profound effect on warfighting success, particularly in democratic nations. The United States’ success in World War II would not have been possible if the nation had not been united for these causes. In contrast, the lack of support for the Vietnam War and the Iraqi War—whether from

politicians, the population, or both—exacerbated what many would consider a failure, particularly when augmented with other factors. Furthermore, with the advent of immediate global communication through the Internet, tyrannical governments today have an even smaller chance of success compared with Roman, Chinese, or other dynasties during ancient times. An interesting example of this phenomenon is North Korea. The rest of the world recognizes the fanatical, oppressive leadership of the Kim dynasty, which has remained in power for over 60 years. Whether inspired by adoration or fear from the populous, North Korea is an example of how domestic support can overcome shortfalls in economy and technology in order to advance their military. For developed nations, domestic support can vary depending on the issue at hand, whether it is national security, global responsibility, or human rights.

If domestic support represents the internal relations of a government with its people, foreign support represents its external relations with other governments. Modern international politics are an intertwinement of economies, cultures, military prowess, and a host of other issues. Sanctions imposed by the United Nations, as well as other bilateral and multilateral agreements, have the power to cripple a nation in one area if they are not cooperative in another. For example, North Korea’s food agreement with the United States was canceled because of its illegal rocket launch in April 2012. Foreign support can be mixed, too, as shown by the Syrian uprising against al-Assad. Most nations condemned the regime’s violence, yet the area has been void of UN peacekeepers (as of the time this paper was written) because of the opposition of Russia and China, which are vetoing members of the UN Security Council. The lack of foreign support can also have an economic effect on militaries in peacetime, as shown by the potential withdrawal of Canada, Italy, and Norway in the development of the F-35 joint strike fighter. Without these development partners, the vested countries bear a greater cost per aircraft and may, therefore, need to reduce the size of their fleets accordingly.

**Collective Analysis**

Each of the five pillars described above is codependent and cannot be discussed in isolation. For example, the UN imposed sanctions against Iran’s oil exports due to the country’s lack of transparency with regard to its nuclear program. In terms of the five pillars, the rising technological prowess of Iran introduced a serious military threat to other nations in the area. This led to reduced foreign support, which resulted in an attempt to penalize Iran’s economy. The hope was that the hindered economy would reduce domestic support for the nuclear program and inspire the country’s leadership to be more willing to compromise when negotiating with the UN.

However, for many nations, economic stability stems from a diverse portfolio of imported resources; thus, the reduction of oil being imported from Iran can be overcome by

increasing imports from Saudi Arabia. This diversity allows the sanctions to be effective; however, imposing them can lead to rising costs, which may in turn reduce domestic support for the enforcing nations. In the United States, the rising cost of gasoline aggravates people enough to the point where it can influence elections. Thus, the challenge for the UN is how to employ policies that maximize efficiency without sacrificing its own interests. In terms of the focus of this paper, implementing new technology, the five pillars are collectively taken into consideration through the respective technology’s effect on military strategy, readiness (TRL/MRL), economic impact, domestic perception, and foreign perception.

Emerging Technologies

The technologies to be considered are split into five main categories—information technology, material science, energy, robotics, and aeronautics—each with its own subsets, and some being more generic than others. The advances discussed are meant to be the next generation above the current state of the art.

Information Technology: Computing and Telecommunications

As is often cited, the computing industry advances faster than can be recorded. Processing speeds have shown strong correlation to Moore’s Law for over 30 years, but some predict that a limit to computation is approaching due to the physical limitations of the speed of light and the finite size of an atom. When this limit occurs, however, is debatable. Many experts believe performance will peak within the next decade due to the aforementioned physical limitations such as single-atom transistors, but some predictions have it much further in the future. For example, Krauss and Starkman wrote that the limit may not be broached for another 600 years. The Krauss and Starkman study based its computations less on engineering and material limits and more on the nature of energy in an expanding universe. The approach of the Krauss and Starkman study may have ignored some undeniable restraints, but it at least gives way for unforeseen innovation and ingenuity in the rapidly advancing field. For example, recent advances in nanotechnology have allowed the usable production of graphene, which many believe is the next miracle material. Graphene is essentially a single layer of carbon atoms arranged in a honeycomb structure that exhibits extraordinary conductivity as well as mechanical, thermal, and optical properties. For computers, replacing silicon with graphene could create microchips 100 times faster than today. Other advanced methods include using photons to transmit information, a process known as quantum computing.

Japan, and the European Union have already made plans to launch and test satellites based on quantum computing, which, aside from incredibly quick transmission speeds are also inherently hacker-proof and wireless.\(^8\)

At the turn of the twenty-first century, residential wireless networks were relatively rare, but now are standard and commonplace. Commercial airlines have begun offering wireless fidelity and will soon switch their communication links from ground-based towers to satellites.\(^9\) A new antenna will enable long-range, secure military satellite communications for airborne platforms, providing voice, video, and chat capabilities at very high speeds.\(^10\) The antennae are receivers of the data and satellites are the transmitters, but changing the nature of the signal itself could have a drastic effect. Current signals transmit through radio waves in the gigahertz-scale region, but attempts have been made to transmit through microwaves or infrared waves, which would be 1,000 times faster, in the terahertz-scale region.\(^11\) On the more innovative side, illegal file-sharing networks have started using aerial drones to host their servers in an attempt to evade law enforcement, a concept that could be mimicked by military vehicles on or near the front lines.\(^12\)

Data transmission is only useful if it can be stored, however. Flash memory has become the latest and greatest due to its small size, large capacity, and low cost. Many researchers are racing to replace it with their ideas; for example three-dimensional (3D) optical memory storage. The transition from floppy disks to CDs showed the advantages of optical memory over magnetic tape, but a CD is only two dimensional. Enabled by nanotechnology, most designs for 3D optical memory are still in development, but the ultimate product will be revolutionary. Researchers from Rice University have produced a chip that is rugged enough to survive 1,000°F, flexible enough to fold like a sheet of paper, and transparent enough to be used in windshields.\(^13\)

In the Digital Age, all military systems benefit from faster, more secure communication. The advent of radio before World War I forever changed military tactics through advanced situational awareness. The United States already holds a significant advantage

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in all forms of computing on the battlefield, but the criticality of the nuclear enterprise and the growth of cyberespionage are constantly raising the stakes. Because computers are not independent weapon systems (outside cyberwarfare), foreign nations have not previously protested U.S. development or integration of revolutionary advances. Domestically, the advances would have a clear commercial application and would, therefore, be welcome. Financially, the advances would be a huge boon once developed, but the upfront cost may be too much for one organization to absorb. Fortunately, the wide applicability and high interest in academia spread the research cost and allows for faster development. Yet, though advances in computing and telecommunications are welcome because they enable other technology increases, the close relationship to cyberwarfare will drive the direction of research.

Information Technology: Cyberwarfare

Cyberattacks represent the hallmark of warfare in the Digital Age. They are often compared with a nuclear attack, and they could be just as debilitating—yet are far more likely to occur. The average person experiences cyberwarfare through ploys known as phishing, whaling, or spoofing, often at an attempt to commit identity theft. For the armed forces, the consequences are much more severe. The Center for Strategic and International Studies has identified 97 incidents since 2006 of successful attacks on government agencies, defense and high-technology companies, or economic crimes with losses of more than $1 million. The list of incidents, however, is only limited to publicly known attacks as some victims may not wish to make it known (or do not know themselves) that they were attacked. Furthermore, the list does not include the countless attempts that occur on a daily basis. The lack of an effective response to a cyberattack has increased their prominence since there are essentially no consequences. Some even believe that Chinese cyberespionage is to blame for the rising costs of the F-35. In March 2012, the deputy secretary of defense, Ashton Carter, stated that he is not “remotely satisfied” with the Pentagon’s cyber capabilities. These cyberattacks have infuriated government and military officials for years, prompting the establishment of a new unified command center known as U.S. Cyber Command, which encompasses all aspects of offensive and defensive cyber–war fighting and is supported chiefly by the Army, Navy, Marines, and Air Force. The Obama administration likely utilized Cyber Command for its cyber-


attacks on Iran known as Olympic Games, which purportedly included the infamous Stuxnet virus.\textsuperscript{17}

At a conference two weeks after Carter’s comments, the secretary of the Air Force, Michael Donley, remarked that the Air Force has 45,000 trained and certified professionals in cyberspace and is continuing to grow.\textsuperscript{18} As with any military campaign, these professionals will likely study vulnerabilities in U.S. systems, including the nuclear triad. Foreign governments understand the issue as well as the United States and have probably stood up their own commands to some degree; thus, any objections to advances in cyberwarfare would be seen as hypocritical, particularly among industrialized, unfriendly nations. The average American, however, primarily views cyberattacks as a means of identity theft and may not be able to conceptualize a sophisticated offensive capability. Defensive advances would undoubtedly be supported and also aided by commercial ventures wishing to protect their interests.\textsuperscript{19} Unfortunately, the novelty and increasing complexity of cyberwarfare make drafting international policy extremely difficult, and the repercussions of attacks are negligible. And because protective measures lag behind strikes, the solution may not be technologically based. Only once a physical war or loss of life occurs will meaningful agreements take place that alter the scope of cyberwarfare.

\textit{Information Technology: Sensors and Imaging}

Because a photographic image provides a distinct piece of evidence useful for a range of purposes, sensors and imaging of sensitive locations, documents, and weapons make up the heart of IS&IR. Photographs of Soviet missile bases taken from a U-2 prompted the Cuban Missile Crisis. Depictions of gadgetry in James Bond novels and movies are not far off from the actual surveillance equipment used in Cold War espionage. The launch of Sputnik began the space race and introduced spying from vast distances in space. Conveniently, technology used to look down at the Earth from orbit often comes from sensors used to look outward from orbit at the universe. For example, the European Space Agency is constructing the largest array ever built to study the stars with over a billion pixels.\textsuperscript{20} But just as important as imaging from space, imaging at the ground level could play a large role in the nuclear triad. For IS&IR, recent advances in lasers allow for femtosecond-scale bursts that reflect off surfaces, allowing for an imaging system

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that can peer around corners.\textsuperscript{21} Advances in nanomaterials enable heightened infrared or thermal imaging.\textsuperscript{22} Aside from IS&R, however, advances in microscopic imaging are allowing researchers to view extremely fast movements in chemical reactions,\textsuperscript{23} and the first-ever image of atoms forming a molecule.\textsuperscript{24} These techniques could possibly be applied to nuclear physics so that subcritical nuclear tests would become more valuable for the knowledge gained and M&S would become more effective.

As stated above, the military aspects of sensors and imaging branch from IS&R to M&S. The financial payback of developing such technology is debatable, as limited applicability exists on the commercial side. Law enforcement would be the primary sector for IS&R applications; but with limited budgets, local offices outside major cities may not be able to justify the cost of such sophisticated systems. Microscopic imaging, however, may have more suitors. Even just within the nuclear industry, private companies wishing to advance their civil power generating reactors would benefit from the information gained from atomic-scale observations of actual reactions. Whether this would garner a favorable return on investment is undetermined and requires much further analysis. The general American public would likely support advances in sensors and imaging due to their application to personal point-and-shoot digital cameras. Internationally, the reaction would not be different. Governments may protest if and when advanced systems are deployed on military vehicles, but typically the details of these systems are kept classified. Ultimately, advances in sensors and imaging indirectly benefit the triad by enabling IS&R and fundamental research and do not have any major obstacles for development.

\textit{Material Science: Advanced Materials}

Materials science has been a backbone of technological superiority for millennia. Iron hand weapons are stronger than bronze. Aluminum has a greater strength-to-weight ratio than steel. Composites are tailorable, while isotropic materials are not. Possessing advanced materials has always and will always be a critical component to winning on the battlefield. The best hopes for the next generation of advanced materials seems to revolve around smart materials and nanotechnology. Smart materials, also called metamaterials, are materials that react to the environment around them. The most common method is the application of a small amount of electric voltage to change its intrinsic properties.\textsuperscript{25} Reading glasses that change to sunglasses when one steps outside are reacting to a change in light. A special type of plastic is being created that reacts to damage


\textsuperscript{23} Michael Bishop, “First Step Taken to Image Ultra-Fast Movements in Chemical Reactions,” Institute of Physics, March 16, 2012, \url{http://www.iop.org/news/12mar/page_54659.html}.


by bleeding and healing itself.\textsuperscript{26} Smart materials have the potential to change the basic nature of engineering design due to their flexibility. Likewise, nanotechnology has seen vast growth over the past few years because of the possible super materials it could introduce to the world, such as graphene. Nanotechnology focuses on the microscopic scale of changing the molecular structure of materials and could lead to revolutionary advances in many industries. Large structures could take advantage of a paint that uses carbon nanotubes to detect structural cracks,\textsuperscript{27} or a “nanoear” could be developed to listen to the faintest, most microscopic sounds.\textsuperscript{28} Both smart materials and nanotechnology are being heavily researched and have a rapidly rising TRL/MRL, but application to the nuclear triad may be too far away for discussion today. Nonetheless, all forms of advanced materials have spin-offs to civil applications, which in turn will likely lead to domestic and foreign support. For example, the Minerals, Metals, and Material Society has identified 54 specific breakthrough opportunities that could eliminate $65 billion in unproductive energy expenditures as soon as in the next 2 to 10 years.\textsuperscript{29} These opportunities are not militaristic; so the nuclear triad will logically allow the commercial sector to fund development and reap the gains when the time is right.

\textit{Material Science: Additive Manufacturing}

For any design, development is not worthwhile if it cannot be manufactured feasibly. Additive manufacturing is a process in which a powdered substance is sprayed into layers using an adhesive to form larger-scale geometry. The eventual shape can either be a prototype or final product depending on the application. A trade by many names, additive manufacturing is also often referred to as rapid prototyping or 3D printing. Its boon is that it allows designs to transition from a computer screen to a physical product within a matter of minutes. Typically these products are metallic or plastic based, but do not have quite the same properties as an isotropic product would; but again, they may be

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\item \textsuperscript{26} Catherine Hockmuth, “Smart, Self-Healing Hydrogels Open Far-Reaching Possibilities in Medicine, Engineering,” University of California, San Diego, News Center, March 5, 2012, http://ucsdnews.ucsd.edu/pressreleases/smart_self_healing_hydrogels_open_far_reaching_possibilities_inmedicine_en/.
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suitable depending on the application at hand. An additive manufacturing capability is often discussed as a need for astronauts at the International Space Station, and the same argument could be made for sailors inside a submarine. As a complex machine that is disconnected from the rest of the world for months at a time, a submarine could experience any number of unexpected failures. With the ability to create custom parts within its hull, a submarine would be more self-sufficient and could reduce the number of spare parts it has to carry; thereby reducing operating costs significantly. Furthermore, additive manufacturing has become far more common in industry and academia, so the domestic reaction would be mild. Likewise, the foreign reaction may be slightly negative, but not significant enough to make a difference. The technology would bring an advanced capability to the submarines, but those capabilities do not have significant battlefield use. If the submarines can already maneuver about the world without detection, increasing their mean time between failures will not add a new capability that poses a threat.

**Material Science: Cloaking**

The F-22 and F-35 stealth aircrafts are fifth-generation fighters and are unparalleled by the aircraft of any other nation. The B-2 is the only operational stealth bomber in the world and has proven its worth in combat. Despite U.S. superiority in the skies, the demand for greater capabilities is ever growing, and advancing detection systems expedite the date of obsolescence of these vehicles. Although the technology seems far-fetched, the Navy has recently put out a call to develop vehicles with ultraviolet (UV) cloaking.Cloaking is essentially a means of stealth or invisibility and may not be as unreachable as expected.

All forms of detection—whether through eyesight, sonar, or radar—are based on reflections of certain types of waves. For eyesight, reflections of visible light off an object are detected by the retina in the eyeball. For sonar, sound waves are detected; for radar, infrared waves. Current stealth technology is based on evading radar detection by using materials and shapes that either absorb the infrared waves or reflect them away from the originating sensor. Although no formal definition classifies a stealth material from a cloaked one, recent usage is beginning to distinguish one from another. Broadly speaking, cloaking can be thought of as the overall masking of an object from detection, whereas stealth has become mostly associated with infrared waves. If this definition is adopted, stealth would become a subset of cloaking. At that point, further subsets can

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be defined for subsets like UV cloaking, visible light cloaking,\textsuperscript{33} thermal cloaking,\textsuperscript{34} magnetic cloaking,\textsuperscript{35} or virtually any other means of detection. While the TRL/MRL of these advanced forms of cloaking may seem low, the high potential for military purposes would keep sensitive information from the public. After all, stealth technology seemed decades into the future even as the F-117 was deployed.

Because the B-2 is already stealthy, submarines are difficult to detect by nature, and intercontinental ballistic missiles (ICBMs) deploy within a matter of minutes, the benefit of cloaking to the nuclear triad by be vastly outweighed by the cost. Naturally, avoiding surveillance is a desirable feature, but if a lesson is to be learned from the F-22’s production, it is that operating costs can be extremely high.\textsuperscript{36} Then again, the realizable benefits of the F-22 as a fifth-generation fighter jet could be decades or more into the future. Although the TRL of certain forms of cloaking could potentially see a dramatic rise due to heavy academic interest, the MRL may remain low for quite some time. This, in turn, drives an unfavorable economic impact, which would also induce an unfavorable domestic reaction. The lack of a suitable civil spin-off application worsens the argument for cloaking and, even if one did exist, the risk of proliferation to another country would prevent its use. If, however, cloaking were employed either in the nuclear triad or in conventional forces, the foreign reaction would surely be that of disapproval as it only increases the technological asymmetry on the battlefield.

**Energy: Solar Power**

Advances in solar power give a good example of how a purely peaceful technology could have unintended international consequences. For years, solar-based energy generation has been plagued by high costs and low efficiencies in terms of energy and cost. The growing need for alternative energies and the availability of the sun’s energy have driven the market to develop new methods for making this a viable power source. Energy efficiency (the ratio of solar energy input versus electrical energy output) can


be increased by changing the shapes, or the materials of the panels used, or even using biomimicry. Naturally, lower-cost materials will also increase the cost-efficiency of the panels. More drastic changes to the panels include nanotechnology-based energy conversion and liquid-based cells that can be applied like paint. Even before these technologies are implemented and put into production, the successful intercontinental flight of the Solar Impulse vehicle shows that the industry has come a long way in recent years and that the TRL/MRL of solar power technology can be deemed medium-high. The impact on the economy and domestic perception are both very positive, but foreign perception is contingent upon applications within the military and, of course, the United States’ willingness to share knowledge.

Militarily, the potential capability to produce a solar-powered aircraft provides tremendous boons to IS&R operations with UAVs and increased endurance for long-range bombers. Solar-powered UAVs offer a permanent, nearly undetectable “eye in the sky;” particularly when flown at high altitudes where solar intensity is greater. These UAVs are already being explored; however, application to a long-range bomber may be more complex. The need for stealth clearly trumps the need for an alternative energy source if the two cannot be symbiotic. The primary advantage of a solar power source on a long-range bomber would be to eliminate the need for refueling operations midflight. Without the need for large, heavy tankers to support the mission, the logistics and covertness are greatly improved, but the amount of power needed is well beyond any foreseeable capability of solar energy.

Even if the United States were to improve its solar energy industry to the point where it replaces—or at least makes a significant contribution to the replacement of—expendable resources such as coal, natural gas, or oil, the international reaction could be negative if this knowledge was not shared. Ideally, any game-changing advances in alternative energy would be shared with all nations, but if this technology is developed by the commercial market, financial considerations will play a large role. Foreign nations could accept higher costs to overcome areas such as international patent rights and intellectual property, but since the technology gives a clear battlefield advantage, export control may also be involved with discussions. A lack of willingness to fully share trade secrets will lead to deteriorating relations, increased espionage, and higher costs to the United States for protecting and monitoring equipment. Furthermore, implementing alternative energy advances will reduce the global demand for petroleum, directly affecting those nations that belong to the Organization of the Petroleum Exporting Countries, which will not react well. Although the advancement of alternative energy sources seems like a simple issue at first glance, its impact should not be taken lightly. The above-mentioned application to the nuclear triad through bombers and UAVs would give the United States a major tactical advantage, and thus may meet resistance for the pure and simple reason that it is a technological advance.

Energy: Conservation and Independence

Some analysts argue that the two worst threats to the country in terms of severity and likelihood of occurrence are a nuclear terrorist attack and a shutdown of the electrical grid via cyberterrorists. Doomsday scenarios of a life without the main power grid are devastating and contain many common themes, one of which is that prevention is possible if the appropriate measures are taken beforehand. True to their name, microgrids provide a way to partition the main electrical grid so that a shutdown in one area does not have devastating effects in another. The controls between each partition also allow for the most efficient use of power, since a city’s draw can be throttled to only what it needs. Microgrids are effective ways to isolate key infrastructure, such as military bases or missile silos, from cyberthreats in another part of the world. Furthermore, microgrids are even more effective when combined with an independent energy source, such as a small modular reactor (SMR). SMRs are basically downsized versions of nuclear power plants. Approximately the size of a minivan, SMRs operate independently with a fission-based fuel source and when combined with a microgrid have been shown to have a fairly high TRL/MRL with the capability to power a small city. SMRs could be used to power an entire base, but a more direct application to the nuclear triad exists. SMRs are designed to be securely buried underground and left untouched for up to 25 years, similar to the fleet of ICBMs currently in their silos. Single-handedly, one SMR could power an entire missile wing either as the primary or backup power source. When paired with a

microgrid, SMRs provide an independent, low-maintenance, and reliable power source that is adept to the longevity of the ICBM mission.

Economic analyses of the use of SMRs and microgrids show a great payback from the initial investment,\textsuperscript{46} and case studies are still being performed.\textsuperscript{47} The domestic perception would be very similar to that of large nuclear power plants. The public adores cheap, abundant energy, but it fears a looming disaster or exposure to radiation. For microgrids, independent operability would be welcomed, but the initial cost of installation may be too much for some to accept. Internationally, the reaction to SMRs would be similar to the proliferation of nuclear energy for peaceful purposes. Thus, the political handling of implementing SMRs would be familiar, but so would the risks. As for microgrids, all nations, no matter their level of development, would welcome them if the financial benefits could be made clear. As both technologies are further verified, however, the concerns will decline and the potential economic benefits will become more apparent.

\textbf{Energy: Alternatives}

Solar power and energy conservation are aspects that most directly relate to the nuclear triad; however, the entire energy industry is much more diverse. The automobile industry has faced heavy pressure regarding carbon emissions and has made great strides toward advancing fuel cell technology over the past decade.\textsuperscript{48} Wind farms are becoming a far more common sight along the horizon.\textsuperscript{49} Tidal, geothermal, and biomass energy sources are also being heavily researched; but even if none of these forms of alternative energy finds application in a nuclear carrier vehicle, their prevalence in civil applications will have an effect for the reasons described in the above sections. Reduced manufacturing costs create a more cost-efficient military, thereby allowing greater production rates. The benefits of alternative energy have an impact on every aspect of the military to some degree, whether it is conventional or nuclear, operations or support, in peacetime or in combat. Civil applications also benefit and, thus, the high support leads to increased funding and, as the potential benefits transcend into reality, support further increases. Some forms of alternative energy (wind, fuel cells) already have a high TRL/MRL, but others need more time (tidal, biomass). Nonetheless, the future for alternative energy is bright, and the roadblocks are few.

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Robotics: Unmanned Vehicles

In the past two decades, UAVs have seen considerable development and have repeatedly proven themselves on the battlefield. From 2005 to 2011, the use of UAVs in Iraq and Afghanistan grew from 5 percent to 33 percent and continues to climb.\(^{50}\) Advances in UAVs are dependent on subsystem technologies, such as communication security, networks, and sensors. A subclass of UAVs are remotely piloted vehicles (RPVs), which require a human operator at a base station within the vicinity. As the subsystem technology advances, new capabilities emerge. The subsystem advances lead to an increased ratio of operators to RPVs, faster data downlink speeds, and increased operating range from the base station. The lack of these advances leads to vulnerabilities, as was shown famously with the downed RQ-170 Sentinel in Iran and the invasion of malware in 2011.\(^{51}\) The success of UAVs has led to increased funding for the development of other unmanned vehicles. Essentially, every type of manned vehicle has an unmanned counterpart. Unmanned ground vehicles have been extensively used for improvised explosive device detection. The X-37 represents an unmanned space vehicle, but is still in its infancy. Unmanned rotorcraft are soon to enter the battlefield.\(^{52}\) For ships and other naval vessels, unmanned surface vehicles and unmanned underwater vehicles (UUVs) are used. Like UAVs, UUVs have a direct counterpart within the triad and are currently being investigated by the Navy for mine detection.\(^{53}\)

Whether aerial or underwater, unmanned vehicles could play a large role in nuclear operations. Potential roles include IS&amp;R activities, forward scouting, or as communication relay stations, depending on the time frame of the particular military campaign. The conflicts in Iraq and Afghanistan have proven the usefulness of unmanned vehicles for IS&amp;R. As scouts, they could be directed to evaluate a target in minutes or seconds, compared with the hours or days that may be required to position a satellite. They could be programmed to not only identify potential threats but also for 3D mapping of the terrain.\(^{54}\) Each vehicle would be part of a network, which may contain satellites or other types of unmanned vehicles for a vast communication system. The fear of losing one of these vehicles has already materialized with the Iranian recovery of the RQ-170 Sentinel. American leadership has expressed doubt about Iranian claims that it has interpreted data from the vehicle, but, nonetheless, this instance shows a vulnerability that must be


protected. As mentioned above, the readiness of unmanned systems is dependent on the readiness of the sophisticated subsystems that are placed aboard them.

The economics of unmanned systems are mainly beneficial. The chief counterargument lies in their usefulness and vulnerabilities. With satellites already able to provide secure data transmissions to any spot in the world, the sentiment is that they are unnecessary. This sentiment has been largely weakened in the past decade as UAVs have proven to be a very valuable asset in the Middle East. Looking beyond the military, however, unmanned vehicles have already been spun off into commercial roles. By providing valuable data regarding agriculture, water resources, air quality and pollution, UAVs offer a low-cost solution to many civil problems. For this reason, their development should be welcomed with domestic support; unfortunately, the issue may not be that simple. Because each UAV failure gains much media attention, and because the public mainly knows UAVs for their military roles, portions of the American public may actually disapprove of them. Plus, with an expected increase of use in law enforcement, public perception may further deteriorate. Robots have been used on bomb squads for years, but unmanned robots in the sky will inevitably draw a negative reaction from many. Scenarios in which machines take over humanity are great material for Hollywood, and unfortunately the unwarranted fears have carried over into real life. Even pilots themselves have opposed UAVs due to what they perceive as a lack of control and visibility. The economic advantages gained from UAVs are hampered by these fears, and legislative measures have only recently been able to overcome them.

Internationally, the reaction will be similar, depending on where UAVs are used. The benefits that unmanned vehicles bring will be a major boon to impoverished nations, but many will forever remember their military roles. Then again, these fears could actually turn into an advantage for the United States. If UAVs are associated with a U.S. military presence, they could be used as a deterrent that would be visible to the population, whereas bombers and submarines are not. For a tightly run, autocrat regime, the leadership may not share with its people if a serious threat is within the vicinity, thus reducing the intent of deterrence. If the general populous were made aware through means of a low-flying UAV, the leadership would be trapped into a corner and might be pressured by its own people to concede. Of course, this could also backfire incredibly. Rather than pressure their leadership toward cooperation, the population may instead express further support, claiming that they are being persecuted or bullied. Using unmanned vehicles for military roles, particularly as deterrents, must be a case-by-case decision, but their peaceful roles would be welcomed by all. Figure 1 shows what many would consider to be an unusual image. A team of female engineers from the United Arab Emirates (UAE) recently took part in a competition to design, build, and fly a UAV of their own. Although U.S.-UAE relations are good and the UAVs are for academic purposes, the image of

Arab women with hijabs working on the vehicles that beleaguered the Middle East, and the fact that the competition was sponsored by an American corporation, illustrate that peaceful applications of unmanned vehicles can have a unifying effect between nations.

Figure 1. An American Industry-Sponsored Competition for Female Engineers from the United Arab Emirates: An Example of How UAVs Can Be an Integrator between the United States and the Middle East


Robotics: Industrial Robots

For manufacturing purposes, robotics are perhaps most famous for their improvements to the auto industry. By taking human factors out of the potential risk analysis for defects, companies are able to operate more quickly and more efficiently. The success has been carried over to other industries as well. In 2011, the Taiwanese electronics giant Foxconn was using 10,000 robots in their manufacturing plants, with projections to bring that total up to 300,000 in 2012 and up to 1 million in 2014. The Japanese government estimated the industry at $5.6 billion in 2006 and $26 billion in 2010, and it projects $70 billion in 2025.

With a very high TRL/MRL, the statistics are showing how robots can help all forms of manufacturing and industrial output. Thus, the logical argument is that if the robots have made such a tremendous impact on the commercial world, they could also make one on the military world. Many industrial operations in the nuclear sector are specialized due to the high security and technical requirements, but as robots become more commonplace, they also become more affordable. Understandably, fissile material will never be left into the control of an automated robot without human oversight, but the
challenges of sustaining a weapon system over several decades span more than just that. Maintenance costs are typically 50 to 60 percent of life-cycle costs, and the auto industry has proven the positive impact that robots can have.

Even though the economics and readiness level are favorable for industrial robots, the domestic perception may still be negative due to the loss of jobs. The traditional argument is that workers must simply adapt to a new type of work; that is, to learn how to operate the robot to do the work rather than to do the work themselves. Unfortunately, this argument ignores the fact that the conversion is hardly even. A robot may create one job for an operator, but it would eliminate several for workers on the manufacturing floor. If a worker’s union decided to protest the installation of an industrial robot, that company would be stumped with no economically viable way to proceed. Consequently, a generic assessment of the economics of integrating robots at a production plant cannot be made because of the difference in cultures and operations from plant to plant. But given the level of contractor reliance that the federal government has on production and manufacturing, that assessment can be left up to the plant managers. These managers are a part of a commercial industry and are more swayed by economics and less by politics. If the economics for the implementation of manufacturing robots is favorable, the international reaction will be similar to that of energy production, where an advance in civil applications only indirectly benefits the military. In the case of energy production, the benefit to the military was greater cost-efficiency; for industrial robots, the military obtains a better-quality product and greater cost-efficiency. This indirect military application will not be as highlighted as the prospect for a global, civil benefit from furthering the use of robotics; therefore, foreign support will likely be high.

Robotics: Other Applications

The potential applications for robotics are as widespread as can be imagined. Research is currently under way on insect-type flying robots that could one day serve as IS&R platforms. Self-reconfiguring modular robots can be deployed in harsh, unknown terrains that humans cannot enter, and hardened versions could be deployed after a nuclear event to take immediate measurements. Even shipboard, robots are being looked at to fight fires, and smaller versions may be useful aboard submarines or bombers. The merits of the impact of advances in robotics technology, however, are difficult to assess. Reflecting on the arguments concerning unmanned vehicles and industrial robots, the economic, social, political, and military effects must be studied case by case.


Aeronautics: Aircraft Design

As a stealth, flying wing, the B-2 represents a very modern constitution of design innovation, an aspect that is ubiquitous with aviation history. The Wright brothers were not nearly the first to attempt to build a flying machine, but their ability to finally design an adequate flight control system is what enabled them to become the first to succeed. Major innovations are easily recognized for their significance, such as the concepts for turbojets, swept wings, or composite airframes. Other innovations are not as noticeable, but many are just as significant, such as wingtips, vortex generators, or cabin filtration systems. Even failed experimental designs are stepping stones to proven, yet unusual aircraft, such as the SR-71 or the Rutan Voyager. In general, discussing the impact of new aircraft is difficult due to the secrecy that must be maintained if they are developed for military purposes. Still, innovations in the public sector could be transferred to the military if they are successful. For example, rising fuel costs and pressure from environmental enthusiasts have led to increased research in biofuels by the commercial aircraft industry.60 Power inefficiencies during taxiing are being tackled by attempting to regain energy from landing gear.61 The concept of “feathering” demonstrated by SpaceShip One and the design of cylindrical wingtips represent two of many creative designs that could see further usage (figures 2 and 3).62 Even biplanes are being reexplored for their potential to reduce noise and drag in supersonic aircraft.63 Nonetheless, the military mission does differ from the commercial world, and it likely will not convert its aircraft if doing so would mean a loss in capability. But with only a portion of military aircraft being fighters, the commonality may be greater than expected. Aircraft for cargo, surveillance, or even trainers could take advantage of commercial innovations. For the nuclear triad, stealth bombers do not require significant maneuvering (depending on enemy detection and defense systems) and may or may not be able to take advantage as well. Support aircraft, such as the Airborne Launch Control System, are typically not limited by treaty and could undergo drastic modifications. For example, a reemergence of blimps or “lighter-than-air” platforms (LTAs) as IS&R systems or communication relay stations seems to be occurring.64 A developed power, like Russia or China, would have no trouble detecting and targeting an LTA in its airspace, but rogue nations or terrorist cells would have difficulty shooting down the high-altitude, stealthy observers. Like solar-powered UAVs, a solar-powered LTA could be a permanent eye in the sky, but with a much larger communication range due to its physical size and flight

Because the military mission has a much heavier focus on capability, the benefits of incorporating commercial innovation would likely be financial more than anything else. The state of the national economy fluctuates, but since the Department of Defense has, by far, the largest budget of any federal department, the general public would support such innovations. The same might not be said for capability-driven innovations, however. Just as the American public is politically polarized, the need for new weapons technology is debated between the sides, particularly if it is costly. Internationally, the debate on capability-driven innovations would be the same, except that the two sides then would be ally or enemy. For financially driven innovations, any objections would wane as the commercially-produced technology would be available to anyone for the right price.

**Aeronautics: Hypersonics**

Many consider the next great milestone of aviation to be a feasible means of air-breathing hypersonic flight—that is, to produce a fuel and air combustion engine and its carrier vehicle that can travel at speeds greater than about Mach 3–5 (a formal definition does not exist, but this is generally the area considered to be the transition from supersonic to hypersonic). Hypersonic research is typically only possible through a few means. Space
vehicles reentering the Earth’s atmosphere can reach speeds up to Mach 50, but, of course, require an expensive launch. Wind tunnels at NASA use a vacuum to draw large amounts of air through a very small cross-section available for testing. Chemical propulsion with rockets is reliable, but has a short duration and can be costly. These hurdles have hindered research; yet the lessons learned through limited experiments and small gains, coupled with theoretical M&S, have led to successes in vehicles like the X-43 and its scramjet engine. After having been anticipated for years, the X-43 finally had its first successful flight in 2004.\textsuperscript{65}

A high-speed engine clearly has applicability to long-range bomber aircraft. Of all proposed hypersonic engine designs, scramjets have the greatest readiness, but still must overcome several issues before being seriously considered for use. For one, high-speed vehicles are typically required to be extremely lightweight, and this may conflict with the mission of the bombers to deliver high-yield weapons and a crew of at least two. Also, aerodynamic drag and the heat it induces at hypersonic speeds drives the geometric shape of the vehicle, which may conflict with the shape requirements for stealth. At first glance, the shape requirements seem similar (sleek, smooth surfaces), but subtleties may arise during the design process, and the need for stealth outweighs the need for hypersonics.

Currently, most hypersonic research is for military purposes, but the spin-off into the commercial market is direct. For this, the general public has thus far supported the development of hypersonic technologies. This opinion may be swayed as the technologies mature and the economics become more clear. After all, supersonic engines were developed in the 1940s and still have not found a large-scale role in the commercial air industry. The Concorde was the most famous supersonic heavy airliner, but its infamous crash in 2000 led to its entire fleet being permanently grounded. Several designs for supersonic business jets are beginning to emerge into reality; but nonetheless, these are still decades behind military technology.

If the United States were to suddenly announce the deployment of a hypersonic vehicle, the foreign response would be overwhelming—not because of the technological marvel that it would be, but because it would be a dramatic extension of the war-fighting superiority that the United States maintains. Although the impact of hypersonics is not as high as nuclear science, the technology could possibly be forced into the same type of containment via treaty that nuclear weapons have had to endure over the past few decades.

\textit{Aeronautics: Systems Engineering}

Aerospace systems are all a conglomeration of various subcomponents, each with a different purpose. The Space Shuttle has often been called the most complex system ever built by human beings. Both air and space vehicles depend on some form of computing, material science, energy production, robotics, and a wealth of other types of technology.

necessary to thrive. Advances made in each of these technologies individually often overshadow an ability that the United States has refined and performed very well over time: the ability to perform systems engineering so that all these technologies function when integrated together. The science of systems engineering is not easily described, and thus it is difficult to teach in a classroom setting. Expertise is typically gained through experience. Individualism is a keystone of American culture and, because of this, anyone who wants the experience can get it. Even George Washington was famous for allowing his young soldiers to take positions of high responsibility, a military tradition that carries on today. This type of culture is not apparent in many other nations, and experience cannot be stolen via espionage. Even today, as nations are suspected of stealing or illegally sharing information on long-range missiles, nuclear reactors, or stealth fighters, the transfer does not register an immediate capability gain because of the experience required to operate these highly complex systems of systems. Russia’s recent failure of its Phobos-Grunt mission shows that, even with decades of experience in space, combining the sophisticated technology is still extremely difficult. Financial benefits of good systems engineering are mostly seen through reduced operating costs. Reliability is a fundamental aspect of systems engineering and is often achieved through a risk analysis. Identifying and fixing the areas that are most likely to fail reduce the need for expensive maintenance. The public may not realize that they support good systems engineering, and other nations may not know how to react to a skill learned through experience, but the benefits are far-reaching.

Summary and Conclusions

In all, this paper has reviewed 15 different types of technology for their impact on the economy and politics if they were integrated into the nuclear triad. Again, the scope of this study is not to provide a deep look into each technology, but rather to give a broad assessment and determine which types deserve closer inspection. From the preceding evaluations, metrics can be applied to each of the evaluating criteria, but an important fact to remember is that not all parameters should be treated equally. For instance, often the military need is a greater concern than foreign perception. For this, a weighting scale was developed based on the importance of each parameter. This scale is subjective, per the author’s opinion, and is not scientifically based. Creating the scale in this manner was intentional because fluctuating national priorities prohibit a static scale. The scoring metric and weight scale for each parameter is as follows in table 1. When this scale is applied to the technologies reviewed, the scores given in table 2 are obtained:
Table 1. Technology Scoring Metric

<table>
<thead>
<tr>
<th>Score</th>
<th>Military Effect</th>
<th>TRL/MRL</th>
<th>Economic Impact</th>
<th>Domestic Perception</th>
<th>Foreign Perception</th>
</tr>
</thead>
<tbody>
<tr>
<td>−2</td>
<td>Negative</td>
<td>Low</td>
<td>Expensive with low payback</td>
<td>Very unsupportive</td>
<td>Very unsupportive</td>
</tr>
<tr>
<td>−1</td>
<td>None</td>
<td>Low-medium</td>
<td>Expensive with some payback</td>
<td>Unsupportive</td>
<td>Unsupportive</td>
</tr>
<tr>
<td>0</td>
<td>Low</td>
<td>Medium</td>
<td>Mixed or unknown</td>
<td>Negligible or mixed</td>
<td>Negligible or mixed</td>
</tr>
<tr>
<td>1</td>
<td>Medium</td>
<td>Medium-high</td>
<td>Commercially supported</td>
<td>Supportive</td>
<td>Supportive</td>
</tr>
<tr>
<td>2</td>
<td>High</td>
<td>High</td>
<td>Commercially led</td>
<td>Very supportive</td>
<td>Very supportive</td>
</tr>
</tbody>
</table>

Weight | 40% | 20% | 25% | 10% | 5% |

Table 2. Technology Scoring Results

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Military Applications</th>
<th>TRL/MRL</th>
<th>Economic Impact</th>
<th>Domestic Percent</th>
<th>Foreign Percent</th>
<th>Flat Total</th>
<th>Weighted Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>40</td>
<td>20</td>
<td>25</td>
<td>10</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computing and Telecommunications</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>8</td>
<td>1.75</td>
</tr>
<tr>
<td>Cyberwarfare</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>-1</td>
<td>-1</td>
<td>2</td>
<td>1.15</td>
</tr>
<tr>
<td>Sensors and imaging</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>1.35</td>
</tr>
<tr>
<td>Advanced materials</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>1.2</td>
</tr>
<tr>
<td>Additive manufacturing</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>1.7</td>
</tr>
<tr>
<td>Cloaking</td>
<td>1</td>
<td>-2</td>
<td>-2</td>
<td>0</td>
<td>-2</td>
<td>-5</td>
<td>-0.6</td>
</tr>
<tr>
<td>Solar Power</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>7</td>
<td>1.35</td>
</tr>
<tr>
<td>Conservation and independence</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>0.8</td>
</tr>
<tr>
<td>Alternatives</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>0.55</td>
</tr>
<tr>
<td>Unmanned vehicles</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>-1</td>
<td>-1</td>
<td>3</td>
<td>1.35</td>
</tr>
<tr>
<td>Industrial robots</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>0.7</td>
</tr>
<tr>
<td>Other robotic applications</td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
</tr>
<tr>
<td>Aircraft design</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Hypersonics</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>-2</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>Systems engineering</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>1.7</td>
</tr>
</tbody>
</table>
A few immediate observations stand out when studying the scores applied. First, the military would not apply a technology that is detrimental to it, so no advances scored negative in that category. Second, any actions of the government that would cause an outcry from the U.S. population would be kept secret, and are, therefore, unknown to the author. For this, no technology received a score of −2 for its domestic reaction. And third, the information technology–related advances received the highest scores, which is not surprising considering their well-recognized potential. Rather than translating a high score as a technology that should be immediately invested in or applied to the nuclear triad, a high score indicates a technology that should be studied more thoroughly in an analysis similar to this one, but in far more depth. Because the weighting scale was subjective, table 3 shows the order of scores with and without the weights applied.

<table>
<thead>
<tr>
<th>Flat Ranking</th>
<th>Weighted Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computing and telecommunications</td>
<td>Computing and telecommunications 1.75</td>
</tr>
<tr>
<td>Advanced materials</td>
<td>Additive manufacturing 1.7</td>
</tr>
<tr>
<td>Solar power</td>
<td>Systems engineering 1.7</td>
</tr>
<tr>
<td>Additive manufacturing</td>
<td>Sensors and imaging 1.35</td>
</tr>
<tr>
<td>Energy conservation and independence</td>
<td>Solar power 1.35</td>
</tr>
<tr>
<td>Systems engineering</td>
<td>Unmanned vehicles 1.35</td>
</tr>
<tr>
<td>Sensors and imaging</td>
<td>Advanced materials 1.2</td>
</tr>
<tr>
<td>Other forms of alternative energy</td>
<td>Cyberwarfare 1.15</td>
</tr>
<tr>
<td>Aircraft design</td>
<td>Aircraft design 1</td>
</tr>
<tr>
<td>Industrial robots</td>
<td>Energy conservation and independence 0.8</td>
</tr>
<tr>
<td>Unmanned vehicles</td>
<td>Industrial robots 0.7</td>
</tr>
<tr>
<td>Cyberwarfare</td>
<td>Other forms of alternative energy 0.55</td>
</tr>
<tr>
<td>Other robotic applications</td>
<td>Hypersonics 0.4</td>
</tr>
<tr>
<td>Hypersonics</td>
<td>Other robotic applications 0.2</td>
</tr>
<tr>
<td>Cloaking</td>
<td>Cloaking −0.6</td>
</tr>
</tbody>
</table>

Intuitively, both lists show computing and telecommunications at the top, with areas like advanced materials, solar power, additive manufacturing, and systems engineering not far behind. Counterintuitively, cloaking, other robotics applications, and hypersonics are near the bottom. A science fiction enthusiast would argue that these technologies would revolutionize the battlefield, and they would be correct. Unfortunately, their low readiness implies a high cost for development, particularly without a clear commercial
spin-off. The low overall score implies that the technology is several years away from serious conversation about its feasible applicability to the nuclear triad.

Finally, the author acknowledges that all scores given are subjective and arguable. For the more generic types reviewed, readiness was assessed by the availability of its next generation above the current state of the art. Domestic and foreign perceptions are based on people and, therefore, change in time. Economics also change as some technologies enable others. The most critical aspect—the applicability to the military—cannot even be discussed in an openly available medium. In a fiscally tight environment, however, research agencies compete more than ever, and government officials could plausibly be overwhelmed by the large amount of technical jargon used in proposals and exploited by lobbyists. Hopefully, this study provides a comprehensible manner in which different types of technologies can be compared and leads to better decisionmaking for modernizing the U.S. nuclear triad.
Preventing Nuclear Terrorism
Destigmatizing Nuclear Security and Promoting Regional Engagement
Matthew Cottee

The paper assesses the state of the nuclear security regime in Southeast Asia. The region is important for a number of reasons, most notably its variety of constituent states and their nuclear ambitions. Indonesia and Malaysia are considering civil nuclear programs; Vietnam is in the early stages of developing such a program; and Myanmar has been accused of clandestine nuclear ambitions. But given numerous other pressing security concerns, nuclear terrorism is not currently a priority for regional actors. Moreover, the concept of nuclear security has been stigmatized as a tool that developed states have attempted to impose globally in spite of vastly divergent capabilities and perceptions of the threat of nuclear terrorism. Regional interest in nuclear security is therefore limited. However, the nuclear security regime must be truly international to be effective in preventing an act of nuclear terrorism. Drawing on empirical evidence gathered in Southeast Asia, this paper explores the extent to which the universality of nuclear security can be enhanced, and how future iterations of the regime may be strengthened with “buy-in” from regional actors.

The threat of nuclear terrorism has developed a new resonance in the post-9/11 security environment. It was named as the number one threat to world security by the former director-general of the International Atomic Energy Agency (IAEA), Mohammed ElBaradei, in 2008. President Obama echoed this warning when he stated that the possibility of nonstate actors obtaining fissile or radiological material was the “most immediate

1. Matthew Cottee is a Ph.D. candidate in the Department of War Studies at King’s College London. His doctoral research explores the evolution of the “nuclear security” regime and changing perceptions of the threat posed by nuclear terrorism. The research in Southeast Asia was conducted as part of a project funded by the Carnegie Corporation of New York. The author would like to thank John Warden and Stephanie Spies as well as the CSIS Project on Nuclear Issues team for their hard work and logistical support throughout the 2012 Nuclear Scholars Initiative.

and extreme threat to global security” the following year.\(^3\) Responses to this threat have consequently produced what is referred to as the “nuclear security regime”—a broad and overarching web of policies, conventions, and initiatives that include binding and nonbinding instruments, as well as bilateral and multilateral agreements, aimed at curbing terrorist access to vulnerable fissile materials. But this architecture is fragmented, overlapping, and complex. Moreover, though the threat is deemed to be transnational or international in nature, “the global nuclear security regime is fundamentally weak because implementation lies with individual states.”\(^4\) To ensure effective prevention of a nuclear terrorist event, an international response is required.

President Obama has been central in emphasizing the threat posed by nuclear terrorism. In April 2010, he convened a summit to highlight the far-reaching implications of nonstate actors obtaining vulnerable fissile material. The first Nuclear Security Summit represented the largest number of state leaders gathered by a U.S. president since the end of World War II. It was billed as “an unprecedented meeting in response to an unprecedented threat.”\(^5\) But this assessment of the threat is not universally shared, as demonstrated by the indifferent responses by individual states, including several in Southeast Asia. In order to strengthen the concept and encourage the broader development of a nuclear security norm, it is important to encourage buy-in from those countries that feel less threatened by the specter of nuclear terrorism than the United States, and therefore less inclined to engage with global efforts to prevent it. By focusing on Southeast Asia as a test case, it is hoped the experiences and challenges presented in the region can inform future nuclear security policy more broadly.

Numerous countries in unstable regions of the world, particularly the Middle East and Southeast Asia, are embarking on civilian nuclear power programs. They perceive no real threat of terrorism, especially one involving nuclear materials. Although an attack anywhere in the world is likely to produce global ramifications, indiscriminately affecting all, this possibility still lacks the impetus to convince a number of states to commit to the nuclear security regime; the issue is often viewed as a problem exclusively for states possessing nuclear weapons or civilian nuclear infrastructures. Moreover, divergent threat perceptions represent only one of the obstacles to be overcome. There is no overarching body to ensure compliance, nor is there any verification procedure for existing policies or conventions. Expanding the role of the IAEA is one option for providing the nuclear regime with greater power, but its resources are already stretched and many states lack the appetite to commit to more regulation in the field of nuclear materials and technology. Finally, there is a stigma attached to nuclear security. It is viewed by some members of the Non-Aligned Movement as a pretext for preventing states from


freely accessing nuclear technology or materials for peaceful purposes, in spite of their rights under Article IV of the Nuclear Non-Proliferation Treaty (NPT).

This paper seeks to examine how Southeast Asian states perceive the nuclear security agenda and how it may be advanced. The potential options for enhancing nuclear security at both the national and regional levels are initially encouraging. Channeling efforts via established regional institutions, notably the Association of Southeast Asian Nations (ASEAN), could enhance the nuclear security regime. Furthermore, the precedent set by the 1995 Bangkok Treaty on the Southeast Asia Nuclear Weapon-Free Zone (SEANWFZ) has demonstrated that norm-setting agreements in the nuclear field can be achieved regionally. From a Western perspective, however, Southeast Asia faces a number of challenges, namely, previous associations with A. Q. Khan’s illicit proliferation network, weak border controls, and an active conventional terrorist threat in the form of Jemaah Islamiah. The influence of regional mechanisms as well as multilateral and bilateral relationships are therefore explored to assess the best way to strengthen nuclear security in the region.

The “Nuclear Security Regime”

Although fears of nuclear terrorism have been heightened in recent times, the threat is not new. Early thinking on clandestine nuclear attacks dates back decades and has become increasingly prominent as the growth of commercial nuclear power generation has been paralleled by a rise in incidences of international terrorism. Efforts to prevent nonstate actors from acquiring nuclear material or attacking nuclear facilities became a mounting concern. Over time, policies have been created to strengthen the control of nuclear materials, beginning in 1975 with the IAEA’s publication of Information Circular 225 (INFCIRC/225). This document, now in its fifth edition, contains guidelines for the physical protection of nuclear material and forms the basis for what is now understood as the “nuclear security regime”—a system of instruments and initiatives aimed at limiting the potential for a nuclear terrorism incident. As the threat of nuclear terrorism has grown, responses have evolved, culminating in Obama’s Nuclear Security Summit process.

But approaches and strategies vary in scope, membership, and required level of commitment. The Convention on the Physical Protection of Nuclear Material (CPPNM), for example, which was negotiated at the IAEA in Vienna and opened for signature in 1980, is an important instrument with broad membership that underlies the nuclear security architecture because of the legal requirements it places upon states to protect nuclear material in transit. This was amended in 2005 in an effort to broaden its application. The International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT) is another formally binding instrument aimed at criminalizing acts of nuclear terrorism. In terms of legal commitments, all states are obliged to prevent the spread of weapons of mass destruction to nonstate actors under UN Security Council Resolution

1540. However, the Group of Eight’s Global Partnership Against the Spread of Weapons and Materials of Mass Destruction, initiated in 2002, and the Global Initiative to Combat Nuclear Terrorism, announced in 2006, are just two of the many informal, nonbinding initiatives that also form the nuclear security architecture. These instruments are more focused in their aims, and state participation is voluntary.

Concern about the contemporary threat has increased since the events of 9/11 and the realization that catastrophic attacks on American soil are feasible. Reports suggesting terrorist groups—notably al Qaeda—had sought to acquire nuclear materials and technical expertise further enhanced the fear of a surprise nuclear attack. This explains the urgency with which newer policies have been created—minimizing lengthy negotiation and countering specific threats such as destroying weapons of mass destruction or securing radioactive sources in the former Soviet Union, as was the case with the Global Partnership. The evolving nature of responses explains, in part, the appearance of the current policy landscape. In the wake of the events of 9/11, the threat is now seen to be more explicit, so responses cannot afford the luxury of mass consensus and protracted discussion. As a result of its ad hoc development, the nuclear security regime forms an incomplete picture.

When compared with more established nonproliferation efforts, the nuclear security regime has neither a legally binding accord such as the NPT nor an overarching verification mechanism in the style of the international safeguards regime. The strength of the NPT is often debated, but it provides nonproliferation efforts a sense of cogency and legitimacy that nuclear security lacks. The IAEA is responsible for validating states’ declarations about quantities of nuclear material and activities, whereas nuclear security instruments cannot undermine state sovereignty for risk of disengagement. This balance leaves “detailed implementation up to each state party. International verification of compliance and penalties for noncompliance are unknown.” Notwithstanding the voluntary nature of nuclear security standards, “there are no reporting or peer review requirements comparable [to those in the field of nuclear safety], nor is there effective peer review of domestic physical protection systems.”

Nuclear Ambitions in Southeast Asia

Having highlighted the weaknesses, the spread of nuclear materials and technology to parts of the world deemed relatively unstable or lacking the necessary institutional wherewithal is a significant concern. Given its variety of constituent states and their nuclear aspirations, Southeast Asia is an important region, and its commitment to nuclear security efforts is important. Indonesia and Malaysia are considering civil nuclear

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9. Ibid., 29.
programs, Vietnam is in the early stages of developing such a program, and Myanmar has been accused of clandestine nuclear ambitions. To be sure, the popularity of nuclear energy has been checked by the events experienced in Fukushima, but a number of Southeast Asian states remain committed to nuclear power in the longer term.

In Malaysia, nuclear power has often been mentioned as an important component of its energy mix. A final decision on introducing nuclear power was expected in 2013, although it is likely to be delayed to allow for a detailed assessment of events at Fukushima by the Malaysian Nuclear Agency. Indonesia also has had an interest in nuclear power for some time, with a first reactor scheduled for 2010 as part of its Long-Term National Development Plan. Although the reactor is nonexistent and President Susilo Bambang Yudhoyono has publicly questioned the role of nuclear power in the wake of the Fukushima disaster, the official development plan still stands, albeit behind schedule. A final decision is not thought to be likely before presidential elections in 2014 given the negative public opinion against nuclear energy. Although Vietnam is in the early stages of developing a nuclear program, it is the most technically advanced state in the region and plans to have a nuclear power plant online by 2020. A total of 10 reactors are planned by 2030. The regional reaction to Vietnam’s progress will likely be an important factor in other states’ decisions whether to pursue the development of nuclear power.

**Threats and Challenges**

The nuclear developments in Southeast Asia, whether aspirational or real, generate anxiety. From a Western perspective, the region faces three key challenges and these drive the nuclear security agenda. First, as Trevor Findlay warns, “the acquisition of reactors by states with a poor security track record and non-existent security culture would represent a significant challenge to the global nuclear security regime that it is currently ill-prepared to meet.” Malaysia was a key part of A. Q. Khan’s nuclear black market, acting as a transhipment hub and manufacturing base for nuclear components. But historical associations with the illicit proliferation network are just one element. The contemporary weaknesses of Malaysia’s security architecture were also highlighted when,

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12. Ibid., 5.


following the seizure of dual-use material en route from China to the Middle East at a Malaysian port, Malaysia’s home minister, Hishammuddin Hussein, admitted that the country was still “likely being used as a transit point . . . for WMD [weapons of mass destruction]” in 2011.16 Weak export controls are therefore a significant worry. Regional commentators suggested that trade regulations are in fact often driven more by economic considerations than security.17

Second, the region suffers from a terrorist threat in the form of Jemaah Islamiah. The potential for the most active terrorist organization in the region to steal nuclear material or sabotage nuclear facilities is believed to heighten the perceived sense of threat in Southeast Asia. There are worrying suggestions linking Southeast Asian nationals to al Qaeda’s ambitions of obtaining WMD capability in 2004.18 However, interviewees in the region were all quick to suggest that the threat posed by Jemaah Islamiah was vastly overplayed; any links between the terrorist organization and an act of nuclear terrorism had certainly never been made, they stressed.

Finally, Findlay suggests, “None of this engenders confidence in the ability of aspirant nuclear energy states to manage the security of nuclear facilities that they may acquire, especially since other deficits in physical and institutional infrastructure and governance, including corruption and mismanagement . . . have implications for establishing effective nuclear security regimes.”19 The lack of procedural experience for overseeing, protecting, or accounting for nuclear material is a significant practical concern. This was reinforced by one expert from the region who stated, “Nuclear is new. We don’t have lawyers, administrators, people who understand the nitty-gritty of agreements.”20 The challenges of nuclear power highlight common issues justifying the importance of nuclear security: insufficient human capacity; the absence of interagency coordination; and poor understanding of concepts such as “nuclear security culture” or “dual-use” goods.21 The fears of more developed states are best summarized by Sidney Drell, George Shultz, and Steven Andreasen, who caution: “States new to the nuclear enterprise may not have effective safeguards to secure nuclear . . . materials or the capability to safely manage and regulate civil reactors.”22

17. Project researcher’s interview with a Malaysian specialist, December 2011.
20. Project researcher’s interview with a Malaysian specialist, December 2011.
Regional Engagement

Given the situation outlined here, to what extent has the nuclear security regime been adopted by key states in Southeast Asia? Indonesia has signed and ratified the CPPNM and its 2005 Amendment. Officials have stated that the country is committed to ratifying the International Convention on the Suppression of Acts of Nuclear Terrorism at the most recent summit in Seoul. It has not yet signed up to any voluntary instruments, generally viewing agreements outside the United Nations as discriminatory. Malaysia, meanwhile, has signed the ICSANT but does not yet have the CPPNM or any other international nuclear security-related legislation in place. Perhaps most worrying, given its advanced progress on development of a civil nuclear power program, Vietnam has only signed up to the Global Initiative to Combat Nuclear Terrorism. While representatives of both the Malaysian and Vietnamese governments claimed that the amended CPPNM would be ratified soon, the list of actual commitments portrays the limited engagement in Southeast Asia. More broadly, the Nuclear Materials Security Index, produced this year by the Nuclear Threat Initiative and the Economist Intelligence Unit, viewed corruption as pervasive in Southeast Asia and rated Vietnam—the most developed nuclear state in the region—poorly across a number of indicators used to judge the security of nuclear materials and facilities in the country.

Divergent Threat Perceptions and Ideological Differences

As the limited commitment to nuclear security demonstrates, combating nuclear terrorism is not currently a priority for states in Southeast Asia. But why is this the case? Western perspectives of the threat are not universally shared, causing states to view the regime differently. Nuclear security is seen to be an exclusive concern of developed states that possess nuclear materials and facilities, many of which have already experienced terrorist attacks. These divergent perceptions of the threat of nuclear terrorism not only undermine any hope for a truly global nuclear security regime but also have the potential to entrench ideological differences associated with the wider nonproliferation regime. Experts in Southeast Asia were quick to note that issues other than nuclear terrorism, such as health care and economics, dominate domestic political agendas. A nuclear weapon has not yet been stolen or constructed by a terrorist organization as far as we know, let alone detonated. The threat of nuclear terrorism is therefore abstract. One Malaysian scholar, Shahriman Lockman, suggests that “developed countries should stop describing in alarmist terms the security risks associated with nuclear energy programs. Nothing more surely undermines the case for serious approaches to non-proliferation.


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and nuclear security than exaggeration of threats.”

Similarly, the 2010 Nuclear Security Summit “did not forge a genuinely common assessment” of the threat posed by nuclear terrorism. In addition, officials in the region commonly lack “a genuine appreciation of why proliferation needs to be prevented. In some developing countries, the risk of proliferation is regarded as the developed world’s peculiar obsession rather than as a real threat to the nation’s own security.”

Related to this division between developing and developed states, the ideological lines along which disarmament negotiations experience friction also present themselves in the nuclear security realm. This was highlighted most strikingly when former British prime minister Gordon Brown mooted the idea of nuclear security becoming “an integral part of the global nuclear framework—a new, fourth ‘pillar’ of the NPT regime.”

The concept quickly proved to be politically controversial and stopped being used starting in late 2009 because nuclear security was seen as a responsibility by some states but not others. As Deepti Choubey has highlighted, “Many states, particularly those for whom nuclear terrorism is not a top priority, may object to attempts at creating equivalence between this fourth pillar and the other three.” The suggestion of an additional pillar was seen as unfair by many nuclear aspirants, who felt cheated by developed states placing more conditions on the peaceful use of nuclear energy in spite of limited disarmament efforts themselves. The nuclear security regime is seen as an unfair set of “restrictions to hinder progress.”

The nuclear security regime and its constituent initiatives have therefore been viewed with a certain degree of suspicion as “barriers to economic development at best, and, at worst, as part of a deliberate strategy on the part of the most developed states to maintain the status quo.”

In addition to a lack of urgency because of the nature of the threat, legislation fatigue also contributes to the slow take up of initiatives. Indonesian officials, for example, expended great effort in 2011 to push through domestic legislation allowing the country to accede to the Comprehensive Nuclear Test Ban Treaty. Having done so, the notion


27. Lockman, “Nuclear Option.”


29. This is evidenced by the addition of the control of radiological sources to the Communiqué of the 2010 Nuclear Security Summit, because radiological terrorism represents a threat to all countries and not those merely containing fissile material.


31. Project researcher’s interview with a Malaysian specialist, December 2011


of suggesting additional nuclear-related commitments to parliament in quick succession were deemed unfavorable and less important. In addition, the nature of the legislation itself is important since “officials from Indonesia, Malaysia and Vietnam have openly expressed reservations [with United States–led initiatives], arguing that they do not wish to be associated with the U.S. ‘war on terror,’ which is widely regarded among their populations as anti-Muslim, unilateral, pre-emptive, and disproportionately military.”

These domestic perspectives have combined to create a stigma—a feeling that nuclear security is being employed by the developed states to hamper nuclear aspirants. This view is not helped by what could be seen as hypocrisy, the United States having been slow to ratify and implement the amended CPPNM and the ICSANT, despite being referred to as “essential elements of the global nuclear security architecture” by the 2010 summit communiqué. Relations are further undermined by nuclear weapons states refusing to sign the protocol of the SEANWFZ.

Potential Next Steps

The lack of a common perception of the threat of nuclear terrorism and the politics of nuclear governance make the vision of universal adherence to the various nuclear security instruments difficult to conceive. Although the sharing of intelligence assessments on the threat has been suggested in an attempt to demonstrate the risk posed globally, national sensitivities preclude this from being practical. As Tanya Ogilvie-White observes, “The rationale for the introduction of an inclusive and comprehensive security apparatus is that global frameworks are only ever as good as their weakest link.”

Given this premise that states outside the nuclear security regime provide a loophole for terrorist or criminal organizations to exploit, how can buy-in by all be encouraged despite the differing perspectives on threat and response highlighted above? This paper proposes a shift in how the nuclear security regime is portrayed in order to avoid being stigmatized and undermine claims of discrimination.

Although a key part of the “grand bargain” of the NPT, unrestricted access to the peaceful applications of nuclear energy is not free of caveats. Conditions of nuclear supply exist and shift with changing situations and events. Notwithstanding the different views examined in the previous section, the provision of nuclear security is not a bargaining tool or barrier to entry but a responsibility for all states. For this to be realized, a change of mentality is required. Although established nuclear states have been able to adapt and develop measures to ensure domestic nuclear security over time, the possibility of nuclear terrorism is now greater, demanding that aspirant users of nuclear power

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entry-into-force-by-indonesias-ratification/?textonly=1.

34. Ogilvie-White, “Non-Proliferation,” 12.
start the implementation process before developing nuclear infrastructures. The collapse of the Soviet Union and the legacy threats left behind (e.g., poorly guarded nuclear facilities and fears of “loose nukes”) have influenced the contemporary focus on preemption and prevention. As a result, the two previous Nuclear Security Summits have called on states to sign up to key policy instruments and initiatives in an effort to cultivate and advance a nuclear security norm, encouraging states to abide by a set of rules despite the lack of legal commitment or verification mechanism. However, the ratification of a convention does not necessarily equate to widespread implementation where it matters. A greater number of signatories may enhance the norm, but this does not necessarily equate to a tangible reduction in risk at the facility level. An Indonesian interviewee suggested the more developed states view the nuclear security regime as a series of ratifications.38 While the development of norms is certainly worthwhile, it ignores the differing perspectives toward nuclear security. Greater attention should therefore be given to actually reducing the risk of nuclear terrorism through the effective implementation of nuclear security efforts. The paper now evaluates some potential ways of achieving this.

The first possible way of enhancing nuclear security efforts is via established regional frameworks. A number of multinational institutions already exist in Southeast Asia and set much of the nonproliferation agenda in the region. These frameworks could be used to enhance regional governance and generate local interpretations of nuclear security requirements. This approach does not rely on an imposed perception of the threat of nuclear terrorism to drive action. Instead, regional leaders can discuss ways to improve nuclear security, providing a greater sense of inclusivity and ownership than being pressured into action by outside forces. As Findlay remarks, regional initiatives “may have more immediate traction than global ones.”39 An Asian version of the European Atomic Energy Community was mooted in discussion by a few regional experts as a potential way to coordinate nuclear efforts in the region, which could eventually ensure regional standards and provide guidance and oversight, even extending as far as nuclear security. While cooperation in the region is important, the sensitivity of sharing national information in this field was seen as a major flaw.40 The creation of such an institution would also take a long time since it would have to be created from nothing.

At a broader level, ASEAN, the dominant existing regional forum, was thought not to have the institutional capacity to deal with an issue as sensitive as nuclear security. Designed as a forum for regional discussion, it focuses on geopolitical and economic affairs and has championed the “ASEAN Way,” which seeks to avoid “forcing its diverse and mutually suspicious members into legally binding standards,” instead preferring informal consensus building.41 This approach is at odds with the nuclear security regime,

38. Project researcher’s interview with Indonesian specialist, December 2011.
40. Project researcher’s interview with Vietnamese specialists, December 2011.
which states in the region view as a “West-dominated global governance agenda.” Although ASEAN would appear to be the ideal forum in which to encourage discussions of nuclear security, given its long-term confidence and consensus-building capabilities, talks on hard security topics, such as nuclear security, are too sensitive. Furthermore, the specific reaction to nuclear terrorism in Southeast Asia is part of a widespread unease with agendas dominated by the more developed states. Other regional frameworks, such as the Asia-Pacific Economic Cooperation (APEC) forum, also fracture internally because some states are happy with the imposition of increasingly formalized procedures while others seek guarantees about protection of cultural diversity and political heterogeneity in response to Western domination of the issues. It is therefore difficult to transpose the Western global governance agenda onto regional institutional frameworks. The Asian Senior-Level Talks on Proliferation (ASTOP) have proved more successful by focusing on ad hoc single issues rather than formal institution building and include officials from the region as well as Australia, China, South Korea, and the United States. This forum “is conducted according to Asian diplomatic conventions, and as a result appears to foster a greater degree of trust amongst participants, thus achieving more in terms of consensus and compromise.” Such an approach, focusing on a specific single issue and respecting regional customs, would appear crucial in enhancing nuclear security efforts.

Although entrenched and relatively successful in specific areas, regional institutions in Southeast Asia still suffer a number of weaknesses. As a result, they may not be the best solution to encourage greater engagement with the nuclear security regime at the regional level, perhaps with the exception of the ASTOP. A brief analysis of regional institutions provides an important insight into how diplomacy in the region works, however, further highlighting why the region’s commitment to the nuclear security regime has thus far been limited. Traction seems to be achieved when trust can be built between participants, which the large global Nuclear Security Summits fail to do. Given the stigma attached to certain security agendas, enhancing bilateral relationships with a focus on nuclear security with key states in the region could be a more practicable route to explore.

Enhanced bilateral relationships with a focus on nuclear security have a number of advantages. First, implementation is easier since assistance can be targeted and the result of a mutual effort. Compliance can then also be verifiable. Second, the reason for nuclear security efforts can be tailored to the particular weaknesses of that state, rather than imposing standardized regulations aimed at a threat that is not widely recognized. Third, and finally, the domestic benefits of nuclear security efforts can be explained and demonstrated more effectively.

One Indonesian expert suggested that nuclear security “must be implemented wholeheartedly at the national level in a results-orientated process.” Bilateral relationships,

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42. Ogilvie-White, “Non-Proliferation,” 14.
43. Ibid.
44. Ibid., 18.
45. Project researcher’s interview with Indonesian specialists, December 2011.
as opposed to multilateral or regional institutions, would help achieve that goal. States can get a better grasp of what the other is trying to achieve and evaluate its particular concerns while providing oversight and measuring productivity. Bilateral assistance would also cut through the sense of discrimination felt by certain states as these relationships can replace the legally binding standards that are viewed with suspicion by certain states and go against the “ASEAN Way.” Governments or domestic agencies could be dealt with on an individual basis or in more exclusive groups depending on their weaknesses or aspirations, helping to combat not only the lack of drive and low capacity to act but also the lack of trust between actors at all levels. Moreover, bilateral ties are easier to tailor to specific domestic concerns and also respect the “cultural particularities” of the region—principally noninterference and informal diplomacy—highlighted above.46 Understanding and respecting these cultural rules are fundamental to encouraging regional buy-in. When asked why Indonesia should care about nuclear security, one official listed the reasons as “domestic capacity building; a platform to generate more unification moving forwards; and inclusivity.”47 These aspects should be emphasized. Of course, the difficulty of aligning the areas of concern could be problematic. A number of bilateral relationships already exist, however, and should be expanded and deepened. Although a specific area of concern for the West may be less important for a Southeast Asian state with other priorities requiring investment and resources, and vice versa, the threat-reduction programs targeted at the former Soviet Union also experienced this problem. U.S. and Russian officials disagreed on what should be prioritized with regard to threat reduction, meaning a balance had to be struck. However, over time, threat reduction programs arguably built trust between the two parties and represent a useful precedent for encouraging nuclear security efforts elsewhere.

Second, if the nature of cooperation can be refocused from nuclear terrorism to more prevalent regional issues, it may then experience more buy-in from those states currently displaying disinterest. Targeted capacity-building projects could accommodate the long-term aims for nuclear aspirant states in preparation for the development of nuclear power. This would help overcome “barriers to entry” rather than create them. It seems illogical not to welcome guidance and support from knowledgeable states that have developed nuclear security expertise over an extended period of time. Visibly broadening the stakeholders involved beyond the primacy of the United States is also beneficial since it helps reduce the ideological differences that currently undermine the regime. Further engagement from states with existing links into Southeast Asia such as Australia, and, perhaps more important, China, which already has close economic and cultural ties with the region, should be encouraged. In this regard, it is once again important to ensure that such efforts are encouraged by both parties, as opposed to being seen as an imposition. This overcomes Lockman’s criticism of a hyped threat being used to justify security measures. As we have seen, if states in Southeast Asia perceive a particular issue to be insensitive to regional concerns, it only serves to lessen any efforts in that area. The importance of “softer” approaches to nuclear security, such as assisting in the

46. Ogilvie-White, “Non-Proliferation,” 5.
47. Project researcher’s interview with Indonesian specialists, December 2011.
creation of nuclear security culture and improving human resources, help reinforce the already existing “harder” approaches of improved equipment and resources, creating a more holistic nuclear security regime.

Finally, emphasizing the domestic benefits of certain initiatives under the nuclear security umbrella could also make them an easier sell politically (e.g., highlighting the importance of border security and export controls and attempting to implement UN Security Council Resolution 1540 to a higher standard, which could help to combat regional security priorities such as illicit movements of drugs or other contraband while enhancing the nuclear security regime).\textsuperscript{48} Another option is to build on the success of the concept of “gift baskets,” initiated at the most recent Nuclear Security Summit in Seoul, which provided like-minded states with shared concerns to work together toward a resolution. States joined to thwart the illicit trafficking of nuclear or other radioactive materials, draft national legislation to implement nuclear security agreements, and promote the security of nuclear materials while in transit.\textsuperscript{49} The focus on single issues pertinent to particular states broke the nuclear security regime down into discrete strands and made it more manageable and less imposing, thereby fostering greater trust and mutual confidence. Furthermore, “gift baskets” demonstrate an informal approach, which fits with Southeast Asia’s diplomatic model, producing tangible cooperation on issues otherwise seen as too sensitive.

\section*{Conclusion}

This paper has explored the divergent threat perceptions associated with nuclear terrorism. It is largely a preoccupation of more developed states and viewed with less importance in Southeast Asia. Such differences in the perceived threat help to explain why the nuclear security regime has not been universally accepted as a necessary response. However, this provides only a partial explanation. The broader politics of nuclear governance means that nuclear security has been stigmatized as a tool of the developed states, imposed globally in spite of vastly divergent capabilities and perceptions of the threat of nuclear terrorism. The regime is further weakened because implementation lies with individual states. If response is driven by threat and states do not perceive the risk of nuclear terrorism to be a priority, then it follows that implementation will be limited. Moreover, there is no overarching body to ensure compliance, nor is there a verification mechanism to assess the application of existing policies or conventions.

The limited commitments to, and indifferent implementation of, the nuclear security regime are troubling for the more developed states, which question the strength of a regime with so many loopholes. This imbalance between perceived threat and necessary

\textsuperscript{48} Brian Finlay, “Curbing Proliferation through Development: Nuclear Terrorism Is Not a Preeminent Concern for Most Countries, but Preventing It Has Benefits They Should Consider,” \textit{Stanley Foundation Courier}, \url{http://www.stanleyfoundation.org/publications/report/MErpt910.pdf}.


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response represents a key weakness. Based on an analysis of the different perspectives of the actors involved, the preceding section has put forward some suggestions as to how future iterations of the nuclear security regime may be strengthened with greater buy-in from regional actors. Shifting the focus of the regime away from what is seen by some as a questionable threat will help to change opinion from a discriminatory or stigmatized set of rules and commitments to a responsibility with both domestic and global benefits. Although established regional institutions demonstrate how advancement may be achieved, they are not seen as having the capacity to deal with an issue as broad and sensitive as nuclear security. However, “concrete action and cooperation is more likely at the bilateral and subregional level,” because a greater sense of inclusivity and trust can then be generated informally.\textsuperscript{50} While the universalization of treaty ratification is important, more priority should be given to targeted assistance, where the risks are most explicit and implementation is imperative. The more developed states must continue to drive the process, but they need to be aware of the sensitivity of local particularities in seeking a balance between supporting and imposing. It should be noted, however, that there is no quick fix; strengthening the nuclear security regime will be a slow and challenging process.

\textsuperscript{50} Ogilvie-White, “Non-Proliferation,” 20.
In recent years, the debate over the role that nuclear weapons play in international peace and security has been brought into the public realm in a dramatically different way. Nuclear weapons are increasingly seen by many as destabilizing relics of a Cold War security paradigm, the continued existence of which is seemingly at loggerheads with the international nonproliferation regime. As such, in 2009 U.S. President Barack Obama reaffirmed “America’s commitment to seek the peace and stability of a world without nuclear weapons.” At present, the geopolitical climate that will be necessary in order to facilitate deep nuclear reductions; and ultimately, nuclear abolition does not exist. Indeed, even if dynamics in the international system were more conducive to “global zero,” there would still be a great deal of technical work to be achieved before progress could be made. As stipulated in several UN resolutions and international agreements, there are four fundamental criteria for assessing the pathway to a world free of nuclear weapons: Disarmament should be at once verifiable, transparent, irreversible, and legally binding. This paper proceeds in two sections. First, the tension between verification and the need to protect confidential information is explored, along with a brief consideration of some of the specific verification challenges that will arise in a regime designed for generating high confidence in the destruction of warheads. Second, the mandate of the International Atomic Energy Agency in its implementation of nuclear safeguards, along with its specific confidentiality procedures, are examined to determine what lessons can be drawn from the already institutionalized multinational verification of nuclear nonproliferation for multinational disarmament.

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And they shall beat their swords into plowshares, and their spears into pruning-hooks: Nation shall not lift up sword against nation, neither shall they learn war any more.—Isaiah 2:4

Since the collapse of the Berlin Wall in 1989, there has seemingly been a paradigm shift in international relations. Once “essential to maintaining international security during the Cold War because they were a means of deterrence,” the anachronism of nuclear weapons is increasingly debated in the public realm. Globalization has fundamentally changed the rules of the game, and the great powers, no longer in direct conflict with each other, face a more immediate threat from nonstate actors. Nuclear weapons have assumed a less overt position in national security strategies; and as the costs, both financially and to national security, of maintaining large nuclear arsenals are seen by many to outweigh any potential benefits they may afford, prominent policymakers and academics have reinvigorated the argument for nuclear abolition. In addition to a shift in the international security paradigm, throughout the 1990s and into the first decade of the twenty-first century the nuclear nonproliferation regime, centered on the Nuclear Non-Proliferation Treaty (NPT), has continually been weighed and found wanting. The argument that in order to put a hold on proliferation and increase monitoring and technological controls in non–nuclear weapon states (NNWS) that nuclear weapons states (NWS) must address disarmament responsibilities at a greater pace has become increasingly salient. Indeed, in recognition of this new dynamic, U.S. president Barack Obama reaffirmed in Prague, in April 2009, “America’s commitment to seek the peace and security of a world without nuclear weapons”—a statement that has undeniably blown new life into the nonproliferation regime.

Seemingly, the world has been made ripe for a “renaissance of nuclear disarmament;” however, the challenges that await on the road to what has become known as “global zero” are many and are not relegated clearly to either political or technical dimensions but are rather a complex amalgamation of the two. As stipulated in several UN resolutions and important policy papers, there are four fundamental criteria for assessing the pathway to a world free of nuclear weapons: Disarmament should be at once verifiable, transparent, irreversible, and legally binding. The discussion that follows interrogates the nature of the sensitive balance that must be struck during disarmament verification between transparency and confidentiality and explores what lessons can be learned for a


3. This is frequently evidenced by several key events, including the discovery of Iraq’s nuclear weapons program in 1991, Pakistan and India’s nuclear tests, North Korea’s tests and withdrawal from the NPT, the bombing of Syria’s covert nuclear reactor, and Iran’s noncompliance with its NPT obligations.


multilateral nuclear disarmament approach from the verification of the NPT, specifically the International Atomic Energy Agency’s (IAEA’s) implementation of nuclear safeguards. An analytic undertaking of this specificity necessarily prompts another series of broader questions: What are the challenges to verifying disarmament? What difficulties would a multilateral disarmament regime encounter?

It quickly becomes clear that answers to such questions are functions of a political context that, at present, simply does not exist. Of particular importance, this discussion deals with what is primarily a technical challenge to multilateral nuclear disarmament by addressing confidentiality procedures and practices that would be integral to such a regime rather than the political challenges that must be surmounted before such a change can occur or, indeed, the desirability of such change. This discussion proceeds in two sections. First, the tension between verification and the need to protect confidential information is explored, along with a brief consideration of some of the specific verification challenges that will arise in a regime designed for generating high confidence in the destruction of warheads. Second, the mandate of the IAEA in its implementation of nuclear safeguards, along with its specific confidentiality procedures in practices, are examined to determine what lessons can be drawn from the already-institutionalized multinational verification of nuclear nonproliferation for multinational disarmament.

Challenges Presented by a Multilateral Approach to Nuclear Verification

Verification versus Confidentiality

To date, the majority of nuclear arms control treaties—for example, SALT, INF, START, and SORT—have been bilateral, involving only the United States and Russia and, if they had any verification measures at all, have concerned verifiable limits to delivery vehicles. Some of these treaties have provided for the counting of warheads to ensure that only the number limited by the treaty are deployed; indeed, New START, which has been in force since February 2011, does provide for the counting of actual warheads. That being said, verifying global zero would naturally have to deal more directly with the destruction of warheads themselves. This fact is further complicated by two closely related issues. First, a global zero disarmament regime would eventually have to be expanded beyond the United States and Russia to include other NWS and potentially stra-
technically significant NNWS. Second, it is generally accepted that as numbers decrease, the need for more intrusive verification of disarmament, or confidence that other parties are in fact fulfilling their obligations, will increase.

That being said, the closer an inspector is to observing the disarmament process, the higher his confidence is likely to be that disarmament is actually taking place; however, as disarmament inspections become more intrusive, the inspector will also have greater access to classified design information and potentially overall military strategy. In addition to these concerns, the desire to protect classified information also has a legal impetus, established nationally and internationally. As Persbo and Bjorningstad have asserted, a NWS “cannot according to Article I of the 1968 Nuclear Non-Proliferation Treaty, ‘assist, encourage or induce’ a non-nuclear-weapon state to manufacture a nuclear weapon or other nuclear explosive device.” This concern becomes especially problematic when considering the development of a multilateral nuclear disarmament regime in which the inspectorate would likely comprise individuals from both NWS and NNWS. It is also important to acknowledge that depending on the nature and the intrusiveness of a verification regime, state parties may not only have to be concerned about protecting information related to warhead design but also facility design and security practices, and force operations.

Over the years, a fair amount of research into these verification challenges has been carried out, first in the 1960s by the United States and again, beginning in the 1990s and continuing on to present day. In 1968 the United States Arms Control and Disarmament Agency began Field Test FT-34, also known as Project Cloud Gap. It was important that this initiative followed an American proposal before the Disarmament Committee at Geneva for both the United States and the USSR to transfer weapons grade U-235 from dismantled nuclear weapons to peaceful uses under international safeguards. The purpose of Project Cloud Gap was to build and test inspection procedures to monitor the demonstrated destruction of nuclear weapons at different levels of intrusiveness and determine the amount of classified information revealed in each round. Four levels of access to the disarmament process were tested. At the highest level of access, a total number of 112 items of classified information were revealed; at the next highest level of access, 60 items were exposed; 41 items were revealed at the third level of access; and finally, 34 items were uncovered at the lowest level of intrusiveness tested.

12. Ibid., 8.
After Project Cloud Gap, research into verification initiatives waned for many years; it was not until after the breakup of the Soviet Union in 1991 that such projects were revived. Indeed, concerns regarding the safety and security of fissile material and nuclear weapons in former Soviet republics led President Bill Clinton and his Russian counterpart, Boris Yeltsin, to establish a joint working group in 1994, tasked to consider pathways for the transparent and irreversible destruction of nuclear weapons. As a result of this cooperation, methods and tools to create transparency in the dismantling of nuclear warheads and the disposition of fissile material were developed, as have tools to aid in confirming warhead dismantlement without revealing classified design information. These advancements are discussed in more detail in the next section.

Stockpile Declarations, Warhead Authentification, and the Disposition of Fissile Material

The literature that discusses technical challenges of reaching global zero identifies three problem areas: stockpile declarations, warhead authentification, and the disposition of fissile material. While accurate stockpile declarations are absolutely essential to verifying a world free of nuclear weapons, this body of research focuses on exploring the latter two challenges. This is because, unlike stockpiles declarations, warhead authentification and fissile material verification both deal with determining what is there rather than what is not there and, as such, are not only concerned with the validation of information but also with the protection of that same information.

Confidentiality procedures and practices as they relate to verifying the destruction of warheads would have to be especially fine-tuned because of the potential or direct access to a plethora of sensitive information, including warhead design information (through the warhead itself or the weight and isotopic ratios of the removed fissile material), facility design information, and where and how the materials or warheads are stored. All this information is proliferation sensitive and potentially threatening to not only national, but also international, peace and security. The most important part of disassembly is also the most sensitive—the removal of the “physics package,” the nuclear core, or the “pit” and the surrounding high explosives, from the warhead. It is generally accepted that “inspectors able to observe how the device is actually configured may eventually deduce how the high explosive is supposed to interact with the heavy metal during detonation.”

There is also a concern that sensitive electronic components would also be completely exposed, and as a result most proposals assume that disassembly will have to be carried out in a restricted area, or a “black box.” Furthermore, it is highly unlikely that in future bilateral arms reductions, much less in a multilateral disarmament regime, inspectors


15. Ibid.
would be allowed to observe the actual disassembly of the warhead. The question remains, then: How do inspectors verify that an actual warhead is being dismantled inside the black box? Several advances in research have been made to mitigate the challenge posed exactly by this dilemma with the creation of authentification technology that relies on a set of agreed-on warhead attributes while simultaneously shielding specific, classified design information. The initiative behind such a development and its application to multilateral disarmament are discussed in more detail in the next section.

The difficulty and the necessity of protecting warhead design information continues as the core (primarily made up of either highly enriched uranium (HEU) or plutonium) and surrounding high explosives are separated and proceed down different waste flows. Disarmament verification regime designers are faced with the continuing challenge of controlling access to warhead design information, which is still represented by the weight and isotopic ratios of the removed fissile material. Therefore, inspector access has to continue to be well balanced—at once shielding classified design information and enabling them to generate strong confidence that no material has been diverted for reconstitution.

Several different methods have been designed for the disposition of both HEU and plutonium. Plutonium could potentially be vitrified with high-level waste or, alternatively, uranium-plutonium mixed oxide fuel could be fabricated for irradiation in a nuclear reactor. As for HEU, it could simply be down-blended with natural uranium to make low-enriched uranium (LEU). Verification preconversion of both types of fissile material presents fewer challenges than verification postconversion. As Bowen and Persbo have explained, “at the front end of the process, material accountancy could be conducted by simply counting the incoming pits” and “inspectors would also weigh the amount of unclassified material that the pits will be blended with.” However, the problem will remain that once conversion has taken place, “inspectors may still be able to deduce the average weight of the pits by subtracting the amount of nonclassified material from the total output and then simply divide by the number of pits.” Clearly the technical challenges to verifying the destruction of nuclear warheads is extremely complex, regardless of whether verification is undertaken in a bilateral or a multilateral context. To generate confidence throughout the entire “flow” of the destruction process, it would be essential to have viable containment and surveillance mechanisms in place at every stage, especially considering the number of stages of limited/imperfect access (e.g., removal of the physics package). The costs of such a regime have yet to be properly explored, and it remains to be seen whether such deep and lasting verification procedures would be prohibitively expensive.

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16. Ibid., 8.
17. Ibid.
18. Ibid.
Verifying the NPT

The International Atomic Energy and Safeguards

In negotiating the NPT, the five de facto NWS and the remaining NNWS struck a formal bargain centered on three pillars: the nonproliferation of nuclear technology with a military application; international cooperation among NWS and NNWS to develop nuclear technology for peaceful purposes; and, finally, to pursue negotiations for the cessation of the nuclear arms race, nuclear disarmament, and general and complete disarmament. Article III of the NPT outlines the commitment of NNWS party to the treaty to

[undertake] to accept safeguards, as set forth in an agreement to be negotiated and concluded with the International Atomic Energy Agency and the Agency’s safeguards system, for the exclusive purpose of verification of the fulfillment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices.19

The term “safeguards” refers to a “comprehensive set of internationally approved technical and legal measures, applied by the IAEA, to verify the political undertakings of states not to use nuclear material to manufacture nuclear weapons and to deter any such use.”20 Over the years, as both technology and the international political climate have changed, IAEA safeguards have evolved considerably and in three distinct phases. The first safeguards ever in place originated in the 1960s before the ratification of the NPT and were primarily designed to ensure that nuclear trade did not lead to the spread of nuclear weapons. The second phase began following the ratification of the NPT with the development of comprehensive safeguard agreements (CSAs), modeled in a document, designated INFCIRC/153. Under CSAs, a state undertakes to accept safeguards “on all source of special fissionable material in all peaceful nuclear activities within the territory of the State, under its jurisdiction or carried out under its control anywhere, for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices.”21

However, in the 1990s, two events would necessitate the implementation of the third phase in the evolution in safeguards. In 1991, it was discovered that Iraq had been developing a clandestine nuclear program at the same facility in which the IAEA conducted routine inspections of declared nuclear material and, not long after this revelation, inconsistencies between the declarations made by North Korea and information from IAEA inspections and other sources surfaced. The third phase of IAEA safeguards began in 1997 with the development of the Model Protocol Additional to Agreement(s) between state(s) and the IAEA for the Application of Safeguards, modeled on INFCIRC/540, or, more simply, the Additional Protocol (AP). The AP seeks to provide the IAEA “with information about and the right of access to, the entire nuclear programme of a state,

19. Nuclear Non-Proliferation Treaty, article iii, paragraph 1.
21. IAEA, INFCIRC/153, part 1, paragraph 1.
including all buildings (and not only nuclear facilities) on a nuclear site, nuclear related research and development, including that which does not involve the use of nuclear material, external nuclear trade, and extensive rights to take environmental samples.”

Ostensibly, where CSAs authorize the IAEA to verify the correctness of a countries declaration, the AP gives the IAEA the directive to also confirm the completeness of that declaration—casting its employees not only in the role of “nuclear accountants” but also that of “nuclear detectives.”

The implementation arm of the IAEA is known as the Technical Secretariat, which is made up of approximately 2,200 multidisciplinary professionals from roughly 90 countries. There are six major departments within the Technical Secretariat, headed by the director-general, that work to fulfill the IAEA’s mandate, including a Department of Safeguards, which has approximately 250 inspectors working to implement the IAEA’s verification agreements.

Implementation of Safeguards

The question remains: What precisely are the techniques and procedures used by the IAEA in implementing safeguards? In practical terms, IAEA safeguards are usually separated into three different categories: nuclear materials accountancy, containment and surveillance, and on-site inspections (OSIs). When discussing the methods used by the IAEA, it is important to remember that the IAEA has access, especially under the AP, to a huge range of facilities throughout the fuel cycle (i.e., milling and mining of uranium, enrichment, power generation, etc.), each with a different function and forms of material. Therefore, depending on the facility, the individual methods take on a varying degree of importance. After concluding a safeguards agreement, member states present the IAEA with the design information of their facilities and detailed inventories of their nuclear material. The IAEA is charged with verifying the design of a facility throughout its “life-cycle”—construction, use, decommissioning, and so on, to ensure complete familiarity with the premises and that the inspections designed for a site are comprehensive. Similarly, as member states are required to submit facility design proposals and changes to the IAEA, they are also obliged to update nuclear material inventories as it progresses through the fuel cycle.

Following receipt of declarations, the IAEA begins to conduct various types of OSIs to confirm member states’ compliance to the NPT. Today, the IAEA uses four different types of OSIs. First, visits are carried out in order to verify design information; next, routine inspections will begin to confirm statements made in state reports and inventories; ad hoc inspections are used to validate declarations made in initial reports regarding the nature and status of nuclear material prior to import and export; and last, the

IAEA has the ability to conduct *special inspections* which are meant to be used when a member state is under suspicion of noncompliance.\(^{25}\) Ultimately, IAEA inspections have been viewed as a model of sorts for international OSIs as we know them today; indeed, Agency practices clearly served as a template for international negotiators with regard to inspections for the Comprehensive Nuclear Test Ban Treaty and the Chemical Weapons Convention.\(^{26}\)

One of the central purposes of inspections is nuclear materials accountancy, which is often likened to a banking system, “with the IAEA playing the part of an auditor.”\(^{27}\) However, unlike the money counted by traditional bankers, “nuclear material often comes in forms that cannot be counted exactly (e.g., powders, liquids, metal pieces, etc.)” and as such “must often be measured by techniques that provide uncertain answers.”\(^{28}\) The IAEA uses two different types of analysis to verify that member states’ declared inventories of material at specific sites are accurate: destructive analysis (DA), and nondestructive analysis (NDA). DA requires that a homogeneous sample be broken down or destroyed so that it may be subject to the analytical chemistry technique of mass spectrometry. Nuclear material and environmental samples are collected throughout certain inspections and sent to either the IAEA’s Safeguards Analytical Laboratory in Seibersdorf, Austria, or to one of the Network of Analytical Laboratories, which have been certified by the IAEA. It is important that the laboratories used for these safeguards purposes are bound by strict confidentiality agreements.\(^{29}\) NDA is performed during OSIs. Several different techniques are used in NDA but essentially radiation, from material decay or outside stimulation, is measured to help inspectors determine the composition or volume of a certain material.

Containment and surveillance are both complementary processes to human inspections. Containment, in safeguards parlance, refers to the “group of features of a nuclear facility (part of such a facility) or that category of equipment that prevents access to, movement or interference with nuclear or other relevant material or with IAEA safeguards equipment or data.”\(^{30}\) Containment can, therefore, refer to a wide range of facility design features or items, including the walls of a room, a storage pool, large metal containers, and cabinets, and so on. In order to guarantee the continuing integrity of the containment implemented by the IAEA, tamper-resistant seals—which can be elec-

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\(^{27}\) IAEA, *Evolution of IAEA Safeguards*, 50.


tronic, metal, or fiber optic—are used by inspectors along with surveillance equipment.\textsuperscript{31} An example of an instance during which seals are frequently used by Agency inspectors is on the refueling hatch of a nuclear reactor. The placement of a seal enables the IAEA to confirm that the reactor is only being refueled according to a predeclared schedule by confirming that the fuel rods have not been changed since the last inspection. Surveillance, in safeguards parlance, refers to “the collection of information by inspectors or instruments (normally the latter) in order to monitor the movement of nuclear material and to detect an interference with containment or tampering with IAEA safeguards devices, samples and data.”\textsuperscript{32} Remote monitoring and closed-circuit television are examples of two of the primary forms of surveillance. While surveillance is used to monitor the flow of nuclear material and to ensure the integrity of containment practices, surveillance equipment is itself contained and often sealed. A good example of this is a “twin camera enclosed in a sealed, tamper indicating box which at regular intervals takes a picture of a spent fuel store.”\textsuperscript{33}

\textit{IAEA Confidentiality Procedures and Practices}

Just as safeguards have evolved, so have the measures—legal and practical—used by the IAEA to protect confidential information. The Statute of the IAEA and each type of safeguards agreement, including the model document which preceded the NPT’s entry into force (INFCIRC/66), all state the Agency’s responsibility to protect certain information as it carries out its verification duties.\textsuperscript{34} The statements made concerning information protection in INFCIRC/153 begin in paragraph 5, which describes that a CSA between the IAEA and a member state “should provide that the Agency shall take every precaution to protect commercial and industrial secrets and other confidential information coming to its knowledge in the implementation of the agreement.”\textsuperscript{35} Paragraph 5 outlines that no information shall be shared with other member states, organizations, or individuals relating to the implementation of safeguards within the country in question and that information will only be passed to Agency staff members on a need-to-know basis.\textsuperscript{36} In addition to this, the Agency commits to only seeking “the minimum amount of information and data consistent with carrying out its responsibilities,”\textsuperscript{37} and it is required to “secure the consent of the state to the designation of Agency inspectors to that state” and arrange inspections in such a way to “ensure protection of industrial secrets or any other confidential information coming to the inspector’s knowledge.”\textsuperscript{38}

\begin{itemize}
  \item \textsuperscript{31} Ibid.
  \item \textsuperscript{32} Ibid.
  \item \textsuperscript{33} Ibid., 53–54.
  \item \textsuperscript{34} Statute of the International Atomic Energy Agency, article 7, paragraph F, states that IAEA staff “shall not disclose any industrial secret or other confidential information coming to their knowledge by reason of their official duties for the Agency.”
  \item \textsuperscript{35} IAEA, INFCIRC/153, part 1, paragraph 5.
  \item \textsuperscript{36} Ibid.
  \item \textsuperscript{37} IAEA, INFCIRC/153, part 1, paragraph 8.
  \item \textsuperscript{38} IAEA, INFCIRC/153, part 1, paragraph 9.
\end{itemize}
As discussed above, following the revelations of both Iraq’s and North Korea’s non-compliance to the NPT and IAEA safeguards, and AP, modeled in INFCIRC/540, was developed to give increased monitoring authority in member states to include complimentary access to suspicious sites, research-and-development projects, and the use of environmental sampling in facilities to provide an even more comprehensive assessment of a country’s nuclear program. This increase in access to information augmented the concerns of many member states regarding the Agency’s confidentiality regime. As such, the confidentiality provisions set forth in INFCIRC/540 are much deeper and explicit. Confidentiality is addressed twice, first in Article 7 and again in Article 15. In explaining the breadth of the confidentiality provisions included in member state Aps, it is useful to refer to the points made by Ambassador Susan Burk, then assistant secretary of state for nonproliferation, in her testimony to the U.S. Senate Foreign Relations Committee in early 2004. In order to assuage the concerns of senators on the committee regarding the increased access an AP can grant IAEA inspectors, Burk described the preliminary agreement reached with the Agency regarding the protection of confidential information in the U.S. AP; they are as follows:

- Information on nuclear research-and-development activities that must be declared to the IAEA is limited to location and general description and does not include details or results.
- Similarly, the required information on nuclear-related manufacturing is also limited to location and the scale of operation without details.
- Access is designed to be infrequent.
- Inspection activities are limited and relevant to detection of undeclared nuclear material and activities.
- Unlike the Chemical Weapons Convention, there is no provision in the Safeguards Agreement of the Additional Protocol for any other state to request access in the United States.
- The IAEA is required to maintain a stringent regime for protection against disclosure of commercial, technological, and industrial confidential information, and the regime is subject to periodic review and approval by the United States under the U.S. Safeguards Agreement or for access under the U.S. AP.
- Whenever requested by the United States, managed access arrangements must be used to prevent disclosure of proliferation sensitive information, or proprietary or commercially sensitive information.
- Both the IAEA and its officers or employees may be subject to legal process in the event of unauthorized disclosure of confidential information. The IAEA can withdraw immunity of inspectors in cases of abuse.39

Essentially, what Burk’s testimony further emphasizes is that safeguards agreements between member states and the IAEA are tailored to meet the confidentiality needs of individual member states. The agreements are highly flexible, enabling the member state to decide where the confidentiality regime begins and where it ends and even to choose which inspectors can operate within its borders.

It should also be highlighted that the IAEA handles information in a very “traditional way,” meaning that it is “highly compartmentalized” so that certain types of information are only available to certain classes of personnel. This is evidenced by the processes used to develop the state evaluation reports (SERs), “probably the most sensitive and most controlled document handled by inspectors.” A small SER team is made up of staff from various responsible Divisions/Sections. The members of that team only see their part of the report. The country officer (inspector), the senior inspector, and the section head are the only people who see the report in its entirety while it is being prepared. It then goes to the divisional director and possibly the divisional coordination section head for review. From there it goes to a selected review board for approval. Access to facility design information provided by member states is also strictly need-to-know and is filed in a secure and monitored room in Vienna; however, design information or design verification results that are deemed by the member state to be too sensitive to store in Vienna are secured on site in an IAEA-provided tamper-indicating cabinet that is locked and jointly sealed by the facility operator, member state and the IAEA. In addition to this, all parties must be present when the files are opened and being used. It is also worth noting that the IAEA has, at least in the past, regularly preformed “systematic penetration tests to confirm the effectiveness of its [information] security measures.”

To date, the IAEA has had a good track record for protecting confidential information. In an interview about confidentiality procedures and practices, successes and failures, a lawyer in the Department of Safeguards candidly described the history and some of the basic elements of the confidentiality regime in place, stating that the Agency has only had one instance where there were concerns raised about specific breaches of the confidentiality by an IAEA inspector. So we make sure to limit access to information: it’s kept sealed, under camera, lock and key; we encrypt communica-

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40. Interview with Andreas Persbo, July 10, 2010; email correspondence with a former senior IAEA inspector who wishes to remain anonymous, July 2010.
41. Email correspondence with a former senior IAEA inspector who wishes to remain anonymous.
42. Ibid.
tions; we don’t publish specific information to the Board of Governors unless it is necessary for the implementation of safeguards.\textsuperscript{44}

Essentially, through a myriad of legal and practical procedures—in some instances using the same measures used in safeguards implementation (i.e., containment and surveillance)—the IAEA has developed a robust regime for ensuring the protection of information.

**Lessons Learned from Implementing Safeguards**

As described above, the IAEA’s regime for handling confidential information is highly tailored by individual member states through specific, mutually approved agreements. These legal proceedings are further buttressed by legal protocols and practical measures developed by the Agency itself, including binding confidentiality agreements for all members of staff (permanent and temporary); the use of containment and surveillance to not only enable the Agency to request the minimum amount of information from member states required for verification but also to ensure that information stored at facilities and back in Vienna is not accessed by uncleared personnel; information is highly compartmentalized among Agency employees; and important communications, video or otherwise, are encrypted. These are all measures which would naturally be incorporated in a multilateral disarmament verification regime.

As discussed above in the section outlining the IAEA’s methods of verification, IAEA safeguards are usually separated into three categories: nuclear materials accountancy, containment, and surveillance and OSIs (with the latter two in many instances in the service of the former). The largest contributions that could be made by the IAEA’s experience in verifying the NPT to nuclear disarmament regime would be in the areas of materials accountancy and the disposition of fissile material. Naturally, with its expertise in nuclear accountancy, the Agency has unique and extensive experience with tagging, sealing, and monitoring the shipment and storage of nuclear material.\textsuperscript{45} Such practical measures would not only restrict inspector access but also generate confidence that former weapons fissile material was not being diverted before or following conversion after its departure from the restricted disassembly facility. However, the question remains: With such restricted access measures in place, how can inspectors verify that the material removed from a “black box” and placed under their observation is in fact material from an actual warhead and ensure that no material is diverted without being privy to the classified design information (i.e., the weight and isotopic composition of the material)?

A great deal of work has in fact already been done to answer this question, and the negotiators of a multilateral disarmament verification regime would not need to start from scratch in designing procedures and practices for this phase of disarmament. From


1996 until 2002 the IAEA, in cooperation with the United States and Russia, developed special technical provisions “to allow the NWS to submit dismantled nuclear weapons components or other classified forms of fissile material to verification without giving IAEA inspectors access to information on the design or manufacture of the weapons.”

Essentially, the NDA techniques that the Agency uses to determine the composition and quantity of masked material during its safeguarding in NNWS has been adapted to operate using what has become known as an information barrier (IB). Essentially, an IB “consists of procedures and technology that prevent the release of sensitive information during a joint inspection of a sensitive nuclear item, and provides confidence that the measurement system into which it has been integrated functions exactly as designed and constructed.”

A technical IB is sometimes referred to as “red light / green light” technology because, ultimately, it reports whether or not a measurement falls above or below a certain threshold by flashing a red or green light as opposed to openly calculating sensitive design information. In this instance, the NDA techniques would function as usual but the IB operating system would only report whether or not the isotopic ratio being measured was above or below a certain limit.

Recently, an IB was actually successfully used in an exercise between the United Kingdom (a NWS) and Norway (a NNWS) as they sought to develop procedures and technology to enable a NNWS to verify the disarmament of a NWS.

Previously, it has also been suggested that built-for-purpose disassembly facilities be constructed in order to generate confidence that no material is being diverted while a warhead is being taken apart away from the watchful eyes of inspectors. In order for these facilities to fulfill their purpose, design verification inspections, similar to those implemented by the IAEA under its safeguards agreements with NNWS, would need to be conducted throughout the construction process. The design of facilities such as these would need to remain classified for facility, national, and international security purposes. The combined legal (i.e., inspector confidentiality agreements) and practical confidentiality procedures (i.e., the restricted dissemination of information among employees and the containment and surveillance of files both on site and off site) used by the IAEA could readily serve as a model in response to such a demand.

The fact that the IAEA has already developed much of the practical experience that would be required of a nuclear disarmament regime has led many to the conclusion that “engaging the IAEA to assist with transparency and verification measures seems appro-


49. Unfortunately, a detailed explanation of this exercise is outside the scope of this paper. For more information, see Bowen and Persbo, “How Might States,” 10–11.
appropriate and logical as successive steps are taken towards nuclear disarmament”; after all, “establishing another body for this purpose could undermine the IAEA safeguards system and would introduce duplicate safeguards responsibilities.”50 The Agency itself has announced that it is poised and ready to become involved in nuclear disarmament, describing that “nuclear non-proliferation and disarmament are mutually reinforcing, and the IAEA will be well positioned for the advancement of both.”51 Essentially, the above proposals would have the IAEA take on a similar role to that which is enjoyed by the Organization for the Prohibition of Chemical Weapons (OPCW), the multinational body charged with implementing the total disarmament and nonproliferation requirements set forth in the CWC. Naturally, as was the case with the OPCW, the extent to which the IAEA would be involved in a destruction verification regime would be a function of many factors at the time of negotiation, including the degree of proposed intrusiveness, the geopolitical climate, advancements in verification technology, and so on.

In conclusion, the challenges for implementing an intrusive verification regime for nuclear disarmament are extremely complex. Any arms control verification regime must strike a balance between efforts to be transparent and generate confidence that reductions are actually taking place and the restraints placed on state parties by national and international legal commitments and security concerns. The procedures and practices used by the IAEA in implementing safeguards have already served as a template for a handful of other treaty verification regimes in terms of developing managed access procedures, facility design verification, containment and surveillance, OSIs, and so on. As such, as policymakers continue to think critically about how multilateral nuclear reductions can be achieved, it is natural, especially given the nature of some of the technologies used, to consider what can be learned from the IAEA’s experience in verifying nuclear nonproliferation.

It is hard to measure the significance of the facility security and proprietary information that the IAEA has been charged to protect; however, it is immediately apparent that such information pales in significance in comparison with what is protected in a nuclear weapons program and could be made vulnerable in an intrusive disarmament regime, be it bilateral or multilateral. Ultimately, it is common sense to assume that confidentiality procedures and practices will continue to be a function of political realities and tailored to each state. As such, the greatest lesson learned for policymakers by the experience of the IAEA is that a significant amount of confidence and transparency can be generated throughout verification with minimal access to confidential information by international inspectors. All that said, it would be interesting in the future to consider the confidentiality procedures and practices used by the IAEA in verifying the destruction of Iraq’s and Libya’s nuclear weapons programs as well as its experience verifying the completeness


of South Africa’s disarmament. Looking specifically at how inspections were carried out and the handling and storage of information, especially with regard to the access of inspectors from NWS and NNWS, would be extremely illuminating for the rationale of this strain of research.
Breaking the Chains of the Cold War
Nuclear Policy Requirements in the 21st Century
Captain Christopher Diller

The passing of the Cold War, devoid of a nuclear exchange, was a welcome sight. The fruits of globalization have since interconnected the economic and security interests of states around the globe. Interdependence has led to increased cooperation and a collective harmony of interests, but the instabilities within individual states now have more pronounced effects due to their rapid and seemingly unimpeded propagation throughout the international system. Furthermore, the post–Cold War era revealed a dynamic and multifaceted threat environment through genocide, nuclear ambitions, and violent extremism. The Cold War generated an unlikely “stability” via mutually assured destruction, but that has since been replaced by rogue nations seeking regional hegemony and asymmetric advantages to balance adversarial power.

The shift from a bipolar to a multipolar threat environment has produced a contradictory dynamic in the role of U.S. nuclear weapons. U.S. security policy consistently affirms the necessity of nuclear weapons, yet there is a skewed effort to reduce the number of and reliance on these weapons. The Cold War stockpile has remained essentially unchanged due to the lack of clear policy direction, which calls into question the veracity of the U.S. deterrent. Deterrence in this new environment requires fresh thought.

The United States currently has an outdated and oversized nuclear arsenal that is ill suited to face 21st-century threats. However, a refined synthesis of political, operational, and technological considerations could lead to thoughtful modernization of a nuclear

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force that is more effective against a contemporary threat yet smaller and less costly while providing strengthened deterrence and increased assurances.

This paper establishes and builds on three main points. First, nuclear weapons are and will remain a pillar of U.S. national security, as affirmed by all three post–Cold War presidents. Second, deterrence is not a one-size-fits-all formula due to transforming threats, and therefore a legacy arsenal cannot remain effective in our current dynamic threat environment. Third, and finally, the attributes of the Cold War arsenal are different than the requirements needed to support 21st-century military strategy. These main points establish the overall policy shortcomings in arms reduction and deterrence strategy. Next, a series of recommendations for addressing the current shortcomings by defining 21st-century nuclear requirements; adopting a full-spectrum, capabilities-based defense model; and modernizing U.S. nuclear forces. While a variety of counterarguments to these proposals exist, in the end the conclusions established provide a viable path forward for U.S. national security and require immediate consideration.

Post–Cold War Nuclear Policy: Clinton, Bush, and Obama

This section highlights policies from the Clinton, Bush, and Obama administrations. The combination of these administrations comprises all nuclear policy since the end of the Cold War. This review illustrates the overlapping policy themes of perceived threats to U.S. security, the role of nuclear weapons in national security, the goals to reduce reliance on and the number of weapons, and proliferation prevention.

Clinton

The lack of a strategic opponent and the period of relative peace following the fall of the Soviet Union marked new territory for U.S. international and domestic politics. While addressing the United Nations General Assembly, former president Bill Clinton stated, “In a new era of peril and opportunity, our overriding purpose must be to expand and strengthen the world’s community of market-based democracies; . . . for our dream is of a day when the opinions and energies of every person in the world will be given full expression in a world of thriving democracies that cooperate with each other and live in peace.”2 While everyone welcomed the idea of a peaceful post–Cold War era, violence in the Balkans and Africa erupted, the United States continued to support no-fly zones in Iraq, and Kim Jong-Il assumed control of North Korea and subsequently withdrew from the Nuclear Non-proliferation Treaty (NPT).

At the same time, the Clinton administration wrote the first iteration of the Nuclear Posture Review (NPR) in October 1993. When this process concluded the following September, it established several major themes. First, nuclear weapons were playing less of a role in U.S. security than they had in the Cold War. Second, the United States could feasibly move toward a smaller arsenal. Third, although the security environment had changed, the former Soviet Union possessed a large nuclear capability that the United

States still needed to counter. Fourth, the United States will continue to extend a nuclear deterrent umbrella to its allies. And fifth, the United States should set high international standards for nuclear security, safety, and control.³

The National Security Strategy of Engagement and Enlargement, released in February 1995, echoed the NPR in that the United States would retain the triad of strategic nuclear forces sufficient to deter any future hostile foreign leadership with access to strategic nuclear forces. Therefore, the Clinton administration elected to maintain a force sufficient in size and capability to hold at risk a broad range of assets valued by political and military leaders.⁴

The National Security Strategy for a New Century, released in October 1998, began a slight shift in policy focus. The administration identified regional or state-centered threats to U.S. interests—specifically, states actively improving their offensive capability to obtain nuclear, biological, or chemical weapons along with long-range delivery systems.⁵ It stated, “Nuclear weapons serve as a hedge against an uncertain future, a guarantee of our security commitments to allies and a disincentive to those who could contemplate developing or otherwise acquiring their own nuclear weapons.”⁶

The most important change from the Cold War policy came in Presidential Decision Directive 60, according to which the new aim of the nuclear arsenal was to deter a nuclear war rather than attempting to fight and win a protracted nuclear exchange. This marked an important departure from Cold War thinking by ultimately divorcing the defeat capability of weapons from their ability to deter. This led to a philosophy that mere possession of a nuclear weapon constituted a credible deterrent. Finally, the document stated that the United States must ensure the continued viability of an infrastructure that supports U.S. forces and weapons, and that the Stockpile Stewardship Program would guarantee the safety and reliability of U.S. nuclear weapons.⁷

The Clinton administration marked the transition to the post–Cold War era. The threats facing the United States remained unchanged during the beginning; however, rogue states became more of an emphasis as time progressed. The reduced number and reliance were explicit throughout the eight years, but the composition and capability of the stockpile remained virtually unchanged. The only exception was the B-61-11, which was deployed in the late 1990s, but that was a remnant of the Cold War.

**Bush**

President Bush’s National Security Strategy was released in the wake of the 9/11 terrorist attacks. It stated, “The gravest danger our Nation faces lies at the crossroads of radi-

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6. Ibid., 12.
7. Ibid.
calism and technology. Our enemies have openly declared that they are seeking weapons of mass destruction, and evidence indicates that they are doing so with determination.”

On December 21, 2001, the Bush administration released the NPR. This document outlined policies to change the U.S. approach to the role of nuclear offensive weapons in deterrence strategy and presented a blueprint for transforming U.S. strategic posture. The report established a “New Triad” composed of the following (see figure 1):9

1. Offensive strike systems (both nuclear and nonnuclear).
2. Defenses (both active and passive).
3. A revitalized defense infrastructure that would provide new capabilities in a timely fashion to meet emerging threats.

**Figure 1. The New Nuclear Triad**


The Bush NPR put the Cold War planning practices for strategic forces in the past. Few changes had been made in the size and composition of the strategic nuclear force since the end of the Cold War; at the same time, plans and funding to sustain many critical elements of the force were inadequate.10 The NPR declared that the traditional

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10. Ibid., 1.
strategic posture that relied on offensive nuclear forces was no longer effective in deter-
ing potential adversaries in the 21st century. Although the new threats dictated a fewer
number of weapons, the U.S. nuclear force required the capability to hold a wider range
of target types at risk.\footnote{Ibid., 3.}

The NPR pointed out several weaknesses in the arsenal. First, it called for “greater
flexibility” with respect to nuclear forces and planning.\footnote{Ibid., 3.} It stated, “New capabilities
must be developed to defeat emerging threats, and to define and attack mobile and re-
locatable targets, to defeat chemical and biological agents and to improve accuracy and
limit collateral damage.” It also emphasized that the “need may arise to modify, upgrade,
or replace portions of the extant nuclear force or develop concepts for follow-on nuclear
weapons better suited to the nation’s needs. It is unlikely that a reduced version of the
Cold War nuclear arsenal will be precisely the force that the United States will require

The Bush administration identified near-peer states, rogue states, and terrorism as
explicit threats to U.S. security and identified the stockpile as being inadequate to ad-
dress all those threats. Expanded conventional weapons capabilities and two nuclear
weapon modifications were proposed to address the changing threats; the Robust Nu-
clear Earth Penetrator and the Reliable Replacement Warhead. Both these programs had
congressional funding for multiple years but were ultimately struck down.

\textit{Obama}

Shortly after President Obama took office, he delivered a historic speech in Prague
where he highlighted nuclear dangers in the 21st century and vowed that the United
States would “seek the peace and security of a world without nuclear weapons” in order
to overcome these dangers.\footnote{Robert Gates, “Nuclear Posture Review Report,” White House, April 2010, iii.} President Obama’s NPR also stated that “the long-term
goal of U.S. policy is the complete elimination of nuclear weapons.” Recognizing that
nuclear abolition was overly ambitious, he expressed his determination to take concrete
steps toward that goal by reducing the number of nuclear weapons and reducing their
role in U.S. national security.\footnote{Ibid.}

President Obama’s National Security Strategy stated that “there is no greater threat
to the American people than weapons of mass destruction, particularly the danger posed
by the pursuit of nuclear weapons by violent extremists and their proliferation to addi-

Additionally, President Obama’s NPR stated “that as long as nuclear weapons exist,
the United States will maintain a safe, secure, and effective arsenal both to deter poten-
tial adversaries and to assure U.S. allies and other security partners that can count on America’s security commitments.”

The implications of this policy on the arsenal are not clear. Obama’s National Security Strategy of Engagement and Enlargement stated, “Our military must maintain its conventional superiority and, as long as nuclear weapons exist, our nuclear deterrent capability, while continuing to enhance its capacity to defeat asymmetric threats.” This suggests that nuclear weapons need expanded capability to defeat asymmetric threats; however, the NPR explicitly states that stockpile management “can ensure a safe, secure, and effective deterrent without the development of new nuclear warheads or further nuclear testing,” and “Life Extension Programs (LEPs) will use only nuclear components based on previously tested designs and will not support new military missions or provide for new military capabilities.”

Additionally, the Obama administration’s NPR clearly stated, “The massive nuclear arsenal we inherited from the Cold War era of bipolar military confrontation is poorly suited to address the challenges posed by suicidal terrorists and unfriendly regimes seeking nuclear weapons.” Much like his predecessor, President Obama realized that the current arsenal is not effective at addressing current threats both in size and capability. In order to bridge this capability gap, President Obama’s plan is to augment the “credible deterrent” by “reinforcing regional security architectures with missile defense and other conventional military capabilities” to ensure that U.S. extended deterrence commitments are met.

President Obama is an outspoken proponent of nuclear abolition; however, he realizes the importance of maintaining the overall capability. The main objectives of his administration are to reduce the number of and reliance on the weapons while maintaining a credible deterrent. His administration has identified rogue states and terrorist organizations as immediate threats and the fact that the nuclear arsenal is poorly suited to confront these threats. And he has explicitly prohibited updates to the arsenal; however, the B-61 is undergoing a LEP that could provide an enhanced capability.

Table 1 summarizes the three administrations’ goals, which have spanned a period of nearly 20 years. Independent of political affiliation, the administrations have agreed that the United States must have a credible deterrent to support its national security strategy. However, Bush and Obama specifically identified the stockpile as outdated and ineffective, but surprisingly over a period of 12 years it was not updated to meet the requirements.
Table 1. Summary of Presidential Administrations’ Goals

<table>
<thead>
<tr>
<th>President</th>
<th>IDd Strategic Threat</th>
<th>IDd Rogue Threat</th>
<th>IDd Terror Threat</th>
<th>Prevent Proliferation</th>
<th>Reduce Number</th>
<th>Reduce Reliance</th>
<th>Conventional Reliance</th>
<th>IDd Outdated Arsenal?</th>
<th>Stockpile Additions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>Yes</td>
<td>Yes*</td>
<td>Yes*</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>**B-61-11</td>
</tr>
<tr>
<td>Bush</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>***RNEP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**RRW</td>
</tr>
<tr>
<td>Obama</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>****B-61-12</td>
</tr>
</tbody>
</table>

*Broad threat, but not specific.
**Cold War remnant.
***Robust Nuclear Earth Penetrator, Reliable Replacement Warhead, neither developed due to lack of congressional support.
****The B-61 is undergoing an LEP which redesignates it as the B-61-12. The LEP is in the early stages, and the specific details are not yet clear as to the changes.

Deterrence

The subject of deterrence has filled the halls of academia, Congress, the White House, and the Pentagon for decades, so the chances of an earth-shattering breakthrough are unlikely. This section aims to bracket the problem on modern-day deterrence by focusing the reader on the objective criteria of deterrence theory rather than the subjective aspects of this theory.

The concept of deterrence has evolved over the past half century. During the Cold War, deterrence was the cornerstone of U.S. national security strategy, and the world’s fate rested upon its refinements, improvements, and effectiveness. Deterrence is the psychology of a threat.17 The psychology relies on the rationality of the adversary to react to the threat along with the perceived alternatives available to the adversary. Ultimately, it is the adversary that determines the effectiveness of a deterrent. The efficacy of the threat rests on its credibility, and its credibility relies on two precepts: first, a demonstrated defeat capability (weapon) and second, the authority and political will to order its use. To oversimplify, if a country has a nuclear weapon and the will to use the weapon, and if the adversary has reason to believe that it is threatened and values what is being threatened, then a “credible nuclear deterrent” exists. This paper addresses only the defeat capability aspect of deterrence, which for all intents and purposes remains the most fundamental and most objective criterion on which to establish the credibility of the deterrent.

For years, U.S. policymakers have assumed that the United States possesses and maintains a credible nuclear deterrent, and for the majority of the Cold War, this was probably true. The fruits of the Manhattan Project most certainly began the chain of events that built the Cold War stockpile and fueled the arms race; however, the exact capability of Fat Man and Little Boy were vastly improved upon over the course of time. Why? Because the United States faced a dynamic adversary that attempted to reduce the U.S. advantage, and therefore it had to adapt and overcome to maintain its suprem-

acy. Each side went through multiple iterations of stockpile advancement from atomic weapons, thermonuclear weapons, aircraft delivery, intercontinental ballistic delivery, submarine delivery, multiple independently targetable reentry vehicle technology, and ballistic missile defense technology, to name a few. At every intersection, the opposing side had to make a conscious decision to modernize its arsenal to address the new threat, to the point where each side had enough weapons to destroy the world many times over. Although tensions have eased, the United States and Russia still maintain a fraction of that capability. The more important point is that the United States maintains this exact same capability with the exact same weapons. The benchmark for weapons to produce an effective deterrent continually changed throughout the Cold War; therefore, it is reasonable to assume that an effective deterrent today would require an arsenal tailored to meet those needs.

The point of this discussion is to ask the question, is deterrence a one-size-fits-all concept with respect to nuclear weapons? And if an arsenal can deter one actor, can it deter all actors? Affirming those questions may gloss over the fact that the United States is now attempting to deter actors from gaining a nuclear capability, proliferating a demonstrated capability, and/or using a demonstrated capability. To complicate matters, these new actors behave differently than the Soviets in that they may not be rational by Western standards and therefore may not be responsive to Cold War–style brinkmanship. Their motivation for developing or seeking nuclear weapons is a mixture of national pride, asymmetric advantage against a superior conventional adversary, and regional dominance. Additionally, their cultural and religious values differ from the Soviet model; therefore, their decision calculus is vastly different. It is difficult to believe that an arsenal tailored to the Cold War deterrence model is the optimum solution for the multifaceted threats of today.

Those who believe that deterrence is not a one-size-fits-all model but still agree that deterrence is a valuable theory on which to base policy must justify the current arsenal’s ability to support such a policy. The Cold War relied on multiple iterations of weapon designs and delivery vehicles to support deterrence as threats evolved. Since the end of the Cold War, the United States has continued to pursue that exact same policy of deterrence while at the same time expanding the scope of actors and behaviors to be deterred, yet the weapons are exactly the same. If deterrence is not one size fits all, and the most fundamental tenet of deterrence is a defeat capability, it is reasonable to expect a different arsenal to address a different threat.

Effective Deterrence Requirements: Cold War versus Modern Day

The next logical step in defining the problem with U.S. nuclear policy and formulating a solution is understanding what weapon characteristics contributed to an effective deterrent during the Cold War and why. Next, one needs to compare this with what requirements are placed on nuclear weapons today to determine the viability of the Cold War stockpile as an effective deterrent. This becomes a difficult task because the only
requirements placed on the weapons are that they are safe, secure, reliable, credible, and effective—which are hardly metrics. Since there is not a baseline of comparison for the requirements of Cold War and post–Cold War nuclear arsenals, the present requirements placed on the U.S. conventional military are used here as a desirable framework to determine the disparities and frame the solution. The purpose of this comparison is to illustrate the fact that there are no concrete defeat requirements for a “modern” nuclear arsenal. Furthermore, since the current stockpile was designed and deployed during the Cold War, it maintains the characteristics to meet an antiquated military strategy therefore making it incapable of supporting modern military strategy.

The Cold War Situation

The development of nuclear weapons marked a defining point in world history. After the Soviet Union gained a nuclear capability and the arms race was under way, nearly all political and military efforts were directed toward countering and ultimately containing the Soviet empire. Little argument surrounded the necessity of counteracting the Soviet threat, and presidential administrations were defined by their individual approach to countering the USSR.

In the early days of the Cold War, the U.S. military was almost exclusively focused on how to fight and win a nuclear war. Military leadership was typically composed of nuclear operators, and resource allocation was dominated by the acquisition of new nuclear delivery platforms or new weapons in order to bridge an emerging capabilities gap. This one-dimensional approach to military strategy is known as a threat-based approach.

The essence of a threat-based model is an exclusive focus on “who and what” is going to be fought, not “how and when.” It is typically used when threats to U.S. interest are easily identified, much as they were during the Cold War. The ability to quantify a threat provides a rationale for building a force structure. In a two-sided conflict such as the Cold War, this typically leads to niche capabilities and a classic game of one-upmanship between adversaries—that is, an arms race. It is a cyclic process that revolves around what threat the adversary poses to you, and how it is countered.

The military became so Soviet-centric that the nuclear attack option was known as the Single Integrated Operational Plan. This plan dictated the sequence and integration of U.S. forces as they attacked the Soviet Union. The nature of the threat and the creation of this plan led to the size, makeup, and capability of the stockpile and delivery systems throughout the period.

Due to the ever-changing nature of the threat between the United States and the Soviet Union, weapon systems (weapons and delivery platforms) were constantly redesigned and updated. Weapons were intended to have a short shelf life, and there was a robust infrastructure to build, modernize, and repair the arsenal. The ability to quickly and frequently replace weapons tended to undervalue safety and reliability in favor of increased capability and reduced timeline to field new weapons. In order to hedge against the lack of reliability, a redundant targeting strategy existed. If a weapon hit a target and did not detonate, there were additional weapons hitting the same or nearby targets that
would destroy the missed target. Ample funding and resources provided an increased number of weapons, which compensated for the lack of reliability.

The lack of precision, due to the technological limitations of the day, increased the number of weapons required. A redundant targeting strategy also compensated for the lack of accuracy, and this again added to the total nuclear force requirement. The combination of decreased reliability and poor accuracy increased the collateral damage associated with the weapons. However, this was of no consequence when dealing with the Single Integrated Operational Plan. In fact, collateral damage was looked upon as a positive effect since the goal was to maximize damage to the enemy.

What exactly constituted a “reliable” and “effective” deterrent in the Cold War? Loosely defined, it was the combined effects of multiple weapons and multiple delivery platforms attacking hundreds if not thousands of targets. Targeting experts analyzed the probability of a weapon successfully being delivered either from an aircraft or missile within an acceptable distance from the target, detonating at its intended yield, and inflicting the required amount of damage to a target. These reliability metrics translated into requirements, and the requirements guided the development and deployment of the arsenal through the 1990s when the cycle was effectively severed. At that point, the Cold War arsenal, which was designed under the above criterion, instantly became the post–Cold War arsenal, and it is still in service today.

*The Post–Cold War Threat Environment*

The threat environment has changed since the end of the Cold War. The risk of a nuclear exchange with Russia still exists but is greatly diminished. For 50 years, national security strategy was directed toward countering the Soviet Union, and overnight, the threat disappeared without bloodshed. Suddenly the U.S. military found itself in a unique position, but the anticipated peace dividend was quickly spoiled. The U.S. military found itself deployed in places such as Somalia, Haiti, and the Balkan states and enforcing no-fly zones in Iraq throughout the 1990s, which were all part of Clinton’s selective engagement strategy. Increased involvement in military operations, ranging from peacekeeping to sustained aerial bombardment, forced the conventional U.S. military to adopt a strategy to counter emerging threats with fewer but more capable assets. Due to the necessity of limiting collateral damage and the fact that the United States would eventually rebuild many of the target areas, destruction needed to be limited. The post–Cold War military cuts and advances in weapons technology, coupled with a widening range of enemies, required weapons and delivery systems that minimized damage and maximized effects. So came about effects-based operations.

Effects-based operations seek an end state that meets military objectives regardless of which process or platform performs the mission. For instance, if the enemy is reliant on electrical power to conduct operations, effects-based targeting seeks to cut off the power source to the enemy. This can be done in a multitude of ways: a nuclear strike that destroys the power plant, ground forces invading and taking control of the power plant, Special Forces cutting power lines, or precision-guided munitions striking substations...
that relay the power to the enemy. All these options facilitate the required end state but range in the level of effort required and inflict varying levels of damage on the enemy and civilian population.

The idea of effects-based operations logically flows into the idea of a capabilities-based approach to military strategy. The core of a capabilities-based model is to identify capabilities that adversaries could employ and capabilities that could be available to the United States, then evaluate their interaction, rather than overoptimizing the force for a limited set of scenarios. A capabilities-based model attempts to predict how an adversary might fight as opposed to who the adversary might be. This model is necessary when threats to U.S. interests are vague and multifaceted. The ambiguity of threats does not allow for deliberate counterplanning; instead, an adaptable force must be designed that is suited to address a myriad of scenarios. While this creates a force that is not optimized against one specific threat, it is optimized to tackle a much wider range of situations. In comparison with a threat-based model, this approach dictates different requirements when designing, maintaining, and acquiring military assets. Instead of a one-versus-one mentality for military hardware, it seeks platforms that can perform multiple functions, be updated quickly, face multiple threats, and be sustained over a longer period of time.

Summary

What does all this mean? The nuclear arsenal characteristics equate to what was designed during the Cold War and what is now in use. The post–Cold War military requirements equate to the characteristics that define U.S. conventional military strategy and in all likelihood should guide nuclear military strategy. It is clear that these two paradigms contradict one another (table 2). Knowing this, it is difficult to understand how the United States can possess an effective nuclear deterrent if the characteristics of the arsenal fail to support modern military strategy.

Table 2. Nuclear Arsenal Characteristics versus Post–Cold War Military Requirements

<table>
<thead>
<tr>
<th>Characteristics or Requirements</th>
<th>Reliable</th>
<th>Accurate</th>
<th>Low Collateral Damage Required</th>
<th>Redundant Targeting</th>
<th>Fewer Weapons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Arsenal Characteristics</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Post–Cold War Military Requirements</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

So what defines a “reliable” and “effective” deterrent in the 21st century? Based on the analysis above, today’s military faces a much wider range of threats. If the military dictated nuclear requirements to address current threats with the same measures of effectiveness as dictated by conventional strategy, the nuclear stockpile would almost as-

suredly look different. It would likely mimic the requirements placed on conventional weapons regarding reliability, accuracy, and decreased collateral damage, thereby enabling a slimmer, more capable force.

Policy Shortcomings

Evidence from previous presidential administrations suggests that nuclear weapons will remain a pillar in U.S. national security strategy for the foreseeable future. However, multiple flaws in policy and force shaping have weakened the ability of the United States to maintain a credible deterrent posture and substantially reduce the total number of weapons.

Deterrence

Over the past 20 years, the military and policy communities have failed to create concrete requirements and desired defeat capabilities for the nuclear arsenal. This lack of direction has stemmed from an inability to quantify what behaviors and which states the United States is trying to deter. Absent this direction, the nuclear force structure was not molded to support a coherent deterrence policy. A capabilities gap exists between current threats and the U.S. ability to counter those threats, and it is possible that the United States is becoming self-deterred with the extant arsenal.

The Bush and Obama administrations both posited increased reliance on and development of conventional weapons. While increasing reliance on conventional weapons is appropriate, there are targets that U.S. conventional forces cannot defeat, particularly hard and deeply buried targets (HDBTs). Furthermore, there are targets that are invulnerable to a nuclear attack using current U.S. weapons. A previous commander of the U.S. Strategic Command articulated this point: “Our current arsenal, developed in the Cold War, was not designed to address this growing worldwide threat [of buried targets]. There are facilities today which we either cannot defeat, even with existing nuclear weapons, or must hold at risk using a large number of weapons.”

If the United States continues to allow the nuclear stockpile to atrophy, there will be an increased capability gap and a proliferation of targets that are well out of reach of conventional and legacy nuclear weapons. The inability to destroy certain targets undermines the very basis of the U.S. deterrent posture. Furthermore, the countries that pose the greatest threat to U.S. security, such as North Korea and Iran, are the most widely known to build underground structures.

The inaccuracy of current weapons, coupled with their large yield, creates a question of credibility in the stockpile and the leadership’s will to use them. The United States’ enemies understand its aversion to civilian casualties and collateral damage. The fact is that nuclear weapons are the “dumbest” (i.e., most inaccurate and oldest) weapons in the U.S. inventory, and also cause the most collateral damage of any weapon. U.S. adversar-

ies most certainly take this into account when assessing the United States’ decision to employ nuclear weapons. Without precision targeting and the accompanying decreased yield to minimize collateral damage, there is a strong argument that the United States is self-deterred. This decreases the overall credibility of U.S. deterrence.

The U.S. nuclear deterrent appears to have prevented a nuclear exchange during the Cold War. However, Pakistan and North Korea have both gained a nuclear capability since the end of the Cold War. Furthermore, Iraq was on its way to a nuclear program before the first Gulf War and Iran is currently pursuing a latent nuclear capability. It is plausible to believe that these states have proliferated due to an antiquated U.S. stockpile and resultant weakened deterrent.

**Arms Reductions**

The lack of direction has also inhibited thoughtful arms reductions in the nuclear force. Since there is not a clear road map of what capabilities are required of the nuclear arsenal, it is impossible to determine the appropriate size and makeup of the force. Without a starting point of what is required, it becomes more difficult to determine how many weapons, if any, can and should be cut.

The Obama administration recently brokered New START, and there are talks of additional cuts. Doing this will weaken his policy objectives of decreasing reliance and the numbers of nuclear weapons, while maintaining an effective deterrent and extended deterrence. The nuclear arsenal of today was not built with reliability as its top priority. The existing weapons were designed for a 10- to 15-year service life, so their reliability is in question. To make matters worse, the United States is the only nuclear weapons state party to the NPT that does not have the ability to produce a new nuclear warhead. To hedge against this unreliability, a pool of nondeployed warheads is retained. Additional reductions would undermine Obama’s goal of maintaining an effective deterrent based on a stockpile sized to hedge against reliability concerns.

Arms reduction is further inhibited by the extended deterrence commitments. While calculating the number of weapons required to support assurance commitments is not viable, it is safe to say that the United States’ allies rely on its sizable stockpile to guarantee their security. Japanese defense minister Fumio Kyuma was explicit regarding the nuclear requirements of extended deterrence: “The strongest deterrence would be when the United States explicitly says, ‘If you drop one nuclear bomb on Japan, the United States will retaliate by dropping 10 on you.’”

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Recommendations

Define 21st-Century Nuclear Requirements

The policy and military community alike must define the requirements for nuclear weapons in the 21st century. Broad policy objectives are filled with language such as safe, secure, reliable, credible, and effective. One of the primary missions of the National Nuclear Security Administration is to maintain the safety, security, and effectiveness of nuclear weapons in order to provide the nation with a credible deterrent. The Defense Threat Reduction Agency has a unit of nuclear experts that inspect Air Force bases and Navy ports around the planet to ensure the safety, security, and readiness of everyone involved in nuclear-capable forces. This language and these organizations are important, but these “requirements” are little more than adjectives. The fundamental disconnect is the meaning behind these words—particularly “reliable,” “credible,” and “effective”—and how they form a coherent deterrence policy.

Define the threats and behaviors to deter. The policy and military community must come together to determine what behaviors and actors the United States must deter and what constitutes a credible and effective deterrent in this effort. Based on the objective criteria of deterrence outlined in the previous deterrence section, this lays the foundation for what defeat capabilities the United States must possess in order to hold those actors at risk.

The concepts of credibility and effectiveness are interlinked; the measure of effectiveness suggests the credibility of a deterrent. Deterrence effectiveness is immeasurable, but weapon effectiveness (i.e., the ability to destroy or degrade a given target), which is directly tied to deterrence, can be modeled and quantified. This effectively outlines the likely types of nuclear targets and what defeat capability is required.

Understand current nuclear and conventional capabilities. Once the defeat capabilities are defined, military leadership must provide an accurate assessment of what role conventional weapons can fill and what role nuclear weapons must play. This requires an understanding of the current limitations of the nuclear stockpile with respect to reliability, accuracy, and collateral damage, along with the military and political implications of the current “plan” to mitigate these problems.

Define reliability. Reliability, in this case, does not relate to the lack of reliability in the current stockpile, but rather what degree of reliability is needed to face current threats. An actual measure of reliability is beyond the scope of this paper; however, the need to define that measure is critical in shaping requirements. Reliability is a much more important metric now that the scope of a nuclear exchange is smaller and more limited in scale, as compared with the Cold War.

Determine shortcomings. Outlining concrete credible, effective, and reliable metrics and comparing them to current capabilities allows the military to identify shortcomings.

Likewise, it provides a baseline to establish new capability requirements and sizing for both conventional and nuclear weapon stockpiles.

A Full-Spectrum, Capabilities-Based Model

Opening the dialogue between the military and civilian leadership, along with redefining the requirements of 21st-century deterrence, will enable the military and policy community to shift from a threat-based model to a full-spectrum, capabilities-based model that smartly integrates conventional and nuclear weapons strategy. Policymakers and military leadership must grasp the importance of conventional weapons’ role in deterrence. The technological advantage that the U.S. military currently enjoys allows conventional weapons to fulfill the same mission that once required a nuclear weapon. This reduces the number of nuclear weapons required and reduces the overall reliance on nuclear weapons. However, the conventional advantage of the U.S. military is shrinking, and without this edge, the demand for nuclear weapons could intensify and the likelihood of a nuclear exchange could increase.

*Increase intelligence, surveillance, and reconnaissance (ISR) funding.* The ability to maintain information superiority allows military planners to exploit enemy weaknesses and carry out effects-based operations. This allows for precision targeting (both kinetic and nonkinetic) of critical vulnerabilities, and while it may not lead to a full kinetic defeat, it allows for the functional incapacitation of the threat. This is only possible with state-of-the-art computers, software, and ISR platforms such as satellites and manned and unmanned vehicles.

*Guarantee freedom of movement.* The military must ensure freedom of movement and confront the emerging antiaccess/area-denial challenge (A2/AD). A2/AD threatens to deny U.S. freedom of movement to conduct such missions as ISR and interdiction strikes by denying global positioning systems, degrading communication systems, and increasing the number and capability of enemy surface-to-surface and surface-to-air weapon systems. This requires expanding capabilities to dominate the electromagnetic spectrum to reduce the effects of A2/AD and increasing the viability of U.S. systems to operate in a degraded electromagnetic environment. Without the freedom of movement, ISR cannot gather data to guide strategy and precision military engagements become increasingly challenging, potentially opening the possibility for a nuclear option.

*Exploit technology for delivery platforms and weapons.* The United States must continue to exploit weapons technology to the maximum extent possible. This means research and development in nonkinetic weapons systems and directed energy weapons for future capabilities. There must also be continual emphasis on survivable standoff weapons like the Joint Air-to-Surface Standoff Missile, and advanced cruise missiles such as the Tomahawk Land Attack Missile. The Department of Defense must continue to fund enhanced conventional HDBT defeat weapons such as the 30,000 pound GBU-57 Massive Ordinance Penetrator and follow-on weapons. Additionally, there must be continued sustainment and investment in survivable delivery platforms and key enablers such as aircraft carriers, conventional submarines, EF-18G, B-2, F-22, F-35 and next generation bomber in order to carry out strikes if the situation dictates.
Ballistic missile defense. The development and deployment of a ballistic missile defense system is crucial in reducing the likelihood of a small-scale nuclear attack. The inability to threaten an enemy’s delivery system after launch, coupled with the inability to functionally defeat those delivery systems in garrison with kinetic or nonkinetic effects, increases the likelihood of a U.S. nuclear response. Decreasing the incentives and the likelihood of a successful strike by a rogue state reduces the overall likelihood of a nuclear exchange by either side.

Reliable command, control, and communication. Finally, command, control, and communication systems need to be continually upgraded to effectively integrate these capabilities. This allows proper routing of critical information to the appropriate source at the right time for analysis and for making timely decisions to prevent the loss of life. This prompt flow of information decreases decision and analysis timelines, which serves as a key enabler for synergistic battlespace dominance.

Increase strategic communication. The military and policy community must communicate intentions domestically and internationally within the constraints of operational security. This involves stronger language in the National Security Strategy, Quadrennial Defense Review, National Military Strategy, and NPR as well as public media outlets as to role of nuclear weapons in U.S. policy. America must leave no doubt in its enemies’ minds that if its conventional weapons cannot hold them at risk, its nuclear weapons will. This renewed emphasis also increases the United States’ assurance commitments with allies.

Modernize Nuclear Forces

It the U.S. policy and military communities were to adopt a capabilities-based planning model, the next step would be to update the nuclear force to meet 21st-century military requirements. This would involve enhanced capabilities to address a wider range of threats and thereby close the capabilities gap that currently exists. These updates would also increase the reliability of the weapon system. The combined effects would allow for the deployment of fewer weapons and provide a more robust deterrent while strengthening assurance commitments.

Increase the accuracy of nuclear weapons. As stated above, the weapons in today’s arsenal are less accurate than conventional weapons. The common approach to this problem, even in the military community, is to scoff at the accuracy of nuclear weapons due to their incredible explosive capability. This idea is bred from the immature technology of the day and from the inability to precisely target weapons in the Cold War. Due to their large circular error of probability (CEP) (accuracy metric), the yields of the weapons were increased to make up for increased miss distances. Modern guidance technology makes inaccuracy a thing of the past. Figure 2 illustrates this point.

24. The nuclear weapons capabilities discussed in this section are all generic. The yields and capabilities are for illustration purposes only. No current weapons system information was used in the derivation of the graphs.
Figure 2. Circular Error Probability (CEP) versus Yield (Probability of Destruction, Pd)

In figure 2, the X-axis axis is the CEP, from 0 to 600 feet, and the Y-axis is the probability of destruction (Pd). As you can see, placing a weapon between 0 and 100 feet ensures a 95 percent probability or greater of destruction. As this CEP increases over 100 feet, the Pd sharply decreases. At 200 feet, the Pd is approximately 75 percent; and at 300 feet, it is approximately 50 percent. This increase in CEP is the difference in sending a single weapon versus multiple weapons. The obvious conclusion is that the closer the weapon can get to the target, the higher the confidence in its destruction. The higher the confidence in destruction, the fewer weapons required.

Decrease the yield of nuclear weapons. Increasing accuracy also allows for a decrease in yield. Figure 3 demonstrates this point by showing the required yield and CEP to achieve a constant 0.99 Pd of a given target. As you can see, a 0.1 kiloton weapon placed 30 feet from a target has the same destructive capability as a 70 kiloton weapon (nearly three times the explosive power of the weapons dropped in World War II) at 300 feet. The ability to increase accuracy and decrease yield allows for decreased collateral damage and enhanced destructive capability of a weapon against hard and deeply buried targets.
Reduce collateral damage. Table 3 was derived from a notional target consisting of a tunnel facility 105 meters below the surface. Each horizontal segment compares the associated fallout for a constant overpressure (destructive capability) effect by manipulating the yield of a surface burst and a 10 meter depth of burial burst. The collateral effect radius is the effect distance from the detonation point. The primary effect source is the largest of the collateral effects: base surge, thermal fluence, or blast overpressure. For example, the 50 kiloton surface burst produces a larger collateral effect radius than the 50 kiloton buried burst because the thermal influence is greater because the fireball is above ground. The table illustrates the ability to substantially reduce collateral effects while maintaining the same overpressure to destroy a target with a lower yield weapon at 10 meter depth of burial.

Update nonnuclear components. Developments in computer technology and state-of-the-art electronics can also tackle the potential problems with the nonnuclear components of the weapon that contribute to its reliability problems. Incorporating new digital electronic components allows for multiple redundant internal safeguards, making it an overall safer weapon. The electronic fusing and firing components could also be upgraded and streamlined, making inspections, maintenance, and upgrades to the weapons easier and less costly while at the same time increasing the reliability of the weapon.
Table 3. Weapons Effect and Nuclear Fallout

| Yield (kilotons) | Depth of Burial (meters) | Shock Overpressure at 150 Meters Below the Surface (kbar) | Collateral Effect Radius (kilometers) (primary effect source) | Area of Exposure to 50 Rem or Greater from Fallout after 48 Hours (square kilometers)
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<td>0.25</td>
<td>10</td>
<td>0.1</td>
<td>1.1</td>
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<td>5</td>
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<td>10</td>
<td>0.4</td>
<td>1.2</td>
<td>30</td>
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<td>50</td>
<td>Surface</td>
<td>0.5</td>
<td>5.7</td>
<td>500</td>
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<tr>
<td>4</td>
<td>10</td>
<td>1</td>
<td>2.2</td>
<td>90</td>
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<tr>
<td>175</td>
<td>Surface</td>
<td>1</td>
<td>11</td>
<td>1,400</td>
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<td>50</td>
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<td>600</td>
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<td>2,000</td>
<td>Surface</td>
<td>5</td>
<td>38</td>
<td>8,700</td>
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The way ahead. In order to combine these desired features on a weapon, an idea similar to the Reliable Replacement Warhead and the Robust Nuclear Earth Penetrator must be revisited. This could involve the design of a new warhead based on proven weapons designs or a refurbishment of existing weapons in order to meet the same objectives.

The current B-61 LEP has breathed some life into the movement. One of the goals of the B-61-12 LEP is to place a guidance tailkit, much like a Joint Direct Attack Munition on the weapon to improve accuracy. The details of this program and weapon are still unclear, and it is currently under scrutiny due to cost overruns.

Cost study on sustainment versus replacement. No doubt upgrading and developing weapons would be extremely expensive; however, all the weapons in the stockpile have undergone LEPs and will continue to do so as long as they are operational. A thorough fiscal comparison between past, present, and future LEPs with the anticipated cost of designing and fielding a new weapon is a worthy project. A broad argument can be made that investing and upgrading weapons now saves money in the long run by paving the way for reductions in the total number of weapons (due to increased reliability and effectiveness) and the associated LEPs needed to sustain them indefinitely. This analysis must be done to ensure that taxpayers’ dollars are spent wisely.

Decrease the size of the stockpile. Defining requirements for nuclear weapons and establishing a plan to meet those requirements paves the way for substantial reductions in the overall stockpile. The intent of this recommendation is not to provide a number, but more guidelines that would establish thoughtful cuts in the stockpile.

Adopting a capabilities-based approach shifts the focus from how many targets to what types of targets the United States must hold at risk, likely reducing the requirement for weapons.

Additionally, continued upgrades and improvements to conventional capabilities will continue to decrease the need for nuclear weapons, although not entirely remove the need.

Increasing accuracy and improving the defeat qualities of the stockpile reduces the demand for nuclear weapons because the probability of destruction is greater and more predictable. This dictates a smaller number of weapons to achieve the desired weapons effects. More reliable weapons equate to less of a requirement for weapons. First, the hedge strategy of a nondeployed stockpile can be forgotten with respect to reliability concerns. Second, instead of targeting multiple weapons against a facility, the requirement may necessitate only a single weapon.

**Opposing Views**

*Nuclear Weapons No Longer Have Value in the 21st Century*

Many contemporary thinkers are committed to ridding the world of nuclear weapons altogether. This is a noble goal and on the surface appears desirable, but it is extremely debatable. First, no Western power revels in the ability to wipe humanity off the face of the Earth; the sheer capability to do so is nearly beyond comprehension. However, the threat of mutually assured destruction forces nuclear-capable states to turn toward diplomacy and avoid military confrontation, which possibly has led to the creation of a more peaceful world over the last 70 years. Imagine if every nuclear state simultaneously stuffed the nuclear genie back into the bottle. Next, couple that with global economic instability, struggles for regional dominance, the proliferation of chemical and biological weapons, advanced conventional weaponry, and violent extremist—you have now described a world more volatile and explosive than history has ever seen but without the force that provides the most stability due to its grave consequences. To say that nuclear weapons are stabilizing seems contradictory, but history shows otherwise.

Others believe that nuclear weapons offer little or no added value over current conventional capabilities. The basis for this thinking is that the deterrent effect is equated to the United States’ capability to destroy physical targets, and that current conventional weapons can address these threats. The first flaw in the argument is that while the capability to destroy a target is an aspect of deterrence, it is the adversary that ultimately determines the deterrent value. Also, many assume that conventional weapons can hold all plausible targets at risk. This is not true. This mode of thinking also ignores the potential value of nuclear weapons in deterring a chemical or biological attack on the United States. Finally, it dismisses the value of U.S. nuclear weapons capabilities to other states. Officials and commentators in key allied countries perceive great value in U.S. nuclear weapons for extended deterrence. There is a direct connection between allied percep-
tions of assurance and the value of U.S. nuclear weapons for extended deterrence and nuclear nonproliferation.27

**Updating Nuclear Weapons Damages U.S. Nonproliferation Efforts**

There seems to be incongruence between the United States’ maintenance of its own arsenal and the simultaneous advocacy of nuclear nonproliferation. Likewise, many believe modernizing nuclear weapons will send a provocative signal to other nations that nuclear weapons are still extremely important to the United States and encourage proliferation. The fact of the matter is that nuclear weapons are and will remain a pillar of U.S. national security. While America’s enemies will publicly accuse it of undermining disarmament, the inability to maintain a credible deterrent could have negative implications on nonproliferation efforts.

Many U.S. allies fall under the protection of the U.S. nuclear umbrella. If those states begin to lose faith in the U.S. arsenal, they may elect to develop an indigenous nuclear capability, therefore encouraging proliferation. Following the successful nuclear test by the North Koreans in 2006, a statement signed by 17 former South Korean defense ministers and veterans called on the Seoul government to request the United States to redeploy tactical nuclear weapons, which were removed in 1991.28 Likewise, a Japanese study headed by former president Yahuiro Nakasone concluded that “in order to prepare for drastic changes in the international situation in the future, a thorough study of the nuclear issues should be conducted.” Nakasone stated that Japanese security is dependent on U.S. nuclear weapons, but that the future of the U.S. extended deterrent is unclear.29 While the current assurance posture appears to be adequate, it is not unreasonable to think that an aging stockpile and reduced confidence in the stockpile could open the doors for allied proliferation. Given the role that nuclear weapons play in assurance and extended deterrence, and the role in which extended deterrence plays in nonproliferation, there is no incongruence.30

Others believe that updating weapons runs counter to the NPT. The United States pledged, under Article VI of the NPT, “to pursue negotiations in good faith on effective measures relating to the cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a Treaty on general and complete disarmament under strict and effective international control.”31 This article does not specify a time-bound commitment, but production of new nuclear weapons would contravene the treaty’s obligations “to pursue . . . nuclear disarmament.”32

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27. Payne, 56.
30. Ibid.
32. Ibid.
There are several counterarguments to the concerns surrounding the NPT. First, nuclear weapons are important to the national security of the United States, just as they have been since the NPT was signed in 1968. The end of the Cold War did not put an end to nuclear weapons in the United States or any other country. Second, a large percentage of the U.S. nuclear arsenal was developed under the realm of the NPT. Third, countries that seek nuclear weapons do so independent of the United States; they make their own decisions concerning their security.

The arms control policies and nonproliferation efforts supported by the United States do not necessarily have influence on all actors. A great illustration of this point is Pakistan and India. The United States signed the Comprehensive Nuclear Test Ban Treaty in 1996 (although it was not ratified), yet India and Pakistan still tested their nuclear weapons in 1998. Over the past 20 years, there have been significant reductions in the number of U.S. and Russian nuclear weapons, reductions in alert levels of nuclear forces, and the abandonment of U.S. nuclear testing. Furthermore, no new warheads have been developed, and there has been little to no modernization of the U.S. nuclear force. Despite all this, North Korea has successfully developed and tested a nuclear device, and Iran is well on its way.

New Weapons Will Lower the Nuclear Threshold, Thereby Increasing the Probability of Use

It is important to differentiate between crossing the nuclear threshold and the probability of use of a nuclear weapon. The decision to cross the nuclear threshold is based on a set of criteria that must be met before the commander in chief would order the use of nuclear weapons. Based on the 50 years of evolving nuclear doctrine, along with the new threat facing the United States, the criteria would likely include but not be limited to:

1. A substantial loss of life on the part of the United States or its allies.
2. An imminent threat that would cause a substantial loss of life on the part of the United States or its allies.
3. Conventional weapons’ inability to destroy the target.
4. Time critical, meaning the cost of a failed conventional attack would be too great.
5. A minimal number of civilian casualties.
6. As a last resort.

The probability of use is tied to the number of threats facing the United States that could meet these six criteria. The probability of use is driven by the number of threats, not the possession of a capability.

Understanding the relationship between the threshold and the probability of use, consider the following arguments. Senators Jack Reid and Carl Levin stated, “The ability to limit collateral damage makes a weapon more usable—and thus more likely to be used.” Using Iraq as an example, they ask, “Would we have dropped imprecise ‘dumb bombs’ on Saddam’s suspected hideouts in the crowded neighborhoods of Baghdad?” They draw a parallel between a Robust Nuclear Earth Penetrator–type weapon and a low-yield weapon saying, “developing low-yield weapons could tilt the scales to use, rather than restraint.” Their argument assumes that since precision guided munitions were more usable due to their limited collateral damage, that is why they were used. Furthermore, the same rule would apply to nuclear weapons.

To begin, United States has had low-yield nuclear weapons since the beginning of the Cold War, but has never once used them. Their military utility in Korea and Vietnam would have been priceless, yet the National Command Authority exercised restraint. The same fear existed when the neutron bomb was developed. It was considered a clean and ultimate “battlefield nuke” because it had small amounts of fallout and low collateral damage and many believed it would tempt the commander in chief into using such weapons. Despite this new niche capability, then-president Jimmy Carter stated, “A decision to cross the nuclear threshold would be the most agonizing decision to be made by any President. I can assure you that these weapons would not make that decision any easier.” No evidence exists to suggest that simply possessing a capability changes or lowers the criteria in crossing the nuclear threshold; a state-of-the-art weapon will not change the criteria, lower the threshold for a nuclear strike, or increase the likelihood of a nuclear exchange.

However, the perceived “usability” of the weapon does have a tremendous impact on its deterrent capability. Remember that it is the enemy that determines the effectiveness of a deterrent. The United States’ possession of a more capable weapon conveys to an enemy that the weapon is more usable and therefore more likely to be used against them, much like Levin and Reid’s reasoning. The enemy’s belief that a more credible defeat capability exists will most assuredly influence its decision calculus. For example, during a 2005 U.S. congressional delegation’s visit to North Korea, Representative Curt Weldon discussed U.S. interest in a nuclear capability to threaten HDBTs. According to the bipartisan delegation’s after-trip report, the mention of an enhanced nuclear weapon was the only U.S. military capability that appeared to concern the North Korean leadership and “got their attention,” suggesting a potential deterrent value.

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36. Ibid.
Conclusion

Over the past two decades, the United States has neglected to adapt nuclear capabilities to support its policies and interests. The unmistakable fact is that nuclear weapons are going to continue to play a significant role in U.S. policy and military strategy. The ultimate goal is to optimize a stockpile to support this policy and strategy.

Putting Cold War–style deterrence thinking behind us and clearly defining the requirements for a 21st-century deterrent is the first step in achieving this goal. Once these requirements are realized, policymakers can determine whether or not arms reductions are possible, if the current deterrence level is effective, and whether or not America’s commitments to its allies are sufficient.

Defining requirements is also a gateway to reducing the role and the number of weapons. Shifting nuclear thought to a capabilities-based model will allow the military to take full advantage of conventional weapons, minimize the scenarios that would require a nuclear option, and dictate requirements for a stockpile sized and designed to face a wider range of threats.

Finally, America’s modernizing and optimizing of its nuclear force bridges the capabilities gap by allowing it to hold at risk those targets that current conventional and nuclear weapons cannot. Force modernization will also increase the accuracy, reliability, and credibility of U.S. forces. This in turn would strengthen the U.S. deterrence posture, reassures allies of the U.S. capability, and allows for substantial reductions in the deployed and nondeployed nuclear stockpile.

In 1919, Winston Churchill, then secretary of war, arranged for the oiling and storage of a number of large canons and howitzers. In September 1939, as World War II peaked over the horizon, Churchill tasked the minister of supply to find them, saying, “They were never used but they were the last word at the time. They are not easy things to lose. . . . It seems to me vitally urgent, first, to see what there is in the cupboard; secondly, to recondition it at once.” 39 The United States can learn two important lessons from this. First, threats are constant and ever changing. The “War to end all wars” did not in fact end all wars. Second, preparation is the key to winning wars, and, more important, to preventing them. Preparation can be done only through constant technological advances and the leadership to incorporate these changes.

Deterring Iran’s Nuclear Capability
Patrick Disney

Iran possesses the capability to produce nuclear weapons, and has for more than half a decade, yet has so far shown no sign of pursuing a crash program to develop a nuclear arsenal. Absent some major new development, Iran can be expected to remain a nuclear-capable—though not a nuclear-armed—state for the foreseeable future. This poses a novel security challenge for American policymakers, who must adjust to the changing threat posed by Iran’s nuclear capability while balancing four interrelated though often contradictory objectives: dissuading Iranian weaponization, reassuring regional allies, preventing regional proliferation, and deterring Iranian aggression. Unfortunately for U.S. policymakers, no single strategy can support all four of these objectives simultaneously.

Dissuading Iranian weaponization is rightly the top U.S. priority. Officials in Washington consciously avoid discussing plans for containing a nuclear Iran, focusing instead on efforts to prevent weaponization in the first place. Diplomatic offers designed to reach an agreement with Iran, however, tend to unnerve American allies, which fear any accommodation with Tehran. Such fears raise the risk that U.S. allies in the region might pursue their own nuclear deterrent as a hedge against a possible Iranian weapons capability. Conversely, those approaches that might strengthen the U.S. nuclear umbrella in the Middle East send threatening signals to Iran and make weaponization more likely. The United States thus faces a security dilemma in meeting the challenge of a latent Iranian nuclear weapons capability: The more the United States does to prepare for the day after Iran obtains a nuclear weapon, the greater Iran’s incentive becomes to acquire a nuclear deterrent of its own. Likewise, the type of diplomatic cooperation that holds the greatest promise for preventing an Iranian bomb has the effect of undermining U.S. assurances to allies in the Persian Gulf. Washington’s task, then, is to tailor its diplomatic and extended deterrence frameworks so as not to exacerbate the security dilemma inherent in the Iranian challenge.

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1. Patrick Disney received an M.A. in international relations in May 2012 from Yale University.
Iran’s Nuclear Capabilities

More than four years ago, the U.S. intelligence community published the consensus viewpoint of all 16 intelligence agencies regarding Iran’s nuclear program. That assessment declared that “Iran has the scientific, technical and industrial capacity eventually to produce nuclear weapons if it decides to do so.” In the years since, that assessment has been confirmed by the International Atomic Energy Agency (IAEA), Israeli intelligence, and nearly every other Western government working on the issue. The fact is undeniable: Iran today has the capability to produce nuclear weapons. And it has had this capability for years.

Iran should be considered to have a weapons capability today because it possesses the basic technological mastery of each of the three processes that make up a nuclear weapons program: the ability to produce fissile material, the knowledge to weaponize this material by assembling an actual device, and the means to deliver it. Iran will continue to possess this capability so long as its scientific base remains intact—eliminating nuclear facilities would not destroy its technical know-how. The former head of the IAEA, Mohammed ElBaradei, put it succinctly when he said, “You cannot bomb their knowledge.”

That said, Iran today lacks a clear pathway to a nuclear weapons breakout without early detection. Any move to reconfigure either of its declared enrichment facilities for weapons purposes would undoubtedly be detected by the IAEA’s monitors present in those facilities, and any attempt to halt inspections by Iran would be seen on its face as an intent to weaponize.

Given Iran’s history of evasion, there is a risk that Iran might be operating undeclared facilities; specifically, covert enrichment sites would be most worrisome. But two former Obama administration officials have stated publicly that the United States is very confident that Iran does not possess any secret nuclear sites. This is a profoundly important revelation. If true, it means that Iran’s only available option for sprinting to-

ward nuclear weapons in the near term would require doing so under the nose of IAEA inspectors. This would be extremely difficult if not impossible to do without detection.

In sum, then, the United States has concluded that the most plausible breakout scenario involves a covert site, which publicly available U.S. intelligence suggests does not currently exist. Any other scenario would almost certainly be detected in time for the international community to act preemptively. A nuclear-armed Iran is therefore not yet an imminent threat.

Iran’s Nuclear Intentions

The fact remains: Iran’s leaders could build nuclear weapons if they wanted to do so. What, then, do they want? Do Iran’s leaders want nuclear weapons, and if not, why are they willing to go through such trouble to keep the nuclear program going?

Intentions are always subject to change. Iran could be pursuing nuclear weapons tomorrow but give up the day after—or vice versa. No one knows for sure what the goal is that the Supreme Leader of Iran has in mind. However, there is one contention, based on evidence, that should inform policymakers today: Up to this point, Iran has not actively sought to acquire a deliverable nuclear weapon.

There is no evidence that has yet been made public that the Iranian government possesses a “Manhattan Project” to acquire the bomb as quickly as possible. According to one former intelligence officer aware of U.S. findings, “It isn’t the absence of evidence, it’s the evidence of an absence. Certain things are not being done.” Other Western intelligence agencies and the IAEA have concurred with this view. Given Iran’s scientific and technological know-how, most experts agree that, if Iran’s leaders wanted to acquire nuclear weapons, they should have been able to by now. This is further supported by the fact that Pakistan, which lacked Iran’s scientific and technological base, was able to obtain nuclear weapons in about 10 years, while Iran’s program has been ongoing since the 1980s. Finally, Iran maintains a robust (though far from perfect) international monitoring presence under the Nuclear Non-Proliferation Treaty—an encumbrance that no previous “crash” weapons program has voluntarily permitted.

If it is not a bomb that Iran seeks, what does it want? This is more difficult to tell, because Iran’s official position that its nuclear program is intended for electricity production does not hold up to scrutiny.

9. This is taken from the strong majority of in-person interviews with 23 leading Iran experts in the summer of 2011.
10. If Iran’s nuclear program were solely motivated by the need for electricity production, most experts agree that Iran would not emphasize uranium enrichment far greater than needed to power reactor construction, as it largely has.
Emerging conventional wisdom says that Iran is interested in having the option to build weapons if it feels threatened—what is known as a “latent” weapons capability. Based on an intuition about Iran’s cost/benefit calculation, this view says that Iran likely believes it would pay too high a price for crossing the nuclear weapons threshold, in the form of sanctions, diplomatic isolation, and potentially even war. And it is possible to reap most of the benefits by approaching nuclear weapons status without actually turning the last screw on a bomb. This suggests that Iran’s nuclear program is designed to follow an asymptotic trajectory; the curve of nuclear development approaches the weapons threshold but never reaches it (figure 1).

From the Iranian perspective, a latent nuclear weapons capability is the best of both worlds. Its benefits include the international prestige of mastering nuclear technology; the self-sufficiency on which Iranians pride themselves; a unifying force for the domestic political arena; and, potentially, the deterrent value of having a latent weapons capability. If Iran were to shrink its breakout timeline to a matter of days or weeks, it could credibly claim to possess retaliatory options that involve nuclear weapons, even without producing those weapons ahead of time.

A latent weapons capability gives Iran all these benefits without suffering any more onerous costs than the sanctions and isolation that Iran currently endures. Thus, all the evidence suggests that Iran’s leaders intend to develop a latent—rather than an actual—nuclear weapons capability, and it appears that this will continue to be the case for quite some time.


13. General James Clapper, the director of national intelligence, had the following exchange with Senator Joseph Lieberman at a recent hearing: “Senator Lieberman: ‘If they did have nuclear weapons capability it might well embolden them in their use of terrorism against regional opponents and even the U.S.?’ Gen. Clapper: ‘Yes sir it would serve as a deterrent and even I think to a certain extent the ambiguity that exists now serves as a deterrent and does serve to help embolden them.’” Testimony before the Senate Armed Services Committee, February 16, 2012.
Implications

What are the security implications of an Iranian latent weapons capability? How will an Iranian latent capability alter the security dynamic between Iran and the West?

According to most open-source estimates, Iran today possesses the capability to build a nuclear weapon anywhere from 6 to 18 months after making the decision to do so.14 As Iran’s program progresses, however, that timeline will undoubtedly shrink. A shrinking breakout timeline decreases the confidence in Western capitals that a decision by Iran to acquire nuclear weapons would be discovered in time to take preventive action. As a result, Iran’s security dynamics approach those of a nuclear-armed state, even in the absence of an existing nuclear arsenal. In short, an Iran with a fast-breakout timeline would enjoy some of the benefits of a nuclear deterrent.

This would have four significant consequences for U.S. interests in the region. First, depending on the nature of Iran’s fast-breakout capability, U.S. options for military action could be constrained. Although there are many other reasons for the United States’ hesitancy to invade and occupy a country the size of Iran, an Iranian fast-breakout capability would have a chilling effect on U.S. military options. Any potential U.S. military objectives would necessarily remain limited out of fear of escalation to the nuclear realm—in this case, pushing Iran to develop a nuclear arsenal.

Second, Iran could take advantage of its latent nuclear deterrent to pursue a more adventurous foreign policy at the expense of the United States and its allies. In international relations scholarship, this phenomenon is known as the “stability/instability paradox.” In this case, Iran’s latent nuclear deterrent would secure it against existential threats, allowing its leaders to foment violence at the conventional or subconventional level with relative impunity. Even if Iran were deterred from launching violent attacks against the United States or its allies (as it likely would be), a latent nuclear deterrent could strengthen its hand in the regional balance of power, which is inimical to both U.S. and Israeli interests.

Third, the threat perceptions of American allies in the region—particularly Israel and the Gulf Arab states—would increase. Israel would be less inclined to cede its security prerogatives to its American patron, possibly leading it to launch a unilateral attack in the hopes of destroying Iran’s nuclear capability. This would have dangerous repercussions for regional stability and U.S. interests. Additionally, Gulf Arab allies might pursue nuclear hedging programs of their own in response to an Iranian capability, undermining the integrity of the global nonproliferation regime.

Fourth, a latent nuclear deterrent would cement the Iranian regime, along with its anti-American ideology, ensuring that the United States / Iran conflict remains intractable for perhaps decades to come. Absent domestic reform or revolution, a latent nuclear deterrent...
deterrent would consolidate the Islamic Republic against external threats, allowing it to focus more on maintaining its internal security.

Recommendations

The big question U.S. defense planners must face now and into the coming years will be how to deal with Iran’s latent nuclear weapons capability.

I suggest that the United States should approach this challenge from an extended deterrence perspective, albeit with some modifications. Classic extended deterrence involves deterring acts of aggression against allies by threatening to retaliate on their behalf, even if U.S. interests are not directly endangered. An extended deterrent strategy for countering an Iran with a latent nuclear weapons capability could serve U.S. strategic interests in a number of ways.

First, conveying credible security guarantees throughout the region will help counter any sense of emboldenment that Iran might derive from a latent nuclear capability. Defense planners fear the “stability/instability paradox,” in which Iran’s nuclear deterrent could allow it to pursue an aggressive foreign policy with impunity. Traditional extended deterrence seeks to counter this type of emboldenment, and both academic and historical experience suggest that the United States can expect to achieve this objective with relative ease. History has shown that nuclear weapons are highly effective at deterring attacks against a possessor state, but have rarely allowed a state like Iran to challenge the international status quo simply because it possesses a nuclear deterrent. In short, nuclear weapons are good at deterrence but lousy at coercion.15

Second, an extended deterrence framework would reassure U.S. allies in the region, both to prevent a cascade of proliferation and to persuade Israel not to strike Iran without U.S. backing. The experience of the Cold War provides valuable lessons about how to persuade U.S. allies not to pursue nuclear weapons of their own in the face of a nuclear-capable adversary, and instead to rely on U.S. security commitments—up to and including the U.S. nuclear umbrella. Past experience suggests that the United States will maintain sufficient leverage to persuade its allies not to seek nuclear hedging strategies of their own. What is more uncertain, however, is the United States’ ability to restrain its ally Israel in dealing with the Iranian threat unilaterally. Too many factors complicate the Israeli calculus about a potential strike to list here; however, if the United States sincerely believes that an Israeli strike would be unacceptably damaging to its interests in the region, Washington should be able to communicate as much to the Israeli government. Given the military limitations inherent in any Israeli unilateral strike, Washington should be relatively confident that it can persuade Israel not to launch an attack without U.S. support.

There is, however, a key difference in an extended deterrence framework when facing a latent, rather than an actual, nuclear adversary. That is the nature of a deterrence

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failure. When facing a nuclear-armed adversary, the failure of extended deterrence is understood to mean that an act of aggression is carried out against U.S. allies. When facing a latent-capable adversary, conversely, deterrence failure could result in either conventional aggression or a decision to “actualize” its weapons capability.

When facing a latent-capable Iran, the U.S. deterrent is, as the president has declared, primarily designed to deter Iranian weaponization. The overwhelming superiority of U.S. conventional military power means that America’s check on Iranian aggression is strong. However, this same conventional superiority that deters Iranian aggression actually makes weaponization more likely. U.S. conventional superiority increases the value of an actual nuclear deterrent in the eyes of Iran’s leaders.

Thus, a key difference in deterring a virtual nuclear state as opposed to an actual one is the security dilemma inherent in the United States’ defensive posture. Every step the United States takes to shore up its defenses against a potential Iranian nuclear weapon actually increases Iran’s threat perception and encourages Iranian weaponization. During the Cold War, the United States was able to counter the Soviet Union’s nuclear capability by holding hostage Soviet cities with U.S. nuclear forces; however, such overtly threatening measures directed toward a latent-capable Iran would likely be counterproductive and could convince Iran of the need for its own nuclear weapons.

The challenge of deterring Iran’s latent nuclear weapons capability, therefore, requires a finely tailored approach: seeking to give Iran a reason not to weaponize its capability while simultaneously taking pains not to give Iran a reason to weaponize. Unfortunately, the United States has the least amount of theoretical and historical experience to guide the way for precisely this type of deterrence.

To deal with this unique challenge, the United States must walk a fine line between offering rewards and pressure. Sanctions designed to restrict Iran’s access to sensitive nuclear materials and technologies, done in concert with the rest of the international community, are relatively low risk and play a vital role in U.S. nonproliferation strategy. However, sanctions that are strictly punitive, such as oil embargoes and other attempts to “cripple” Iran’s economy, carry a significant risk of backfiring. Iran is unlikely to be willing to bow to such pressure so long as compliance is seen as akin to a national humiliation, and any amount of pressure that could credibly threaten the Iranian regime might actually encourage Tehran to seek a nuclear deterrent.

In conjunction with a carefully tailored sanctions approach, the United States and its international partners must devise a diplomatic pathway on which Iran can comply with its obligations without losing face domestically. Iranian leaders’ statements about the religious prohibition on nuclear weapons could lend legitimacy to this objective within Iran’s domestic political sphere. Up to now, U.S. and Western nonproliferation policies directed toward Iran have focused on imposing pressure, whether through sanctions, sabotage, or cyberattacks. Such heavy-handed tactics, while they have success-

fully slowed Iran’s progress in recent years, risk guaranteeing that the ultimate goal of Iran’s nuclear program will be to acquire weapons.

Ultimately, the only means by which the international community can gain confidence that Iran will not cross the threshold of nuclear weapons development is a rigorous safeguards and inspections regime operating among Iran’s nuclear facilities. For the United States, this means that American leaders must be willing to acknowledge the reality of a latent Iranian nuclear weapons capability and be willing to accept it so long as it remains latent. The United States may also need to consider abandoning any designs for regime change, except for the gradual process of evolution already under way inside Iran.

These will be difficult pills to swallow. Public opinion at home and among U.S. allies will strongly resist any appearance of accommodating an Iranian nuclear weapons capability. Far from appeasement, however, this is the best option available to the United States—short of a costly war.
Moving from Monitoring to Investigation
Radionuclide Detection during On-Site Inspections under the Comprehensive Nuclear Test Ban Treaty’s Verification Regime
Christine Egnatuk

The Comprehensive Nuclear Test Ban Treaty’s verification regime provides radionuclide detection and on-site inspections as tools to determine if a nuclear event has occurred. Radioisotopes of noble gases are produced during a nuclear event and can be detected up to several years after the event. Over the next few years, many procedural and technical issues associated with radionuclide detection and on-site inspections must be addressed. Specialized equipment, software, and inspection protocols need to be developed so that inspection does not reveal the proprietary information of the nation being inspected. Also, global background levels must be determined for the various radionuclides used for nuclear event investigations.

The need for verifiable techniques for detecting clandestine nuclear activities is increasing as the proliferation of nuclear materials and technology continues. Radionuclide monitoring will increase in complexity as additional commercial nuclear reactors, research reactors, and medical isotope production facilities go online. Differentiating between civilian nuclear operations, which are increasingly prevalent, and clandestine nuclear activities, including underground nuclear testing and explosions, is not as straightforward as previously thought. The use of additional radionuclides, specifically

1. Christine Egnatuk received her Ph.D. and M.S.E. from the University of Texas at Austin.
argon-37, to corroborate radioxenon data is currently being considered, and the development of radionuclide investigation techniques and procedures are being tested in integrated field exercises.

The Comprehensive Nuclear Test Ban Treaty (CTBT) Organization is at the forefront of the global effort to discourage and detect clandestine nuclear activities. The on-site inspection (OSI) procedure is under development to prepare for the CTBT’s entry into force. The OSI procedure includes many facets, and this paper focuses on the detection of radionuclides and the costs associated with sample collection. The addition of the OSI procedure to the monitoring practices currently in place within the International Monitoring System (IMS) will present several challenges. The sample collection procedure will digress from the large sample analysis used by the IMS.

**Getting to an OSI**

The IMS currently provides constant global monitoring for nuclear activities. The IMS consists of 337 facilities, which include seismic, hydroacoustic, infrasound, and radionuclide monitoring. There are 80 radionuclide monitoring stations, only half of which are set up for radioxenon monitoring. The radionuclide monitoring stations are supported by 16 certified radionuclide laboratories. The IMS provides a constant stream of data that can be used to assess global nuclear activities, both clandestine and declared.

The actual determination of whether a nuclear event occurred is analyzed using both IMS and OSI data. Article IV, paragraph 35 of the CTBT states,

> The sole purpose of an on-site inspection shall be to clarify whether a nuclear weapon test explosion or any other nuclear explosion has been carried out in violation of Article I and, to the extent possible, to gather any facts which might assist in identifying any possible violator.

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4. Radioxenon refers to the radioactive isotopes of xenon. Xenon-135, xenon-133, xenon-133m, and xenon-131m are the radioxenon isotopes detected by the IMS. The m refers to the metastable state of an isotope.

5. Integrated field exercises (IFE) are being carried out to practice and develop the procedures necessary to carry out a successful OSI.

6. CTBTO, “Who We Are,” http://ctbto.org/specials/who-we-are/. For a map of the IMS stations, see http://ctbto.org/map/.

7. CTBTO, “Who We Are.”

The IMS has provided radionuclide data after the Fukushima-Daiichi nuclear reactor accident and the 2006 North Korean nuclear test. The 2009 North Korean event was determined to be a nuclear event, but this determination was made without any corroborating radionuclide data. Since the CTBT has not gone into force and North Korea is not a signatory of the CTBT, the option for an OSI was not available for either of the North Korea’s nuclear tests.

Conducting an OSI must follow specific procedures and a rigid timeline. Any nation can request an OSI of another nation suspected of conducting a nuclear event. After a suspected nuclear event, the data from the IMS are analyzed by technological experts and the findings are presented to the Executive Council. Under the CTBT verification regime, an OSI is allowed only after 30 affirmative votes of the total 51 nations that are party to the CTBT. The Executive Council’s decision must be made within 96 hours of the inspection request. This period allows for the assessment of the IMS data by scientists. If the Executive Council votes to allow the OSI, the nation under investigation could expect the set-up and investigation to begin about one week after the vote. The OSI must begin within 72 hours after the arrival at the point of entry within the nation under inspection. The inspection area for an OSI is limited to 1,000 square kilometers. An initial progress report must be submitted to the Executive Council within 25 days after the OSI approval. It is contemplated that the initial report will provide additional data for the Executive Council’s members to consider and hopefully provide a narrowed search area.

Due to external international relationships, the criteria necessary to allow an OSI is a dynamic situation. Each area of the IMS can stand on its own, but the data together provide a thorough picture of the event. The detection of radionuclides coupled with a seismic event allows the use of atmospheric modeling from the position of the nuclear event to the detector site. The seismic data without radionuclide data also do not provide the whole picture of the event. A large waveform without heightened levels of radionuclides could point to a nuclear test, as in the case of the 2009 North Korean event. In an atmospheric test, the radionuclide detector systems in the IMS could detect a nuclear event as

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12. The treaty will be active 180 days after the 44 nuclear-capable nations (listed in annex 2) officially certify their ratification. The nuclear-capable nations include those that participated in and had a nuclear power or research reactor at the time of the treaty negotiations. CTBTO, “Entry into Force,” http://ctbto.org/the-organization/ctbto-after-entry-into-force/entry-into-force/.
small as 0.001 kiloton.\textsuperscript{13} The criteria for an approved OSI by the Executive Council will likely depend on political and economic factors that are outside the scope of this paper.

In the case of an underground nuclear test, the best-case scenario for Executive Council approval for an OSI includes radionuclide corroborating data from at least one IMS radionuclide monitoring station. The detection of radionuclides should be expected within a few weeks after the event, depending on weather patterns, distance to an IMS radionuclide monitoring station, and vent time. The radioactive noble gases, specifically isotopes of radioxenon, are used because of their chemically inert nature and ability to travel a great distance through the atmosphere.\textsuperscript{14} The distance between the IMS radionuclide monitoring station and the nuclear event site should be considered when estimating the detection timeline and signal strength. The strength of a radionuclide signal at an IMS radionuclide monitoring station will likely depend on the distance between the event site and the IMS radionuclide monitoring station. Therefore, this distance should be used to calculate the dilution factor. A contaminated test site could present problems for an inspection team, but these problems can be minimized with planning and proper equipment.

The worst case for the group of scientists assigned to put together the monitoring data into a conclusive package for the Executive Council would include no radionuclide data from the IMS. This does not mean there will be no radionuclides detected during an OSI or from the IMS. Due to unpredictable weather patterns, the IMS radionuclide detectors could receive a signal after the Executive Committee report is submitted. A properly constructed underground test cavity can almost eliminate the accidental prompt leakage of radioisotopes. However, the barometric pumping of the gases produced during the nuclear event will eventually diffuse to the surface.\textsuperscript{15} There is also the possibility of drilling to cavity within the questionable test site, which will provide conclusive data in the event of the test.

\begin{itemize}
\item \textsuperscript{15} The noble gases are likely to travel to the surface due to their inert properties. The barometric pumping would require a delay of the detection. C. Carrigan, “Using OSI [On-Site Inspection] Field Studies and Tests to Define Noble Gas Sampling and Analysis Requirements,” International Noble Gas Experiment Conference, Daejeon, Korea, November 9-14, 2009, LLNL-PRES-41961; and D. A. Haas, H. S. Miley, J. L. Orrell, C. E. Aalseth, T. W. Bowyer, J. C. Hayes, and J. I. McIntyre, “The Science Case for \textsuperscript{37}Ar as a Monitor for Underground Nuclear Explosions,” PNNL-19458 (2010).
\end{itemize}
During an OSI

An OSI is an invasive endeavor, and may be interpreted as a punishment by the nation being investigated. An OSI can be up to 60 days long, with the possibility of a single 70-day extension. The inspection team will be composed of a group selected by the Executive Council. The maximum inspection team size is 40 people, except during drilling. The number of additional people that might be necessary for on-site drilling is not specified. In a report commissioned by Lawrence Livermore National Laboratory, an on-site drilling team of 16 people is required for the Rapid Deployment Drilling System (RRDS) operation.

The nation under investigation could have concerns that confidential information could be uncovered during an OSI. Therefore, steps are taken to shield proprietary information and create equipment with software that only allows the investigation team access to pertinent information. The radionuclide survey equipment currently commercially available provides a full set of data. In order to shield proprietary information from the investigation team, software or other methods to transmit the information about the relevant radionuclides and block the other information need to be created.

The OSI procedure for the handling of the samples is currently being established during the integrated field exercises. The first full-scale Integrated Field Exercise (IFE08) took place in September 2008 at the Semipalatinsk test site, and included 200 technical experts and 50 tons of equipment. The type of samples collected during an OSI will depend on the climate of the inspection area. The possible sample types include water, airborne particulates, gas, plants, animals, and soil. Due to the sensitive nature of the Semipalatinsk site, the collection of soil samples was prohibited and the air samples collected were not analyzed.

An on-site laboratory will need to be set up to analyze the collected samples. The ability to ship samples to an off-site laboratory, which will provide lower detection limits, should also be organized. The sample shipment procedure and chain of custody be-

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16. The maximum allowed time period for an OSI is 130 days.
19. The Semipalatinsk test site, also known as STS and Semipalatinsk-21, is located in Kazakhstan. STS was the primary nuclear test site for the Soviet Union. A total of 456 nuclear tests took place on the STS between 1949 and 1989.
between the inspection site and the off-site laboratory should be established. Using one or more of the International Data Centers is also possible. However, the these centers’ detector capabilities would need to be expanded to be able to analyze specialized radionuclides, such as argon-37.22

The elapsed time between the suspected nuclear event and the entry of the OSI team into the nation under inspection could be as short as 10 days, but could be much longer. The possibility of an OSI request put before the Executive Council up to two years after a suspected event is being considered. This widely varying timeline introduces an increasing amount of variability into the radionuclide investigation. In the case of prompt radionuclide leakage contemporaneous with the nuclear event, the fission products that escape the cavity have varying half-lives and will still be present in the soil in any of the timelines. Without prompt leakage, the inspection team will have to rely on the barometric pumping of volatile radionuclides and noble gases for surface sample collection. Unfortunately, the diffusion rate, final location of seepage, and fractionation of the radioisotopes are dependent on factors that the OSI inspection team will be unable to control or predict. As the elapsed time between the suspected event and OSI increases, detection becomes more difficult. Therefore, more invasive and expensive techniques might need to be used to inspect a suspected nuclear event site.

Radioxenon

Radioxenon isotopes are the predominant noble gas used for nuclear event analysis. The IMS has 40 stations equipped with systems that constantly monitor for four radioxenon isotopes: xenon-131m, xenon-133m, xenon-133, and xenon-135. The radioxenon isotopes are produced from fission and are near the peak production of fission products. Radioxenon is produced during any fission event. Therefore, the global background levels will increase with the addition of new nuclear facilities.

The OSI inspection team will use beta-gamma spectroscopy to measure the activities of the radioxenon isotopes present during the OSI. Radioxenon introduces a shortened timeline for detection. The longest-lived radioxenon isotope, xenon-131m, has a half-life of only 11.934 days.

Radioargon

The addition of radionuclides that also have the possibility of escaping the explosion cavity during and after the prompt leaking phase is being examined. Currently, argon-37 holds promise because of its 35.04 day half-life. The radioargon isotopic signature of above-ground and underground nuclear activities will vary greatly. Argon-37 will be the dominant radioargon isotope produced in an underground nuclear test, and argon-41 will be the dominant radioargon isotope produced through the activation of the stable argon isotopes present in the air.

22. Argon-37 decays to chlorine-37 without releasing a gamma ray. Therefore, the use of a specialized detector system is necessary. Currently, the IDC detector systems include beta-gamma detectors for radioxenon isotopes and high-purity germanium detectors (HPGe) for gamma spectroscopy.
In an underground nuclear event, the radioargon isotopes are produced through the excess neutrons created from fissions interacting with the calcium in the soil. Specifically, argon-37 is produced along with an alpha particle from a neutron interaction with calcium-40. Calcium-40 comprises 96.9 percent of naturally occurring calcium. However, the calcium content varies in different types of soil. Therefore, the induced argon-37 activity will vary in different soil compositions.

Detection Window

The noble gases produced during a nuclear explosion—from both fission and neutron interactions with the surrounding rock and soil materials—will flow from the underground cavity to the surface by way of faults and fractures in the surrounding geography. This occurs with barometric variations, which cause the gases to appear at the surface anywhere from weeks to a year after the underground nuclear event. Detection of xenon-133 at the surface is estimated to be possible up to 50 days postdetonation; and detection of argon-37 is estimated to be possible approximately 80 days postdetonation. The detection window for xenon-133 and argon-37 is predicted to be 85 days and 135 days, respectively. The inspection timelines previously mention are from a model ignores the parent–daughter decay chains, which would heavily influence the xenon-133 activity due to the decay of volatile radioiodine and its metastable state. There are also generalizations used about the induced activities of the argon-37 and xenon-133.

Cost of an OSI

The cost of an OSI will be significant and will be heavily influenced by the sampling frequency. For example, the Provision Technical Secretariat of the CTBTO spent about $6 million on IFE08. This cost does not include the 6,000 man-days, €670,000 from the European Union, or the equipment used. The cost of an OSI is expected to be $10 million to $100 million. The expected cost of the RRDS was quoted at $2 million in 1999. This estimate does not include operation and maintenance costs, the 16-member operation group, or the machinery transportation cost. The RRDS rental cost was estimated at $48,000 per day for operation and $27,900 for standby.
One of the most costly sample collection procedures in the OSI process is drilling. Drilling to the cavity might provide additional and more conclusive data, but may not be necessary. For example, shallower drilling could be conducted and mud and rock debris could be tested and degassed. The presence of radiiodine, radioargon, and radioxenon isotopes in the mud and rock debris would indicate an underground nuclear event. The timeline and explosion yield would dictate the drilling needs.

The question of how good is good enough will be raised. The price of the procedures should be considered and weighed. The number of samples collected could be minimized by collecting samples from areas that are upwind or upriver. The improvement of detection limits in field-deployable equipment will also help to mitigate the costs and other issues associated with off-site testing, transport, and additional personnel.

Results of an OSI

The data collected during an OSI are presented to the Executive Council in several phases. As mentioned above, the initial progress report will be submitted within 25 days after the OSI is approved. The initial report is expected to contain preliminary data and narrow the search area. The report submitted after the completion of the OSI will provide the data and analysis. There is concern that the Executive Council’s members will not have the technical expertise to understand the final report. The use of technical experts outside the OSI team could help present a variety of scenarios, which would introduce the possibility of a long delay before any formal action by the Executive Council.

The Next Steps

The nation under inspection should not have to give up proprietary information that falls outside the scope of that nation’s obligations under the CTBT during the inspection process. There is a need to develop techniques that only give OSI investigators the information necessary to make an assessment. There is not a commercially available item that provides this capability for radionuclide detection. The use of commercially available detection systems that provide a full spectrum should be coupled with software that conceals the unnecessary sections of the spectrum. Proposed software that satisfies this goal will only allow the spectral slots that show the existence of radioisotopes of interest. However, a challenge in the development of such software will be the calibration of the device.

Noble gas detection systems should include a standard procedure for sampling holes and for identifying the location where the sampling was collected. One of the main shortcomings of the IFE08 was the lack of soil sample collection and analysis. The next Integrated Field Exercise is scheduled for 2014 (IFE14). One of the main goals of the radionuclide OSI inspection team should be to establish a reproducible technique for

30. Prah, “Overview of CTBT On-Site Inspections.”
31. If the energy spectrum is shifted due to an incorrect calibration, the visible slots will not show the data. The actual data could be in the blinded sections of the spectrum.
collecting, labeling, and storing gas-soil samples. The OSI inspection team should work on minimizing the number of samples necessary by collecting at optimal time periods with respect to the sample type.

Global radioxenon releases are dynamic and well documented. The radioxenon release from commercial nuclear power reactors is, on average, 1.3 PBq.\textsuperscript{32} Due to the changing weather patterns and differing distances between operational civilian nuclear facilities and inspection sites, the background radioxenon activities are unique for each OSI. Both the magnitude of the signal and the radioxenon isotopic ratios are used. The radioxenon isotopic fission yields are well known, which gives a good estimation of the radioxenon produced at the time of the nuclear explosion within the cavity. Additional research should be done to examine the diffusion rates and fractionation effects of the path from the cavity to the sampling location.

The background levels of argon-37 will vary based on latitude, sample depth, and soil type. The global map of radioargon activities should be a priority. The background levels of argon-37 are predominantly produced through the interaction of the cosmic-ray induced neutron flux interacting with the calcium-40 in the soil. The measurements of argon-37 activities in the soil have predominantly been done in Europe.\textsuperscript{33} The peak argon-37 activities are found at 1.5 to 2.5 meters below the surface.\textsuperscript{34} The measured argon-37 activities vary from less than 3.1 to 120 mBq/m\textsuperscript{3}.\textsuperscript{35}

The background of different geologies also needs further investigation. This step requires analysis of soil samples from around the world. The rock and soil composition at varying depths should also be considered. The calcium composition within the soil will allow for a better estimate of the radioargon produced when neutrons interact with the soil and rock. The cosmic-ray induced neutron flux should also be measured in conjunction with the soil sample collection. The variations in the neutron flux should also be estimated based on solar cycles and seasons. This will create a realistic model for the background levels of argon-37 in different geologies. The data analysis of the radionuclides produced during different nuclear event scenarios in the different geologies needs to also be developed. This will partner the soil and rock composition with an estimated neutron flux generated from a generic nuclear fission event.

In order to produce reliable models, the cross-section data libraries for the radioargon isotopes need improvement.\textsuperscript{36} The cross-section of the calcium isotopes for the production of radioargon isotopes are also incomplete.\textsuperscript{37} Without reliable cross-section


\textsuperscript{34} Ibid., 8660.

\textsuperscript{35} Ibid., 8658. A Becquerel (Bq) is one decay per second.

\textsuperscript{36} This is the “probability” that a neutron will interact with a nuclei.

\textsuperscript{37} \textsuperscript{\textsuperscript{1}}Ca(n,\alpha)\textsuperscript{3}Ar.
libraries, the modeled production of argon-37 will introduce error that the scientist will be unable to quantitatively describe. Problems in the production model will compound problems faced in the diffusion calculations, which will make it increasingly difficult to provide a reasonable estimate of the expected radioargon activities at the sample location.

The detection windows from xenon-133 and argon-37 mentioned above are based on the diffusion rate from a single experiment. Additional work should be done to create a model that incorporates the parent–daughter decay chains. This will require a sensitivity study of the variance in temperature of the nuclear event and the cooling rate after the explosion. The model will be used to determine the refractory versus volatile fission products at the time of a possible prompt vent and consider which elements will be able to escape the cavity.

Conclusions

The technical challenges presented in an OSI are unique and cannot be easily answered by data collected from past nuclear tests. Continuing the integrated field exercises will improve the procedural details and help to discover weaknesses in the planned methods. In IFE14, the soil sample collection method and process will need to be practiced. The soil sample collection method should be established while mapping the global background of argon-37 before the exercise. The techniques for preserving the proprietary information of the nation under inspection should be at least preliminarily developed by IFE14. This should ease the concerns of the host nation and allow the collection and analysis of radionuclide samples during the IFE.

As the development of the OSI procedures progresses, the cost should be constantly considered. The cost of an OSI increases as the sampling frequency increases. In order to minimize costs, the least expensive collection techniques and inspection tools should receive priority. More expensive inspection techniques should be avoided, unless the less costly techniques are insufficient to determine if a nuclear event occurred. However, the more expensive inspection techniques might be appropriate in certain circumstances, such as when dealing with a time-sensitive sample. In the case of radioactive noble gas sample collection, the time window for argon-37 has more flexibility than the radioxenon isotopes.

39. For a simplified model, the assumption will be the refractory products at the time of cooling will not escape even if their daughter products are volatile.
Dynamics in the Nuclear Order
Sensitive Fuel Cycle Technology in the Republic of Korea
Madeleine Foley

As South Korea’s nuclear industry has matured, Seoul has sought full autonomy in its civil nuclear program. South Korea is seeking to enrich uranium for commercial fuel production and to pyroprocess spent nuclear fuel for eventual use in a fleet of fast reactors. As an emerging nuclear supplier, South Korea faces strong incentives to master a full range of fuel cycle services for its domestic and international customers. As a consumer, it faces high domestic political hurdles to long-term and indefinite nuclear waste management. However, introducing commercial-scale sensitive fuel cycle technology to the Korean Peninsula carries proliferation risks, which could complicate efforts to achieve peace and stability on the peninsula. Moreover, the consequences of South Korea’s fuel cycle choices could be far reaching, ultimately endangering the global norm against reprocessing in nonnuclear weapons states. The terms of the current nuclear cooperation agreement between South Korea and the United States place a legal check on South Korea’s enrichment and pyroprocessing aspirations. Despite this, the United States has struggled to develop a strategy to dissuade South Korea from deploying this technology in the long term. A successful solution will square the growing burden of nuclear waste storage in South Korea with the proliferation risks associated with the commercial-scale operation of sensitive fuel cycle technologies on the peninsula.

As South Korea’s nuclear industry has matured, Seoul has sought full autonomy in its civil nuclear program. South Korea is pursuing a closed nuclear fuel cycle to support continued growth and to ensure the sustainability of its domestic nuclear sector. Seoul is seeking to enrich uranium for commercial fuel production and to pyroprocess spent nuclear fuel for eventual use in a fleet of fast reactors. As an emerging nuclear supplier, Korea faces strong incentives to master a full range of fuel cycle services for its domestic and international customers. As a consumer, it faces high domestic political hurdles to long-term and indefinite nuclear waste management. South Korea has an equal, if not greater, incentive to harness reusable material in accumulating spent nuclear fuel.

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through recycle. However, introducing commercial-scale sensitive fuel cycle technology to the Korean Peninsula carries inevitable proliferation risks, which will complicate efforts to achieve peace and stability on the peninsula. Moreover, the consequences of South Korea’s fuel cycle choices could be far reaching, ultimately endangering the global norm against reprocessing in nonnuclear weapons states.

The terms of the current nuclear cooperation agreement between South Korea and the United States place a legal check on South Korea’s enrichment and pyroprocessing aspirations. Despite this, the United States has struggled to develop a strategy to dissuade South Korea from deploying this technology in the long term. To date, Japan is the only nonnuclear weapons state to receive 30-year advance consent to reprocess U.S.-origin spent fuel by subsequent arrangement in 1988. With its 1974 agreement set to expire in the autumn of 2014, South Korea is seeking revised terms granting it similarly unrestricted permission to pyroprocess spent nuclear fuel and to enrich uranium. Current U.S. policy opposes the spread of enrichment and reprocessing (ENR) technology to new states, especially in unstable regions.2 The debate over advance programmatic consent will not conclude with a new nuclear cooperation agreement. Rather, negotiations present an opportunity to take careful stock of the economic and proliferation realities of pyroprocessing. A successful solution will square the growing burden of nuclear waste storage in South Korea with the proliferation risks associated with commercial-scale operation of sensitive fuel cycle technologies on the Korean Peninsula.

This paper begins with a review of the technical characteristics and debate regarding the proliferation risk of pyroprocessing. A discussion of South Korea’s current waste storage capacity and future plans for domestic and international civil nuclear expansion follows. What factors and dynamics inside South Korea have led to broad support for pursuing sensitive fuel cycle technology? The technical community, with the backing of vocal elected officials in South Korea, has waged a successful campaign to build a political consensus around plans to pursue commercial-scale pyroprocessing. Waste management, nuclear sovereignty, parity with Japan in the context of the Pacific alliance, and the desire to hedge against a nuclear-armed North Korea all feature in arguments in favor of pyroprocessing in South Korea.

How does the ultimate decision to pursue sensitive fuel cycle technology complement or conflict with South Korea’s goals to foster conditions for a stable Korean Peninsula? What legal and trade barriers, both bilateral and international, exist to South Korea realizing its pyroprocessing and enrichment goals? If the United States upholds its current policy on sensitive fuel cycle technologies, will South Korea be forced to pursue ENR independently? Absent programmatic consent, do viable and proliferation-resistant alternatives to pyroprocessing exist for South Korea? Finally, does this debate reflect a shift away from the global norm against spent fuel reprocessing?

What Is Pyroprocessing?

Pyroprocessing, also known as electrochemical reprocessing or dry reprocessing, is a high-temperature spent nuclear fuel recycling method developed at Idaho National Laboratory in 1996. U.S. national laboratories have collaborated with the Korea Atomic Energy Research Institute (KAERI) on pyroprocessing since 2002. In the early stages of its development, pyroprocessing appeared to have posed a lesser proliferation risk than conventional recycling methods because the plutonium separated in this process can remain mixed with minor actinides and other transuranic elements (TRU), including americium, neptunium, and curium. Because the recovered plutonium remains mixed with impurities, it is difficult to refine for use in a nuclear weapon.

Pyroprocessing is made up of five phases: pretreatment, electroreduction, electrorefinement, electrowinning, and waste treatment. Electroreduction condenses nuclear waste, reducing the volume and preparing it for the electrorefinement and electrowinning stages. Electrorefinement and electrowinning are the processes whereby reusable fissile elements, uranium and plutonium with minor actinides, are recovered from spent fuel. Unlike conventional spent fuel recycling methods, pyroprocessing occurs at high temperatures and does not use hydrogen and carbon-based acid solvents to dissolve spent fuel rods. The molten metal and salt solvents used in pyroprocessing do not absorb neutrons and therefore cannot act as moderators, eliminating the risk of a criticality accident.

Further research has cast doubt on early optimism regarding the proliferation resistance of pyroprocessing. Pyroprocessing removes many of the technical barriers to producing weapons-grade fissile material, because it removes most fission products from

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8. Furthermore, there is insufficient commercial demand for pyroprocessing as PUREX holds a virtual monopoly on the 2 percent of reprocessed fuel used in power reactors worldwide. As countries continue to develop their fast neutron and breeder reactor programs, demand for pyroprocessing could grow. See “Processing of Used Nuclear Fuel,” World Nuclear Association, May 2012, http://www.world-nuclear.org/info/inf69.html.
the resulting plutonium mixture. In March 2011, U.S. Department of Energy official Richard Stratford made the most decisive U.S. government statement on pyroprocessing to date: “[The department] states, frankly and positively, that pyroprocessing is reprocessing, period, full stop. . . . Electroreduction, combined with electro-refining, has moved to the point that the product is dangerous, from a proliferation point of view.”

Today, limited cooperation between the U.S. and South Korean technical communities continues on electrorefinement, pyroprocessing safeguards, and scale-up for commercialization. South Korea plans to use pyroprocessed fuel from its existing nuclear power plants to fuel Generation IV KAERI-developed, sodium-cooled fast reactors. In 2007, the South Korean Ministry of Knowledge Economy released an energy road map, detailing plans to complete a pyroprocessing–fast reactor fuel cycle by 2028. The road map predicted that South Korea would complete a pilot pyroprocessing plant by 2012, an engineering-scale demonstration plant by 2016, and a commercial facility by 2025. Though South Korea will be hard-pressed to meet these early projections, government support for pyroprocessing remains strong.

Nuclear Power in South Korea: Waste Management and Domestic Capacity Growth

South Korea and the United States signed their first nuclear cooperation agreement with the United States in 1956. With encouragement from the United States, resource-poor South Korea pursued nuclear power to offset its heavy dependence on coal, oil, and gas imports for electricity production. Throughout the 1970s and 1980s, South Korea purchased turnkey nuclear plants from the United States and Canada. South Korea’s first nuclear plant, Kori-1, became operational in 1978. In 1987, it concluded an agreement with Westinghouse to develop an indigenous light water reactor. The resulting design, the Korean Standard Nuclear Plant (KSNP), was an advanced pressurized water reactor (PWR). Since the 1990s, South Korea has produced several evolved models based on the original Westinghouse designs. As the world’s fifth-largest producer of nuclear energy, approximately 30 percent of electricity generated in South Korea is derived from

nuclear. With 23 plants in operation and 9 under construction or planned, South Korea’s dependence on nuclear power will only grow.\textsuperscript{13} Planned domestic nuclear power growth will see an increase in its present output from 20,787 MWe to 29,987 MWe in 2016.\textsuperscript{14}

Despite planned growth, Seoul still lacks a cradle-to-grave solution for its growing nuclear waste problem. Present onsite spent fuel storage at South Korea’s four reactor sites is expected to reach full capacity between 2016 and 2021.\textsuperscript{15} To address this looming crisis, the South Korean National Assembly passed the Radioactive Waste Management Act, which established the Korea Radioactive Waste Management Corporation (KRMC) in 2009. KRMC has taken exception to KAERI’s contention that pyroprocessing is a necessary and appropriate solution to South Korea’s growing stockpile of nuclear waste. According to KRMC, capacity in existing cooling ponds at all four PWR sites can be increased by installing higher-density racks.\textsuperscript{16} New plants at the Kori and Ulchin reactor sites will feature empty ponds. The additional capacity at these two sites alone will delay the need for alternative sites by 10 years. Dry cask storage could house older, cooled fuel for upward of 60 years.\textsuperscript{17} Though on-site and interim dry cask storage cannot be considered sustainable or indefinite solutions, they remove the incentive to rush the commercialization of pyroprocessing. Moreover, if it proceeds with pyroprocessing, South Korea will still need a geological repository to safely store the resulting high-level waste stream. Delaying South Korea’s waste management crisis through added interim and onsite storage allows more time to develop safeguards and accurate material accountancy methods to detect the diversion or loss of separated plutonium.

South Korean Nuclear Exports: Looking Beyond the UAE Deal

In just two decades, South Korea transformed from an importer of turnkey nuclear plants to an exporter of Generation III technology with the sale of four Advanced Pressurized Reactors (APR-1400) to the United Arab Emirates (UAE) in 2010. Following the sale,
South Korea announced plans to capture 20 percent of nuclear exports by 2030. Since South Korea’s principal nuclear exporter defeated competing bids from AREVA and GE-Hitachi Nuclear Energy to win a $20 billion contract, Korea Electric Power Company (KEPCO) has announced plans to sell a further four reactors to the UAE. In addition to the reactors, KEPCO and its subcontracting firms concluded related contracts for the provision of two fuel loads, plant operation for the duration of these two fuel loads, and training of UAE staff.

The nuclear industry is a strategic priority for the South Korean government. President Lee Myung-Bak’s administration has offered strong support and incentives in the form of preferential tax rates and exemptions on imported goods to South Korea’s rapidly advancing industrial sector. KEPCO, under government pressure to win the UAE tender, made a competitive offer to the UAE, assuming the lion’s share of risk during the construction phase of the four plants. In its inaugural sale, KEPCO concluded a lump-sum contract, wherein KEPCO assumed the burden of cost growth in raw materials and construction inputs. Nuclear power plants are capital-intensive and susceptible to cost growth in the early siting, licensing, and construction phases. Though costs vary by project, recent builds have cost upward of $8 billion. The South Korean government’s industrial policy supposes that once a Korean firm penetrates a new market, as KEPCO did global nuclear exports, it can secure progressively favorable terms.

The nuclear export market is small, with only nine established exporters. Due to high initial capital costs, new nuclear builds are high-risk ventures and few and far between. Nevertheless, states seeking to diversify their energy sources, reduce carbon emissions, and limit the risks associated with unpredictable oil and gas prices regard nuclear as an attractive option. Following the Fukushima Daiichi nuclear accident many predicted the paralysis and decline of global nuclear plant sales. Today, however, interest in nuclear power remains strong in many, albeit fewer, countries. With many first-generation plants nearing the end of their service lives, KEPCO stands to capture a portion of these lucrative contracts. If South Korea could commercialize pyroprocessing technology and advanced sodium-cooled fast reactors, it could increase its competitiveness by offering complete fuel cycle services to its customers.

20. Ibid., 9.
Reasonable Doubt?: Peaceful Nuclear Sovereignty and Regional Politics

Proponents of South Korea’s right to pursue pyroprocessing including members of the country’s National Assembly, and the technical and expert communities have cast U.S. refusal to allow South Korea to reprocess spent nuclear fuel as an affront to an increasingly important ally. As Seoul’s nuclear industry advances, perhaps ahead of U.S. firms, the terms of current U.S.–South Korean nuclear cooperation will be increasingly scrutinized inside Korea. Korean officials, including the head of Korea’s Ministry of Knowledge Economy Choi Kyung-hwan, have called upon the U.S. to recognize South Korea’s “peaceful nuclear sovereignty,” characterizing present restrictions as excessive. Negotiators have speculated that the U.S. position is motivated by lingering suspicions that South Korea is seeking commercial pyroprocessing to develop a nuclear hedge, rather than a desire to uphold a tenuous, but three-decade-long, moratorium on spent fuel reprocessing in nonnuclear weapons states. This speculation is complicated by unease regarding North Korea’s nuclear capability and South Korea’s imperfect non-proliferation record, along with a fear that Japan occupies an unshakable seat as senior partner in the U.S.-Pacific alliance.

Under the dictatorial leadership of President Park Chung-hee, South Korea briefly pursued an independent nuclear deterrent in the 1970s. A former general, Park was a nationalist, industrialist, and economic reformer who came to power after staging a military coup in 1961. In an effort to coerce South Korea into abandoning its nuclear program, U.S. president Jimmy Carter threatened to withdraw U.S. tactical nuclear weapons and troops from the Korean Peninsula in 1978. When President Park was assassinated in 1979, Carter made recognition of his successor, Chun Doo-hwan, conditional upon South Korea renouncing its nuclear ambitions and dismantling the military elements of its nuclear program.

South Korea faces a persistent existential threat from nuclear-armed North Korea. North Korea’s continued ballistic missile development and frequent breaches of antinuclear commitments magnify this threat. This is evidenced by a resurgence of public support for an independent nuclear deterrent or the restationing of U.S. nuclear weapons

in South Korea. The 1992 Joint Declaration on the Denuclearization of the Korean Peninsula, a bilateral agreement between North and South Korea, is the only standing nonnuclear commitment between both parties and North Korea’s only legal commitment to denuclearize. In addition to banning nuclear weapons testing, manufacture, production, possession, storage, deployment, and use, the declaration states that neither party shall possess nuclear reprocessing and uranium enrichment facilities. Because North Korea has effectively violated each of these provisions, with the exception of nuclear use, South Korea does not view its civilian enrichment and pyroprocessing ambitions as a material breach of the agreement.

The question remains, if the Joint Declaration is North Korea’s only recorded nonnuclear commitment and serves as a basis for all multilateral appeals for North Korea’s denuclearization, will Seoul’s pursuit of ENR technology act as a spoiler in attempts to normalize relations with North Korea in the future? Seoul is seeking enrichment and pyroprocessing to achieve an autonomous, sustainable, and peaceful nuclear enterprise. Yet, commercial-scale uranium enrichment and pyroprocessing will introduce large quantities of fissile material to the Korean Peninsula. Current nuclear material accountancy, the foundation of the International Atomic Energy Agency’s (IAEA’s) safeguards for commercial fuel cycle facilities, still operates assuming a 1 percent margin of error. This margin leaves reasonable doubt that material could be diverted, further refined or enriched, and used in a nuclear weapon, giving South Korea a latent breakout capability. North Korea will have little incentive to participate in the Six-Party Talks or bilateral negotiations if South Korea acquires a nuclear hedge. Opposition to South Korea’s pyroprocessing and enrichment ambitions is not based on a belief that Seoul is an irresponsible user of nuclear technology. Rather, it reflects an understanding that a change in security conditions in Northeast Asia, however slight, could escalate regional tensions and disrupt prospects for peace in the long term.

In 2004, South Korea reported to the IAEA previously undeclared laser isotope separation experiments to enrich small amounts of uranium to 77 percent. Further investigations revealed that KAERI scientists performed laboratory-scale uranium conversion and plutonium separation in the 1980s. The experiments did not yield significant quan-

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tities of highly enriched fissile material, but they were performed without the knowledge or approval of the South Korean government. Failure to report the experiments represents a violation of South Korea’s reporting requirements to the IAEA. However, because the experiments did not indicate a desire at the highest levels of the South Korean government to pursue an independent nuclear deterrent, South Korea was not declared in noncompliance with its IAEA safeguards obligations.

The prevalence of the sovereignty and parity arguments, which are so popular with the public and nationalist politicians in South Korea, present an obvious conflict with the technical and commercial justifications for South Korea’s pursuit of ENR, advanced by the technical community and nuclear industry. Expert and inexpert constituencies within South Korea have their own motivations for supporting a closed fuel cycle. However, the nature of public debate has created a self-contradictory narrative surrounding Korea’s ultimate goals for its ENR program, which will have to be resolved if Seoul is to rely on U.S. permission for its pyroprocessing and enrichment plans.

The Japan Question: Forming U.S. Spent Fuel Reprocessing Policy

The contention that reprocessing in Japan poses a lesser proliferation concern than reprocessing in South Korea is unacceptable to many Koreans for reasons mired in regional politics and history. U.S. reluctance to extend a similar exemption to South Korea has been interpreted as a sign that the United States doubts South Korea’s stated civil motivations for reprocessing. Media coverage of South Korea’s clandestine experimentation was a major source of embarrassment to the Blue House, especially when contrasted with the international community’s tepid response to Japan’s discovery of a 206 kilograms discrepancy in separated plutonium from its reprocessing activities. Just as the international community and nonproliferation regime have adapted to the reality of Japan’s reprocessing program, South Korea hopes that its own ENR program will be regarded without suspicion.

Japan first adopted civil nuclear technology under the U.S. Atoms for Peace program in 1956, with plans to develop breeder reactor and spent fuel reprocessing programs. By 1974, it still relied on oil imports for more than 70 percent of its energy consumption. The onset of the 1973 oil crisis only magnified Japan’s energy security concerns. The United States’ abandonment of international enrichment services during that decade fueled Japan’s desire for an independent civil nuclear industry, protected from unpredictable international markets. A breeder reactor fleet, run on reprocessed spent nuclear fuel from Japan’s then 10 light water reactors, would offer virtual energy independence.

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U.S. nuclear cooperation with Japan straddles two distinct eras of U.S. policy on spent fuel reprocessing. As Japan’s agreement was revised well before India’s 1974 nuclear test, it contained no proscription against sensitive fuel cycle technology transfer or development. In fact, until 1974, the U.S. Atomic Energy Commission viewed reprocessing as a desirable and economical means for closing the back end of the fuel cycle.\textsuperscript{36} Presidents Gerald Ford and Jimmy Carter oversaw a sea change in U.S. nuclear cooperation, reflecting a new awareness of the proliferation danger posed by large amounts of separated plutonium in new nuclear states. However, the exit of U.S. enrichment services offered a legitimate energy security rationale for reprocessing, as well as a path to weapons acquisition to states seeking to mask their misuse of peaceful nuclear technology. President Ford responded to this threat by suspending the U.S. reprocessing and breeder reactor programs in 1974. President Carter went a step further with an indefinite suspension. His personal stake in the antireprocessing agenda led him to pressure Germany and France to cancel planned transfers of reprocessing plants to Brazil and South Korea, respectively.\textsuperscript{37}

While the U.S. moratorium on reprocessing placed an effective tamper on the spread of sensitive fuel cycle technology, Japan’s reprocessing program undercut the ban’s universality. The Carter administration could hardly walk back on the 1968 agreement. Instead, it honored case-by-case conditions on Japan’s ability to ship or reprocess United States–origin spent fuel.\textsuperscript{38} However, the Japanese government viewed the Carter administration’s case-by-case restriction on reprocessing as overly burdensome and restrictive. This tension, paired with increased animosity over the United States–Japan trade deficit, led to a souring of relations between the two countries.\textsuperscript{39} New leadership in Japan and the United States in the 1980s under Prime Minister Yasuhiro Nakasone and President Ronald Reagan presented an opportunity to repair United States–Japan relations. By lifting case-by-case permissions on Japan’s reprocessing activities, Reagan distanced himself from his predecessor’s controversial nonproliferation policy.

Japan and South Korea share many of the same geographic, political, and technical motivations for commercial reprocessing. Like South Korea, Japan is a densely populated country that is heavily reliant on nuclear power. Geological conditions in Japan


are not ideal for the construction of a deep geological repository for high-level nuclear waste. Seismic activity and local opposition to spent-fuel storage were early catalysts for Japan’s commercial reprocessing venture.\textsuperscript{40} In granting programmatic consent to Japan, the Reagan administration accepted Japan’s energy security rationale for reprocessing as an article of faith.\textsuperscript{41} Nakasone was a nationalist, a strong proponent of Japan’s scientific base, and a believer that Japan should master the full nuclear fuel cycle. He worked to remove barriers to Japan’s unrestricted fuel cycle development, among them, the case-by-case plutonium transfer agreement. Nakasone was not interested in reversing Japan’s anti–nuclear arms pledge. Rather, his principal aim was to establish a “plutonium economy”: material conditions for nuclear breakout in the event of a significant change in Japan’s security condition.\textsuperscript{42}

In 1993, Japan broke ground on the Rokkasho Reprocessing Plant in Aomori prefecture, its first and only commercial-scale reprocessing facility. Rokkasho has an expected annual capacity 8 tons of separated plutonium recoverable from 800 tons of spent fuel, but has not yet become fully operational. Rokkasho’s construction suffered exponential cost growth, while commercial operation was delayed 18 times due to inaccurate early construction timelines and design changes.\textsuperscript{43} The Japanese government invested heavily in its reprocessing venture, which stands at $27.5 billion, and engaged in early consensus building to establish popular support for a closed fuel cycle. However, Japan’s advance fuel cycle development has stalled in the wake of the Fukushima accident.\textsuperscript{44}

Public support for nuclear power and confidence in the government’s ability to regulate Japan’s powerful nuclear industry has eroded. Following the accident, Japan shut down its 54 nuclear plants, pending a thorough review of safety regulations and energy alternatives. Though a number of these plants have come back on line, Japan’s advanced fuel cycle program, including reprocessing and breeder reactor development, will not be resumed, in all likelihood.\textsuperscript{45} Pending possible abandonment of its plans for a closed fuel cycle, Japan is now seriously exploring long-term waste storage solutions that it had

previously dismissed. The future of Japan’s program bears heavily on South Korean advanced fuel cycle plans. If Japan abandons its original vision of commercial reprocessing and a fast breeder reactor fleet, a key precedent for South Korea’s program would become a historical footnote. Certainly, without the anomalous example of Japan to point to, South Korea would have more difficulty convincing the United States to change its long-standing policy against reprocessing in nonnuclear weapons states.

Legal and Normative Barriers to Pyroprocessing in South Korea

South Korea, despite its advanced nuclear industry, faces a host of legal, political, and normative barriers to pursuing sensitive fuel cycle technology. In addition to its standing agreement for civil nuclear cooperation with the United States, South Korea is subject to intellectual property restrictions on United States–sourced reactor components. Beyond these restrictions, there exists an international norm against spent fuel reprocessing. Commercial reprocessing is only performed in five countries, all nuclear weapons states with the exception of Japan. Voluntary export control regimes, including the Nuclear Suppliers Group and country-specific bilateral nuclear cooperation agreements, form the foundation of this 35-year precedent. Because these barriers lack the universality of a comprehensive legal regime, the moratorium on reprocessing can be considered normative, at best, and vulnerable to erosion.

Until the early 1970s, the United States held a monopoly on the global uranium fuel supply for light water reactors. The 1973 oil crisis, which forced many states to reconsider their dependence on imported fossil fuels in favor of light water and breeder reactor programs, had yet to occur. Further, India had not yet tested its first nuclear device, fashioned from plutonium separated from spent fuel originating from the CIRUS heavy-water research reactor. This confluence of events, occurring within a span of just two years from 1973 to 1974, fundamentally transformed U.S. nuclear export policy to place far greater emphasis on the proliferation risk associated with reprocessing technology. The mid-1970s saw the formation of this nonproliferation-oriented trade policy, culminating in a United States–led international moratorium on the transfer of spent fuel-reprocessing technology.

The United States conducts civil nuclear cooperation with partner states through largely standardized bilateral agreements called 123 Agreements, named for section 123 of the 1954 Atomic Energy Act (AEA). The AEA governs the United States’ activities relating to the peaceful applications of nuclear energy, and Section 123 mandates the conclusion of a specific agreement for significant transfers of nuclear material, equipment, or components from the United States to another nation. Under the terms of civil

nuclear cooperation with the United States, express permission must be given to reprocess United States–origin spent fuel. Article VIII (F) of the 1974 agreement states:

When any special nuclear material received from the United States of America pursuant to this agreement or the superseded Agreement requires reprocessing, or any irradiated fuel elements containing fuel material received from the United States of America pursuant to this Agreement or the superseded Agreement are to be removed from a reactor and are to be altered in form or content, such reprocessing or alteration shall be performed in facilities acceptable to both Parties upon a joint determination of the Parties that the provisions of Article XI [which addresses the safeguarding of transferred materials and facilities] may be effectively applied.\footnote{Public Law 83-703 68 Stat. 919: The Atomic Energy Act, U.S. Nuclear Regulatory Commission, 1954, 57–59; see Section 123 (a), http://science.energy.gov/~media/bes/pdf/nureg_0980_v1_no7_june2005.pdf.}

In 1978, the passage of the Nuclear Nonproliferation Act (NNPA) strengthened the nonproliferation bona fides of U.S. sensitive fuel cycle export policy further. The NNPA not only froze U.S. sensitive fuel cycle exports but also levied case-by-case restrictions on any fuel, United States–sourced or otherwise, irradiated in a reactor containing United States–designed components. However, these restrictions do not officially apply to the current U.S.–South Korean 123 Agreement, which negotiated four years before the passage of the NNPA. Consistent with U.S. nuclear export standards at the time, the 123 Agreement subjects the reprocessing of United States–supplied spent-fuel in South Korea to case-by-case consent, wherein a subsequent arrangement to the original 123 Agreement must be negotiated and approved by Congress.\footnote{Fred McGoldrick, “New U.S.-ROK Peaceful Nuclear Cooperation Agreement: A Precendent for a New Global Nuclear Architecture,” Center for U.S.-Korea Policy, Washington, D.C., Asia Foundation, November 2009, 3, http://asiafoundation.org/resources/pdfs/McGoldrickUS-ROKCUSKP091130.pdf.} The renegotiated 123 Agreement will have to subject United States–South Korea nuclear cooperation to the standards contained in the NNPA in explicit terms. South Korea is fast approaching its expected goal to fully indigenize its reactor designs by 2012. This means, however, that it must restrict reactor exports to those countries with a U.S. civil nuclear cooperation agreement in place; it will face fewer formal legal limits on its ENR plans regarding newly constructed plants. If the renegotiated agreement contains NNPA restrictions, indigenous fuel irradiated in Korean-designed reactors will be subject to U.S. reprocessing restrictions because all pre-2012 Korean designs contain U.S. intellectual property.

If its bilateral cooperation agreement with the United States and intellectual property obligations are the sole barriers to pyroprocessing, one must ask: What is keeping South Korea from pursuing a commercial program outside its current agreement once its reactor design has been fully indigenized? First, if South Korea were to pursue pyroprocessing independent of U.S. consent, its program would not mitigate the current waste storage burden, given that the vast majority, two-thirds, of waste material is ineligible for recycling. Once cooperation with South Korea is subject to the additional restrictions contained in the NNPA, all fuel run through South Korea’s PWR reactors will
be ineligible, thus eliminating pyroprocessing as an option for near- and medium-term waste management. Second, South Korea’s leadership will not circumvent U.S. barriers to sensitive fuel cycle development as the potential for damage to United States–South Korean relations would be profound. Finally, an agreement granting South Korea prior consent to reprocess would place it on par with Japan, reflecting South Korea’s growing leadership role in the Pacific alliance. South Korea’s pursuit of enrichment and reprocessing technology is motivated by a desire for official recognition and acceptance of its status as an advanced nuclear power in addition to waste management, regional, and energy security concerns.

_U.S.–South Korean Cooperation: Global Nuclear Energy Partnership to a Joint Feasibility Study_

While the United States officially opposes the spread of sensitive fuel cycle technology on nonproliferation grounds, it actively supports research on developing reliable safeguards to increase the proliferation resistance of sensitive fuel cycle applications such as pyroprocessing. South Korea has been a long-standing international partner in this research. Since 2002, KAERI has conducted joint pyroprocessing research with U.S. national laboratories under the Department of Energy’s International Nuclear Energy Research Initiative (I-NERI). In 2006, U.S.–South Korean cooperation broadened under the KAERI-10 program, which explores methods for safeguarding pyroprocessing facilities. Under KAERI-10, KAERI and Los Alamos National Laboratory have collaborated on material accountancy methods to fulfill the IAEA’s concept of safeguards by design, wherein safeguards are tailored to a specific facility to ensure against the diversion of material.

In 2008, South Korea joined the Global Nuclear Energy Partnership (GNEP), which was established by the George W. Bush administration in 2006 to support a proliferation-resistant nuclear renaissance in the United States and in 25 partner states. In the United States, GNEP promoted advanced research and development of fuel cycle processes and technologies to enable sustained and commercially viable nuclear energy generation. Specifically, the program sought to mitigate the high-level nuclear waste management and proliferation risks associated with the open fuel cycle.

GNEP stemmed from the belief that closing the nuclear fuel cycle in the United States was an essential and long-overdue step in the road to a sustainable U.S. nuclear energy policy. Under GNEP, the United States explored the environmental impact and commercial feasibility of various fuel cycles, including reprocessing, fast reactors, and breeder reactors. The shift in U.S. policy presented South Korea with an opportunity

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50. Manyin, Chanlett-Avery, and Nikitin, “U.S.–South Korea Relations,” 27.


to advance its own reprocessing plans with the administration’s blessing. In 2009, the GNEP budget was zeroed out and U.S. nuclear fuel cycle technology cooperation was recast to reflect the inherent danger of the spread of nuclear fuel cycle technology. In name, GNEP became the International Framework for Nuclear Energy Cooperation (IFNEC). In practice, IFNEC now prohibits South Korean scientists from conducting “hot” pyroprocessing experiments using enriched uranium fuel.

In response to Seoul’s February 2012 request for programmatic consent, the U.S. Department of State has proposed a 10-year joint feasibility study on pyroprocessing. While the study benefits both the United States and South Korea in principle, it does not guarantee any automatic mechanism for programmatic ENR consent. Such an arrangement would undercut the universality of current U.S. policy on the nontransfer of ENR technology to new nonnuclear weapons states. Continued cooperation is desirable for both sides. The technical community in South Korea, and the country’s nuclear enterprise more broadly, still has much to gain from close collaboration with U.S. national laboratories and the U.S. Department of Energy. Cooperation with these entities signals political prestige and a recognition of South Korea’s technical and industrial accomplishments. Cooperation means continued material investment from the United States on pyroprocessing research and development. For the United States, continued collaboration on sensitive fuel cycle applications is important for trust and transparency but also serves as a force multiplier for innovation. The United States has no plans to commercialize spent fuel recycling. Proliferation concerns served as a catalyst for this policy in 1976, but it has been reinforced by the unfavorable economics of pyroprocessing and conventional reprocessing. Though no commercial incentive exists in the foreseeable future for adopting this technology, the United States can only gain from a deeper understanding of advanced fuel cycle applications in the event that its nuclear energy plan or the economics of its current open fuel cycle change down the road.

Can There Be a Meeting of the Minds on Pyroprocessing and Enrichment in South Korea?

South Korea continues to look to pyroprocessing as a panacea for its growing waste management dilemma. However, casting pyroprocessing as a necessary and appropri-

54. Instead, experiments are conducted with natural uranium to avoid full plutonium separation from other fissile isotopes and transuranic elements. Kane, Lieggi, and Pomper, “Going Global,” 3.
ate short-term solution mischaracterizes South Korea’s current waste storage problem. There is still much work to be done on pyroprocessing safeguards. Further, there will be inevitable delays and complications as South Korea scales its current pyroprocessing activities up to the demonstration and commercial levels. By all accounts, pyroprocessing has the potential to mitigate South Korea’s waste storage problem in the long term, but cannot meet its immediate high-level waste mitigation requirements. A constructive approach to this dilemma will include a serious exploration of waste storage options, including expanded interim storage and a deep geological repository for long-term high-level waste.58

In the public pyroprocessing and enrichment debates, South Korea and the United States continue to talk past one another. At a July 2012 press conference, the White House’s coordinator for arms control and weapons of mass destruction, proliferation, and terrorism, Gary Samore said, “There is no danger that Korean industry will not be able to get access to low enriched uranium,” adding, “You don’t have to worry about any limit Korea will have.”59 South Korea’s desire for a domestic uranium enrichment capability stems from a desire for autonomy in its civil nuclear program, not from a fear of a supply shortage. As a nuclear fuel supplier, South Korea is loath to commit resources to importing enriched uranium.

By contrast, much of the public debate in South Korea regarding programmatic consent for enrichment and pyroprocessing hinges on nuclear sovereignty and parity with Japan. These arguments do not address core U.S. concerns regarding the spread of ENR technology. Calls for nuclear sovereignty misplace the source of U.S. concerns regarding ENR technology in South Korea, assuming that the U.S. refusal to amend the restrictions in the current 123 Agreement stem from South Korea’s past nuclear adventurism under Park Chung-hee and undeclared experiments in the 1980s and 2000. Invocation of Japan’s unique reprocessing arrangement provides a compelling argument for many Koreans, but glazes over the unique security conditions on the Korean Peninsula, where the introduction of commercial-scale ENR technology would be destabilizing and ultimately self-defeating.

To be sure, nuclear energy policy in the United States is subject to reinterpretation with each election cycle. Consistency in the U.S. nuclear energy program is a function of slow-moving fuel cycle research, development, and commercialization rather than a decades-long policy commitment to adhere to an open fuel cycle. U.S. presidents, and their Departments of State and Energy, have interpreted the proliferation risk of ENR differently, at times, valuing the benefits of a closed fuel cycle over existing nonprolif-


eration norms. In crafting a long-term strategy vis-à-vis South Korea, the United States must address the possibility that South Korea may wait out the policies of the current administration, secure a position of greater leverage in the Pacific alliance, and revisit its ENR request when the United States is likely to lend a more sympathetic ear.

The issue of South Korea’s advanced fuel cycle choices will prove an important test for U.S.–South Korean relations as South Korea assumes an increasingly important role in the Pacific alliance. South Korea is seeking a partnership with the United States that reflects its sustained economic growth and political maturity. As the memory of the Korean War fades, popular sentiment vis-à-vis the United States will shift away from the traditional dependence dynamic that characterized U.S.–South Korean relations throughout the second half of the twentieth century. The United States requires a creative and diplomatic approach to compel South Korea to live up to its newfound leadership role in the global nonproliferation regime, starting with how it chooses to deploy proliferative technologies such as enrichment and pyroprocessing.
Assessing the Role of Seismic Data Sharing in CTBT Monitoring

Stephen Herzog

Policy analyses of underground test monitoring in support of the Comprehensive Nuclear Test Ban Treaty (CTBT) usually focus on the Primary and Auxiliary Seismological Networks of the International Monitoring System (IMS). In addition to overlooking National Technical Means (NTM), this lens fails to consider thousands of seismic stations and arrays operated by government agencies, universities, and research institutes. These networks serve important functions in earthquake hazard mitigation, tsunami warning systems, and civilian and military disaster responses, but they can also detect waveform data from suspected nuclear tests. This paper explores mechanisms for seismic data sharing in the scientific community and evaluates their potential contributions to CTBT monitoring. It concludes that seismology is the first line of sight for monitoring underground nuclear tests, and scientific data sharing and capacity building can help to detect and deter noncompliance with the CTBT.

Seismic Monitoring and Nuclear Testing

The CTBT opened for signature on September 24, 1996, and has since been signed by 183 states and ratified by 157 states. The CTBT represents the culmination of decades of legal efforts to prohibit nuclear testing, which include the 1963 Partial Test Ban Treaty, the 1974 Threshold Test Ban Treaty, and the 1976 Peaceful Nuclear Explosions Treaty. However, CTBT negotiations at the Conference on Disarmament (CD) in Geneva were protracted and diplomatically challenging. For the CTBT to enter into force, it must

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3. For a thorough and insightful analysis of negotiations, see Rebecca Johnson, Unfinished Business: The Negotiation of the CTBT and the End of Nuclear Testing (Geneva: United Nations
be ratified by the 44 “nuclear-capable” states listed in Annex 2 of the treaty; these are the CD members that had active nuclear weapons, nuclear power, or nuclear energy research programs during treaty negotiations. Eight of these states—China, Egypt, India, Iran, Israel, North Korea, Pakistan, and the United States—have not ratified the CTBT. Several of these countries cite concerns related to global arms control and disarmament, CTBT monitoring and verification, and nuclear weapons stockpile stewardship as their rationales for not having ratified. This paper focuses on the monitoring component of the CTBT, and in particular, seismological efforts to detect underground nuclear testing.

Although the CTBT has not entered into force, the international community has numerous complementary tools for monitoring nuclear tests at its disposal. When completed, the CTBT’s global IMS will consist of 321 monitoring stations and 16 radionuclide laboratories. At the time of writing, 271 of these facilities were certified by the Preparatory Commission for the Comprehensive Nuclear Test Ban Treaty Organization’s (CTBTO PrepCom) Provisional Technical Secretariat (PTS), 16 were undergoing testing, 22 were under construction, and 28 were planned. Hydroacoustic stations account for 11 IMS stations and are designed to detect waveforms from underwater nuclear tests. Infrasound stations constitute another 60 facilities and collect waveform data from low-frequency sound waves associated with atmospheric nuclear testing activities. The 80 IMS radionuclide monitoring stations detect airborne radioactive particulates and noble gases, such as certain isotopes of xenon and argon that would be released by a nuclear test. Data from the radionuclide stations is processed at the 16 IMS radionuclide laboratories. Finally, the 170 IMS seismological stations detect the propagation of seismic waves through the Earth’s lithosphere to assist in discriminating explosions from naturally occurring seismic events and locating possible underground nuclear tests. These four IMS elements transmit data to the CTBTO PrepCom’s International Data Centre (IDC) in Vienna, which makes raw waveform data and aggregated event bulletins available to the National Data Centers of CTBT signatory states. Data will only be available to parties to the treaty after entry into force.

In addition to the IMS, NTM and scientific research networks contribute to national, regional, and global monitoring capabilities. Data from these stations are not transmitted to the IDC in real time, but states can provide it to the PTS and other states to assist in the location and confirmation of potential nuclear tests. NTM are generally classified military assets that assist states in nuclear test monitoring. For example, in the case of the United States, the unclassified version of the National Academy of Science (NAS) 2012 CTBT Study indicates that the U.S. Air Force Technical Applications Center main-

Institute for Disarmament Research, 2009).


5. Half (40) of the IMS radionuclide stations are equipped to monitor noble gas radionuclides using technology provided through the International Noble Gas Experiment (INGE).

6. Of the 170 IMS seismic stations, 50 belong to the Primary Seismological Network, and after certification, send data to the International Data Centre (IDC) in Vienna on a continuous basis. The other 120 comprise the Auxiliary Seismological Network and are equipped to transmit data to the IDC upon request following their certification.
tains NTM technologies in seismic and radionuclide monitoring, as well as satellites. The NAS Study states, “U.S. National Technical Means provide monitoring capability that is superior to that of the CTBTO, but the use of U.S. NTM for diplomatic purposes may be constrained due to its largely classified nature." In contrast to discrete NTM capabilities, national and university networks for scientific research and hazard mitigation are usually far less sensitive, easing the process of data sharing. Civil networks of these types exist throughout the world and can consist of seismic, infrasound, hydroacoustic, radionuclide, and other monitoring technologies.

While this multitude of monitoring tools works in concert to provide layered detection and deterrence of nuclear testing, some technologies are arguably more important than others. The NAS Study indicates that “seismology is the most effective technology for monitoring underground nuclear-explosion testing,” and a recent book on CTBT verification has a marked focus on seismic monitoring compared to its peer technologies. In fact, under a February 1980 mandate from the CD, the Group of Scientific Experts (GSE) began to develop a global seismic monitoring system—much of which is used in today’s IMS—in anticipation of an eventual ban on all forms of nuclear testing. Concerns about underground nuclear testing may stem from fears that countries will pursue decoupling or other masking techniques to conceal evasive tests from the international community. The 2006 and 2009 underground tests by North Korea may also contribute to these concerns. Indeed, horizontal adits and deep vertical shafts offer nuclear weapon states and aspiring proliferators a semicontrolled environment to assess improvements to existing classes of weapons or test new devices.

But with sophisticated IMS stations around the world and significant investment by states in NTM technologies, is there really an important role for scientific seismological networks in nuclear test monitoring? This paper investigates whether seismic stations, such as those operated by the Institute of Geophysics and Planetary Physics at the University of California, San Diego, can assist the international community in detecting, locating, and identifying nuclear testing activities. In pursuit of this objective, this paper

8. Ibid., 38.
identifies and evaluates the possible monitoring contributions of these types of seismic stations.

**Scientific Seismic Networks Complement the IMS**

Governments, universities, and research institutes operate autonomous seismic stations and networks for purposes such as scientific research, earthquake hazard mitigation, and tsunami warning systems. Examples of this include Academia Sinica’s 55-station Broadband Array in Taiwan for Seismology and the 32-station seismic network operated by the King Abdulaziz City for Science & Technology in Riyadh.\(^\text{12}\) Scientific seismic networks may include stations with single-component, short-period sensors for detection of high-frequency waves associated with regional events; stations with three-component broadband sensors for global event monitoring; and multielement seismic arrays. A seismic array is a configuration of electronically linked seismometers dispersed at short distances—around a kilometer—that can enhance detection of small-magnitude events with waveform signatures resembling underground nuclear tests.\(^\text{13}\) The CTBT’s IMS employs both three-component broadband stations and arrays, which transmit data to the IDC via the satellite links of the CTBTO PrepCom’s Global Communications Infrastructure.

Although expansion, technical exercises, and iterated event monitoring experience continuously improve the quality of IMS data, no seismological network is perfect.\(^\text{14}\) But these qualitative enhancements lower the IMS detection threshold, making it increasingly difficult for countries to pursue evasive low-yield testing. The NAS Study’s Seismology Subcommittee converted IMS detection capabilities (given in magnitudes) released by the CTBTO PrepCom in 2007 into nuclear test yields. The subcommittee noted that the IMS Primary Seismological Network can detect, with 90 percent confidence, nuclear tests occurring in hard rock down to 0.22 kilotons in regions of the world exhibiting “better [wave] propagation.”\(^\text{15}\) In regions that are more difficult to monitor,


\(^{14}\) For a discussion of the improvements in IMS monitoring capabilities see David Hafemeister, “Progress in CTBT Monitoring since its 1999 Senate Defeat,” *Science and Global Security* 15, no. 3: 151–183. See also National Research Council of the National Academies, Committee on Reviewing and Updating Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty, 139-159.

\(^{15}\) National Research Council of the National Academies, Committee on Reviewing and Updating Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty, 50–51. In Asia, Europe, and North Africa, these magnitudes decrease to 0.09 kiloton in “better propagation” regions and 0.22 in more difficult areas to monitor. Further, the NAS Study clarifies that the most difficult areas to monitor due to terrain, wave propagation patterns, and seismicity are Iran, Turkey, and other areas of the Middle East.
this number rises to 0.56 kilotons. Further, the NAS Study notes that improvements in the IMS, such as a certified seismic station in Turkmenistan that came online in 2009, have since lowered detection threshold capabilities. A recent book also includes a map of the detection capabilities of these stations, providing a 10 percent confidence level. The authors’ analysis indicates global detection thresholds between magnitudes of 2.8 and 3.2, a sharp contrast to the NAS Study’s assumption of magnitude 3.8 detection. While the IMS’s ability to detect low-yield events may be a sufficient deterrent to aspiring proliferants, scientific seismic stations could assist in monitoring evasive testing in regions of poor wave propagation, failed nuclear tests (“fizzes”), and attempts to decouple or otherwise mask low-yield tests.

Part of the reason behind the small, but continuing, uncertainties in the seismic event detection capabilities of the IMS is the fact that the system is not fully operational. Of the 50 Primary Seismological Network Stations configured to send waveform data to the IDC on a continuous basis, 42 stations are certified by the PTS. A total of 102 of the 120 Auxiliary Seismological Network Stations—which can transmit data to the IDC upon request—are certified. For example, in the Middle East there are nonoperational CTBT-mandated seismic stations in Egypt, Israel, Iran, and Saudi Arabia. Thus, data from scientific research stations becomes increasingly important for ensuring the verifiability of the treaty.

Even after the treaty’s entry into force and the full operationalization of the IMS, scientific seismological stations will assist in on-site inspections (OSI), and attenuation and velocity modeling of the Earth’s lithosphere. If the future CTBTO’s Executive Council calls for an OSI, the inspection team may only search a declared area of 1,000 square kilometers, meaning that data from non-IMS stations could ease the process of selecting an inspection area and hasten the inspection. Data from these stations can also be incorporated into models of the Earth’s lithosphere, such as the Regional Seismic Travel-Time model used by the CTBTO PrepCom. These models enhance nuclear test detection in a circular manner: Data are input into the models, increasing knowledge of wave propagation through the Earth’s crust and upper mantle, which in turn improves international abilities to collect valuable seismic event data.

According to recent scholarship on the CTBT, countries are likely to pursue a strategy of “precision monitoring,” focusing on “one or a few countries of concern, or on

16. Dahlman et al., Detect and Deter, 46.
limited areas of those countries.”20 Most states will likely be satisfied with the regional verifiability of the CTBT, given the IMS detection thresholds provided by the NAS’s CTBT Study and other sources. There is also evidentiary support for this, as the vast majority of the world’s countries (157) have ratified the CTBT. But for some countries—such as the United States, where the treaty’s verifiability remains controversial—the receipt of additional data from scientific networks could increase confidence in precision-monitoring capabilities.21

If scientific seismic networks outside of the IMS and NTM are to assist the international community in monitoring for underground nuclear tests, then data sharing of waveforms becomes increasingly important. For example, the stations run by the United Arab Emirates National Center for Meteorology and Seismology have a limited regional sensitivity radius, as do the stations of the National Seismic Network of Italy. Consequently, countries and research institutes should pursue data-sharing arrangements to receive all the data necessary for their seismic hazard requirements and the precision monitoring of nuclear tests. Seismic data sharing is already relatively common in the scientific community, but not all data are available via a real-time online feed or openly shared between countries. A 2011 poster by the International Seismological Centre in London illustrates the complications that can arise from a lack of regional data sharing, given that the CTBTO PrepCom, Saudi Arabian, Iranian, and Kuwaiti stations in the Middle East are often separated by great distances.22 In the next sections, I evaluate five key seismological data-sharing mechanisms: formal and informal bilateral data-sharing agreements, multilateral data-sharing tools, open-access global seismic networks, computer software programs, and CTBT Cooperating National Facilities (CNFs).

Bilateral Data-Sharing

One of the traditional ways to share seismic data is through formal or informal bilateral data-sharing agreements. These arrangements facilitate the transfer of scientific knowledge for research purposes and can occur on a country-to-country or laboratory-to-laboratory basis. Memorandums of understanding, letters of intent, and business contracts are among the documents that are commonly used in formal data-sharing agreements, while more informal relationships may involve the ad hoc provision of seismic event data.

Scientists employ two main methods to bilaterally share seismic event data: the transfer of archived data, and the installation of a real-time data-sharing stream. Sharing of archived event data can occur through the exchange of compact discs, the use of Inter-

20. Dahlman et al., Detect and Deter, 2.
net file transfer protocol Web sites, and even email messages for small amounts of data. Archived data sharing is helpful for tasks that do not face pressing time constraints; such activities include scientific research projects and lithospheric Earth modeling. Countries and laboratories may also be increasingly likely to share archived data following an event that bears resemblance to a possible case of underground nuclear testing. Real-time and near-real-time data sharing, conversely, often employs technologies similar to those of the CTBT’s IMS and is well suited for continuous seismological monitoring of potential testing activities. Further, institutes collecting seismic event data may choose to share parametric and/or waveform data. Parametric data refers to the parameters of a seismic event, and these data sets may include amplitude and phase readings, location coordinates, and magnitudes. While parametric data is useful in cataloguing earthquakes and other seismic events, real-time streaming of waveform data ensures the highest authenticity of data and provides the source data for technical nuclear test monitoring discussions.

As data sharing is common in the field of geophysics, there are numerous examples of bilateral arrangements to exchange information about seismic events. After the devastating magnitude 7.0 earthquake of January 2010, the Government of Haiti began the process of developing an advanced seismic network for seismic hazard mitigation purposes. Haiti’s technical partners in network development and data sharing include the U.S. Geological Survey (USGS) and Natural Resources Canada, among others. Another example is the agreement signed by Morocco and the United States in 2008 to carry out joint seismological activities in support of the global CTBT monitoring mission.

While bilateral data sharing has been an important asset for the international nuclear test monitoring community for decades, this type of technical collaboration has its limitations. Sharing archived seismic data is fairly inexpensive, assuming that the station operators have sufficient funds to run their instrumentation and process data. But high-quality, real-time data sharing can be prohibitively expensive, because very-small-aperture terminal satellite links, top-notch broadband seismometers, and environmental monitoring software such as the Kinematics Antelope platform—somewhat of an industry standard—can be beyond the budget of some smaller research institutes and developing countries. Additionally, seismic data sharing tends to occur between friends


and within preexisting security communities, as diplomatic tensions can erect bureaucratic constraints that limit the scope of scientific relationships.

**Multilateral Data Sharing**

The seismological community also shares event data through multilateral mechanisms such as file transfer protocol servers and other Web sites that draw their members from the technical staffs of government agencies and laboratories, universities, and other scientific research institutes. These resources generally allow members to share archived—rather than real-time—event waveforms and parameters via upload and download. Online data-sharing tools can be created on a temporary basis for sessions affiliated with conferences such as the American Geophysical Union and Gulf Seismic Forum meetings. By contrast, the United Nations Educational, Scientific and Cultural Organization (UNESCO) works with the USGS to establish more lasting data-sharing resources. UNESCO’s Disaster Relief Section and the USGS organize a series of international workshops on regional seismicity and earthquake hazards, including Reducing Earthquake Losses in the Extended Mediterranean Region (RELEMR), Reducing Earthquake Losses in the South Asia Region (RELSAR), and Reducing Earthquake Losses in the North Asia Region (RELNAR).

The regularly occurring UNESCO RELEMR workshops are a good example of countries coming together to collaborate on earthquake hazard issues and share scientific data. The 32nd RELEMR meeting took place in Sliema, Malta, in February 2012 and drew 65 participants from 27 countries such as Algeria, Greece, Iraq, Israel, Italy, Jordan, Kuwait, Oman, Saudi Arabia, Sudan, Turkey, and the United States.27 These scientists discussed topics like paleoseismology, tsunami warning systems, and methods of protecting school-age children from seismic hazards. Past workshops have incorporated capacity-building training modules on seismic wave propagation analysis, lithospheric Earth modeling, and data sharing to improve event location and magnitude calculations. Since seismometers detect earthquakes as well as nuclear and chemical explosions, many of these international experts are also involved in their countries’ National Data Centers and nuclear test monitoring programs in support of the CTBT.

Because data sharing between countries is a critical component of improving national and regional responses to and preparation for earthquakes and other seismic events, RELEMR and many of its peer workshops include activities of this nature. By allowing scientists throughout the Mediterranean region to upload and download seismic event data, RELEMR’s data-sharing Web site helps to build regional trust and transparency on a technical level. The Web site also enables its users to compare their own national or institute data to waveform and parametric data uploaded by other users. This site, however, does not function on a real-time basis and, like many other online data-sharing

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mechanisms, its usefulness as a scientific resource is entirely contingent upon the enthusiasm of its user base.

Open Seismic Networks: Regional and Global

Outside direct bilateral and multilateral arrangements resulting in information transfers, some seismic networks make their data available in open-access format on the Internet. For example, the seismic network operated by the Maryland Geological Survey in the Mid-Atlantic region of the United States provides interested Internet viewers with waveform data from one of its seismographs. Event data are available on this Web site after a five-minute digital delay, which is needed for most computers to process and display the data. Open-access data from seismic stations and arrays around the world can prove useful for nuclear test monitoring, as well as scientific studies, and civilian and military disaster response/relief programs.

The most widely distributed open network data is from the Global Seismographic Network (GSN), which is administered by the USGS, the National Science Foundation, and the Seattle-based Incorporated Research Institutions for Seismology (IRIS). In concert with foreign partners, these organizations operate “over 150 modern seismic stations globally,” and data are archived on IRIS’s Web site and also made available to researchers in near real time through the Live Internet Seismic Server. IRIS also cooperates with national and university seismic networks around the world to facilitate greater data sharing through the cultivation of scientific partnerships and virtual seismic networks. The GSN’s open-access model provides important waveform and parametric data to both the scientific and nuclear test monitoring communities. Although many GSN stations also serve as IMS stations, in some ways the GSN has a broader global reach than the IMS. The GSN’s focus on transparency and scientific collaboration is less controversial than the monitoring mission of the IMS, which has enabled the network to include stations in countries like Pakistan and Saudi Arabia that have not ratified the CTBT.

While the activities of the GSN set international standards for seismic networking and complement other data-sharing mechanisms and the capabilities of the CTBT’s IMS, the network faces political and technical limitations. First, despite a continually expanding network and frequent outreach workshops, the GSN has failed to make inroads in states such as India and North Korea—staunch critics of the CTBT. Second, in the


developing world, the technical capacity of GSN stations is often constrained by both the instrumentation contributions of the network’s parent organizations and levels of local scientific expertise. For example, multielement seismic arrays are less common within the GSN than in advanced national networks.

**Computer Software Innovation**

Several of the seismic data-sharing mechanisms discussed above entail prohibitive costs for smaller research institutes, as annual licensing fees and operational expenses for high-grade earthquake monitoring software and satellite links can total tens of thousands of dollars. With this in mind, the German Research Centre for Geosciences has created three iterations of the Seismological Communications Processor (SeisComP) software, the most recent called SeisComP3. The SeisComP3 software was developed from 2006 to 2008 as part of the German-Indonesian Tsunami Early Warning System project, which was designed to improve real-time earthquake monitoring, data sharing, and responses to tsunamis in the wake of the December 2004 Sumatra earthquake and the devastating tsunami in the Indian Ocean that followed. SeisComP3 is just one notable example in a trend of international initiatives to make seismology and event data-sharing more accessible on a global scale.

SeisComP3 enables real-time event monitoring and near-real-time data sharing between countries and research institutes without significant expenses such as very-small-aperture terminal links and software licensing/operations fees. Eliminating these expenditures has the potential to revolutionize seismic monitoring and data sharing in the developing world, and there are continuing efforts to modernize the SeisComP platform to deliver the same quality of performance as more established—and expensive—environmental monitoring software modules. For this reason, the European-Mediterranean Seismological Centre (EMSC) in Paris is currently promoting the use of SeisComP3. EMSC facilitates cooperation and data sharing between over 70 research institutes in Europe, Africa, the Middle East, Central Asia, and the Americas. SeisComp3 and other innovative attempts to increase the global scope of seismic data sharing have the potential to modernize event location efforts, not just for hazard mitigation but also for the detection of underground nuclear tests.

**Cooperating National Facilities**

The final data-sharing tools discussed here are CTBT’s Cooperating National Facilities (CNFs). The text of the CTBT specifies that “States Parties may also separately establish arrangements with the [CTBTO] in order to make available to the International


Data Centre supplementary data from national monitoring stations that are not part of the International Monitoring System.” These facilities—which can be for seismic, infrasound, hydroacoustic, or radionuclide detection—must be certified like IMS stations to ensure the authentication of national data that may be transferred to the IDC. After certification, CNFs essentially become de facto auxiliary IMS stations, as the IDC can request their data in the event of a discussion of consultation and clarification, or in the conduct of an OSI. The unclassified version of the NAS CTBT study also discusses the establishment of CNFs to enhance global monitoring of the treaty.

At this point, CNFs remain a largely abstract concept, perhaps because countries feel the need to first prioritize the CTBT’s entry into force. In 2000, a group of Israeli geophysicists published an article in the Bulletin of the Seismological Society of America that argued for the CNF’s certification of existing national network stations in Middle Eastern countries like Israel and Jordan to improve IMS detection and location capabilities in the Eastern Mediterranean region. However, this effort has not materialized. But in the future, as the numbers and locations of IMS stations are specified in the CTBT and are unlikely to change, CNFs offer one of the few methods to directly enhance IMS monitoring abilities.

Conclusion

Seismological networks operated by government agencies, research institutes, and universities that collect event data and engage in data sharing will continue to make marked contributions to the CTBT’s monitoring mission. When discussing CTBT monitoring and verification, policymakers should remember—as noted in the NAS—that in addition to the IMS and NTM, open global seismic networks, national facilities, and research seismometers play an important and sometimes overlooked role. Global test monitoring is a mission shared by all these networks. Still, it should be noted that seismologists engaging in civil or academic research might not be affiliated with National Data Centers or have a professional interest in nuclear test monitoring. But seismology is fundamentally a multipurpose science, as the same instrumentation that helps scientists analyze earthquake waveforms can also assist in the location of suspected nuclear device tests. As the world witnessed in the wake of the 2006 and 2009 North Korean tests, the sharing of seismic data and analyses among the scientific community provided invaluable information to government officials.

However, much like the IMS, the complementary seismic data-sharing mechanisms discussed in this paper face constraints such as instrumentation expenses and politi-
cal sensitivities regarding shared IMS and GSN stations. Efforts for inclusive scientific collaboration projects, bilateral and multilateral cost sharing, and accessible and inexpensive data-sharing methods (e.g., SeisComP3) will improve global test-monitoring capabilities. Seismology is the first line of sight for monitoring underground nuclear tests, and scientific data sharing and capacity building can help to detect and deter non-compliance with the CTBT.
Postdetonation Nuclear Forensics
Methods to Improve the Craft
Karen Koop Hogue

Nuclear forensics, particularly in the post-9/11 world, has received widespread recognition for its potential to help attribute nuclear material to its country or facility of origin. Although the technical capabilities of nuclear forensics have been proven and continue to be developed, their usefulness is limited within a political context if there is not supportive information that could reliably tie the results of nuclear forensics analyses to its source in a timely manner. Particularly in a postdetonation scenario, the timeliness of information becomes increasingly important. Nuclear forensics techniques take time, but if a robust and comprehensive framework existed that contained data that could help identify the source of the material, these techniques could be extremely valuable in answering policy questions like “Who was responsible for the detonation?” “Where did the material come from?” and “What facilities were involved in the production of the device?” As identified in the Nuclear Forensics and Attribution Act of 2010, the international community can most effectively use nuclear forensics to hold countries accountable for their nuclear material by establishing an international framework that would provide evidence that, when combined with traditional forensics and law enforcement, could indicate a particular country or facility of origin. Specifically in a postdetonation scenario, there are two methods that would improve the timeliness and/or ability of data obtained through nuclear forensics towards attribution of the material or weapon: (1) databases or libraries; and (2) taggants, or tracer materials.

Nuclear forensics refers to the scientific processes used to analyze nuclear or radiological material with the goal of obtaining specific signatures that could aid in the attribution of the material to a particular country, facility, or geographic location. Recently, the U.S. government has demonstrated support for nuclear forensics initiatives through a variety of forums. Support for nuclear forensics was included in both the Washington and Seoul

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Nuclear Security Summit Communiqués as well as the Nuclear Forensics and Attribution Act, which identifies the necessity for a “capability to positively identify the source of nuclear material” in order to build an adequate deterrent. Additionally, the U.S. government has funded a variety of initiatives to further develop domestic nuclear forensic capabilities, as well as those of nations around the world. Nuclear forensics techniques can be applied to predetonation materials (including illicitly trafficked or intercepted materials), to postdetonation materials, and to both nuclear and radiological materials.

Although radiochemistry techniques and processes support in-depth analyses of nuclear materials, the ultimate goal of nuclear forensics is to tie the material back to its source. In predetonation scenarios, like illicitly trafficked materials, this could aid in identifying vulnerable facilities or nations and helping to secure nuclear and radiological material. In postdetonation scenarios, nuclear forensics would ideally help policymakers answer questions like “Who was responsible for the detonation?” “Where did the material come from?” and “What facilities were involved in the production of the device?” The public would likely demand answers to these questions within days following the detonation of a nuclear or radiological device, and policymakers would feel intense pressure to take immediate action against parties involved in the detonation. If states or nonstate actors feel like the capability of the United States or the international community to tie material back to its origin is credible, they may be deterred from detonating a device, or assisting in the process by providing material, to begin with. Currently, the capability of the United States to identify the source of nuclear material is limited by the information available that would provide knowledge of isotopic information, weapon design features, and processes used in material production as well as the timeliness of existing nuclear forensics and attribution techniques. This paper specifically addresses two methods that make postdetonation nuclear forensics techniques for nuclear materials more capable of answering the questions that the public and policymakers would be asking following a nuclear detonation: (1) international databases or libraries containing information that links nuclear material to its origin; and (2) taggants, or tracer isotopes, that can be added as a signature to nuclear material.

There has been significant progress made in the technical capabilities of nuclear forensics in the past several years, primarily through the use of different mass spectrometer techniques to analyze isotopic ratios. These ratios can serve as key signatures that can help scientists trace the materials back to specific locations. There are over 250 characteristics that could help identify the source of nuclear material, many of which are isotopic ratios. For example, there are several rare earth elements that may be found in uranium ore that vary in concentration geographically. Additionally, U-234 (a naturally

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occurring isotope of uranium) makes up approximately 0.0055 percent of naturally occurring uranium atoms.\textsuperscript{5} The ratio of U-235 to U-238 atoms in uranium slightly varies geographically. Since existing enrichment methods using gaseous diffusion and centrifuges separate uranium isotopes based on mass, the U-234 remains with the U-235 throughout both of these methods and would therefore remain with weapons-usable highly enriched uranium. Isotopic ratios like these may help indicate the method of enrichment and possibly the mine from where the material originated.

Although many existing technical capabilities can reliably identify particles at a parts-per-billion level, the process takes time. Although the timely and accurate attribution of nuclear material is almost always important, timeliness is much more important in a postdetonation scenario than a predetonation one. The current postdetonation timeline for nuclear forensics capabilities is classified; however, Table 1 contains information adapted from the 2008 joint American Physical Society and American Association for the Advancement of Science report on the state of the art of nuclear forensics. It is highly likely that the current time scale is very similar, indicating that unless the debris from the device matches debris from a previous test, it would likely take weeks or months to identify the key indicators associated with the device. Attributing those key indicators depends on what information is known about nuclear material around the world and existing nuclear device designs.

<table>
<thead>
<tr>
<th>Information</th>
<th>Time Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was it a nuclear explosion? What was the yield?</td>
<td>Hours</td>
</tr>
<tr>
<td>Was uranium or plutonium involved, or both? Simple or sophisticated device? Was it a thermonuclear device?</td>
<td>Hours to days</td>
</tr>
<tr>
<td>Isotopic components of fuel components?</td>
<td>Several days to 1-2 weeks</td>
</tr>
<tr>
<td>Most probable device design? Does it match known designs? Any other key indicators</td>
<td>Few weeks to months</td>
</tr>
</tbody>
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The technical details that would be necessary to suggest the source of the material, or even give evidence to help shorten the list of suspects, would not be available until a minimum of several days and up to months after a device was detonated. Information obtained weeks or months after a materials-trafficking incident would still be extremely helpful; however, information weeks to months after a nuclear device exploded would

be extremely late, at best, and potentially even counterproductive. One can imagine a scenario where the U.S. public puts pressure on the president to act and retaliate after a nuclear terrorism event within days. For example, President George W. Bush announced the war on terrorism and indicated that Osama bin Laden and al Qaeda were responsible for the attacks on September 20, only nine days after the 9/11 attacks. Information obtained weeks or months later would either confirm actions already taken or seriously damage the international and domestic opinion of the United States’ administration if the analysis indicated a different source than the one the United States took action against. In a postdetonation scenario, Washington would likely have a suspect based on a combination of knowledge obtained through intelligence, traditional forensics, and law enforcement efforts. In fact, in some scenarios, Washington may not even want to know the results of a nuclear forensics analyses after a period of approximately two weeks.

Currently, nuclear forensics in the United States already has the capability to provide a detailed analysis that describes a nuclear material sample. In predetonation scenarios, nuclear forensics analyses can likely help shorten a list of potential suspects by discounting nations that do not have certain capabilities or use certain processes within their fuel cycle. In many cases, nuclear forensics could eliminate suspects from a list if there is access to samples of their nuclear materials. For example, the United States could ensure that the material was not its own. However, in postdetonation scenarios, it is more likely that with current capabilities, nuclear forensics analyses could only reliably indicate where the material was not from. Nuclear forensics has the potential to provide the technical evidence that could be the bridge between intelligence, law enforcement efforts, and traditional forensics to positively indicate the origin of material, even in postdetonation scenarios; however, the technical analysis could be much more effective in a policy context with the right support framework behind it. Specifically, with the creation and expansion of international databases containing information about nuclear material from geographic locations and facilities around the globe and the addition of taggants, or tracer isotopes, to nuclear material, nuclear forensics has the capability to be much more timely and capable of providing evidence to the international community, and more likely to reliably indicate a particular origin, rather than just excluding others to shorten a list of suspects.

The Postdetonation Problem: A Technical Challenge

The political usefulness of nuclear forensics in postdetonation scenarios is related to the potential to assist in the attribution of the material, or device, to its origin. Information that would reliably tie the nuclear material or device to the assailant in a timely manner would assist the leadership in its decisions about how and where to react. Information that would tie the nuclear material to a particular facility, or facilities, of origin (e.g., the reactor or reprocessing facility for a plutonium device) would assist the leadership in dealing with very serious security lapses, if the material was stolen, or holding a state

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accountable for assisting in the use of a nuclear device against the United States. In order for nuclear forensics analyses to be the most useful in these scenarios, they need to be provided in a timely manner.

Postdetonation nuclear forensics is a significantly different physics and chemistry problem than predetonation nuclear forensics. Despite being arguably more important within a policy context, attribution using postdetonation nuclear forensics is much more technically challenging. During a nuclear explosion, both the isotopics and the physical form of the material undergo major changes. Depending on the design, yield, and neutron efficiency of the device, the isotopic composition of the postdetonation material can look very different from its predetonation equivalent. There are several potential nuclear reactions that can take place in each material in the device, governed by various probabilities (cross-sections), and each of these reactions would change the material into a different final result. There are ways to predict how the material will change, but these methods take time and resources. The methods include Monte Carlo methods, such as Monte Carlo N-Particle transport codes and weapons codes that utilize data obtained from nuclear testing. Reactor physics codes may be used to approximate the resulting isotopics, but they may not be as accurate. For all these methods, a significant amount of data would need to be input into the codes, including yields and design information about the device. In many cases, including the use of an improvised nuclear device, it is unlikely that this input information would be known. In the context of this unique technical challenge, there are three main challenges that limit the usefulness of nuclear forensics to postdetonation attribution: timeliness, international accountability, and assurance of attribution.

**Timeliness**

Unlike the predetonation use of nuclear forensics, where analyses can take one to four months and still be useful in a political setting, postdetonation forensics needs to provide information that assists in attribution in a much shorter time if the goal is to use it to help identify parties or facilities associated with the device. If the United States were attacked with a nuclear device, there would be significant public pressure on the leadership to respond immediately. Taking weeks or months to answer questions associated with who was responsible for an attack on U.S. soil would severely affect public opinion of U.S. leadership. Any delay in action following a nuclear detonation would also leave the world feeling extremely uneasy and in constant fear of the detonation of more devices.

In order to address the issue of timeliness in a postdetonation scenario, it is important to understand the process of analyzing a postdetonation sample. Following a nuclear detonation, the following steps would need to be taken:

- **Secure the site:** This could take hours to days, depending on the specifics of the detonation.
- **Collect the sample:** This could be done by humans, robots, or potentially aircraft, and it would take minutes to hours.
- **Transport the sample to the lab(s):** For the best results, several samples would be taken and transported to multiple labs for concurrent analysis. The International Atomic Energy Agency (IAEA) has practice doing this with the environmental sample swipes it takes during safeguards inspections. There is the existing Network of Analytical Laboratories, which do very similar mass spectrometry analyses that would be done in a postdetonation analysis.\(^7\) Transportation from the site to the labs could take hours or days.

- **Analyze sample(s):** The samples will be analyzed physically/visually/optically as well as with destructive analysis techniques. For destructive analysis, the sample may be dissolved in various solutions and various elements extracted for the most accurate results using a mass spectrometer. Results include isotopic ratios that existed in the postdetonation samples. This analysis takes days or weeks, depending on what specific chemical reactions must take place to prepare the samples and how long the sample needs to stay in the equipment, like mass spectrometers, to gain reliable data.

- **Attempt to attribute material:** In order to attribute the material to its origin, there must be something to tie the characteristics of the postdetonation sample to a particular origin. If the data match known samples from historical weapons tests, or include signatures of a particular device design, this step may take hours or days. If the data do not match existing information, a country could attempt to obtain equivalent postdetonation isotopic information and try to find the origin of the postdetonation equivalent. This kind of inverse analysis and comparison could be very time consuming if a state is relying on weapons codes or in-depth physics codes to attempt to identify the postdetonation isotopic data equivalent. Monte Carlo methods can take several hours to days to run, depending on the desired accuracy and amount of data, and it would most likely take several iterations to identify the postdetonation equivalent isotopics.

The fact that the steps above take time is why, under current policies, the timing for the first three steps in the process will not drastically change. However, both databases or libraries and taggants could significantly shorten the amount of time required to attribute the material, and taggants could shorten the time required to analyze the samples. Libraries that contained samples of materials could be used to create a database of predicted isotopic signatures that would be expected if that material was used in a nuclear device. Using both reactor physics codes and weapons codes, the isotopic data about the material could be simulated through the fuel cycle and even through a nuclear detonation. The output would be the anticipated postdetonation isotopic data of the material. These data could be logged in a predicted database. In the case of a nuclear detonation, there

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would still need to be an analysis of the material; however, the results could be compared with the predicted signatures in an effort to attribute the material or, more likely, exclude various states or facilities from being suspects.

**International Accountability**

If nuclear forensics were to be used for the purpose of holding states or nonstate actors accountable from an international perspective, as individuals like Graham Allison and Debra Decker have suggested, there should be an international framework with some level of transparency that would present the international “jury” with the evidence against the culprit.\(^8\) Within the current system, some states (namely, states that have nuclear weapons and their allies) may be able to utilize nuclear forensics to indicate the party they feel is responsible for a nuclear detonation; however, the evidence for that decision would most likely be highly classified. By establishing the logistical framework for an international system that could be used for both predetonation and postdetonation attribution of material, the international community could hold states or actors accountable for their involvement in a nuclear detonation. Evidence could be presented through an organization, most likely the IAEA, to the United Nations Security Council. The system would need to be transparent enough to assure nations of the reliability of the information and governed by an independent international body, like the IAEA. Although this system would most likely benefit nations that do not have the technical capabilities to perform nuclear forensics analysis or access to information (i.e., intelligence about weapons designs, specific geographic locations of various facilities, or facts from existing databases) that would help in the attribution of the material, an international framework could also aid the United States by providing evidence that would be accepted by the international community. A more credible capability to positively identify the origin of nuclear material is likely to strengthen the deterrent to keep nations from intentionally or unintentionally providing nuclear material to other states or nonstate actors. Due to the vast number and complexity of the political challenges to establishing this framework, the framework should start out as a voluntary effort to increase the potential effectiveness of nuclear forensics in attributing nuclear material. Both databases and taggants could be used in such an international framework.

**Assurance of Attribution**

Although the techniques used in nuclear forensics processes, particularly within the United States, are highly reliable and sensitive, the challenges associated with tying the signatures to a particular origin make it difficult to pinpoint exactly where the nuclear material comes from. Every technical process has associated errors, and there may be a few locations or facilities whose material resembles one another. Lack of information may create an even more difficult challenge. Even if law enforcement is able to remove a perfectly clean fingerprint from the scene of the crime, if the fingerprint is not

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in a database, the detectives can only verify who did not commit the crime. Similarly, information obtained from nuclear forensics is more likely to exclude states, facilities, or geographic locations from the list of suspects rather than pinpoint the assailant beyond a shadow of a doubt. Therefore, both more comprehensive databases and the use of taggants in nuclear materials would significantly increase the likelihood of nuclear forensics results to reliably attribute material or a device to a particular origin.

There is a valid argument that nuclear forensics may not be necessary to pinpoint the actor in a case of a nuclear detonation. If it was a state actor, the United States has capabilities to track incoming missiles and aircraft. If it were a nonstate actor or an act of terrorism, the organization may want to take credit for its action. However, a nonstate actor may not be willing to share how or from whom it obtained nuclear material. Nuclear forensics, assuming the ability to trace material to its source, could potentially deter states from knowingly transferring nuclear material to nonstate actors, and hold them accountable for doing so. If a state unknowingly transferred nuclear material to a nonstate actor, the state could be held accountable for weak security and a failure to act and report stolen material. Nuclear forensics also could provide value by helping to paint a more detailed picture of networks by potentially uncovering illicit paths and trading networks. For example, in 2005, a Washington Post article suggested that nuclear forensics had been used to tie canisters found in Libya back to North Korea via Pakistan.9

Methods to Improve the Usefulness of Nuclear Forensics within a Policy Context

Databases and Libraries

Databases would improve the political usefulness of nuclear forensics data in a postdetonation scenario by providing comparative information that would assist in the attribution of the nuclear material to a particular origin. The database or library would serve as the catalogue of “fingerprints” with which the forensics evidence could be compared in order to identify the responsible parties. A database would house isotopic data of various nuclear materials, including various isotopic ratios and indicators of specific trace elements that may serve as unique signatures to that sample. Libraries would house the samples themselves. Databases and libraries can decrease the time necessary to utilize nuclear forensics in attribution, contribute to an international framework of accountability, and, as stated above, significantly increase the assurance of attribution of the material to an origin.

Currently, there are no organized efforts to create a comprehensive, international database or library of nuclear material. In the joint 2008 American Physical Society and American Association for the Advancement of Science report on the state of the art of nuclear forensics, one of the main recommendations was increased international

cooperation and efforts to establish an international database. However, in the 2010 National Academies of Science report, authored by some of the same individuals as the 2007 report, there was no mention of an international database. One of the report’s authors privately confirmed that the effort seemed so politically unfeasible that not much attention was given to it in the more recent report. Many states are unwilling to share information about their nuclear material for various reasons, including a reluctance to share proprietary information, as some of the ideal materials would include data from samples throughout the fuel cycle and could give indications as to various manufacturing methods and fuel designs. States also likely fear sharing information that may lead to retribution against the state if the nuclear material were to contribute, even without the state’s knowledge, to nefarious activities. Finally, many states may lack the organization and technical means to collect samples, analyze them, and catalogue the data. Although the National Nuclear Security Administration Office NA-242 is currently encouraging states to establish their own national nuclear databases, there is as yet no effort to establish an international database that could be used for nuclear forensics. The IAEA has access to isotopic information obtained from environmental swipes used at safeguarded facilities, and even outside safeguarded facilities if the country has ratified the Additional Protocol. However, the data are considered “safeguards confidential” information. This means that it would be extremely controversial, and contrary to agreements between the IAEA and its member states, for the IAEA to allow that information to be used with nuclear forensics in an effort to attribute the material.

Databases or libraries could make nuclear forensics more timely by providing both predictive and comparative signatures to compare with nuclear forensics’ analysis results, according to the IAEA. Predictive signatures could be obtained by running the samples through codes that simulate various stages of the fuel cycle or a nuclear detonation. These predictive results could be stored in an additional database. In the case of a nuclear detonation, the data obtained by the nuclear forensics analysis could be compared with these predictive results in an effort to find a match. This comparison would take less time than attempting to inverse the results into its equivalent predetonation and then compare them with isotopic information.

Databases including information about nuclear material from around the globe could also contribute to an international framework that would hold states or facilities responsible for their intentional or unintentional involvement in a nuclear detonation. An international system, even if not comprehensive in scope either in the number of nations’ materials it held or the types of samples it contained (a database containing uranium ore

12. This individual wishes to remain anonymous.
is more politically feasible than one that contains plutonium metal samples from states with nuclear weapon capabilities), would still be beneficial to the international community. The United States can continue efforts to provide assistance and encouragement to states developing their own national databases, but a parallel international initiative, through the IAEA but entirely separate from safeguards information, could establish the logistic framework to house data in a secure manner for use in nuclear forensics and, ultimately, attribution in a predetonation or postdetonation scenario.

Databases and libraries would also significantly help with reliability of attribution in both predetonation and postdetonation scenarios. Without samples, isotopic data, or information obtained through intelligence with which to compare the results, it is extremely difficult to use even the most accurate and sensitive technical nuclear forensics data in an effort to attribute the material to its source. To aid in the reliability of attribution, a database could contain a variety of information, not limited to isotopic data from samples of nuclear material. Ideally, the database or library would be comprehensive in scope and breadth, including data from samples (or the samples themselves) at various stages in the nuclear fuel cycle. For example, the database could contain information about uranium ore concentrate, postconversion UF₆, enriched UF₆, fabricated fuel, and separated plutonium, depending on what fuel cycle capabilities the associated state has. Data could include signatures like the ratios of U-234 to U-238 in samples, which can vary geographically and with the method of enrichment, and the ratios of various rare earth elements, which also vary geographically.¹⁵ In addition to isotopic information, the database could include predictive signatures that may appear in nuclear material based on information like the physical location of nuclear fuel cycle facilities used in weapons material fabrication. For example, if a reprocessing facility is near an industrial plant that emits particular elements through its chemical processes, contaminants from the plant may be present in the nuclear material. Additionally, the database could include information on the methods used within the fuel cycle that may provide indicators that would assist in identifying the origin of material. For example, after police found 202 fuel pellets in Ulm, Germany, they were able to detect sodium contaminants in the fuel at a parts-per-billion range and identify the source of the pellets based on characteristic indicators of the particular method of fuel fabrication.¹⁶ Although this example is from predetonation nuclear forensics, there is potential for these methods to provide useful information in postdetonation attribution efforts as well.

Despite discussions and support for the creation of databases and international cooperation, the framework for a comprehensive database does not exist. This is due to several reasons, the vast majority of which are political and practical challenges, rather than technical. Table 2 includes the political and logistical challenges discussed above, as well as some of the technical challenges that could result from inconsistent measurements if different equipment were used.


Table 2. Political and Technical Challenges to Databases and Libraries

<table>
<thead>
<tr>
<th>Practical and Political Challenges</th>
<th>Technical Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unwillingness of States to share information because of fear of retribution</td>
<td>Lack of technical capability of some States to analyze samples</td>
</tr>
<tr>
<td>What information would the database hold or what samples would the library house?</td>
<td>Potential inconsistency in measurements if analysis is done by different States</td>
</tr>
<tr>
<td>Lack of current framework to house international database/library</td>
<td></td>
</tr>
<tr>
<td>Concerns of authentication</td>
<td></td>
</tr>
<tr>
<td>Lack of organization of States to collect samples/data</td>
<td></td>
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</tbody>
</table>

**Taggants**

Taggants are isotopes or particles that could be added to various parts of the fuel cycle at various ratios to identify that material as material of a particular state, facility, batch of fuel, and so on. They have received very little attention and funding at both the international and national levels, but they are a method that could vastly improve the usefulness of nuclear forensics within a policy context in an effort to attribute nuclear material. Not enough research has been done to address the technical aspects of how various taggants would respond to processes within the fuel cycle; however, it is likely that radiochemists could produce several tags that together would follow the material through the fuel cycle. In theory, tags could be added to uranium at a conversion facility and stay with the UF₆ through the enrichment process or be added to the fuel and stay with the plutonium stream during reprocessing. This means that a combination of taggants could potentially stay with weapons-usable material and therefore reliably indicate the origin of the material, even postdetonation. Isotopes that have low probabilities of absorbing neutrons, low probabilities of being produced from fission, and relatively long half-lives could be added to fuel at various ratios by an independent body, like the IAEA. The IAEA could maintain a catalogue of encrypted and confidential data that served as a key, tying the taggants to the material and its owner. The isotopics of the taggants may change during detonation; however, if taggant materials that were relatively inert to radiation were used, it is likely that a significant portion of the taggant would remain present and identifiable. Even if the taggant were to change during detonation, physics codes could be used to create databases that would predict the postdetonation signatures of the taggants.

Taggants would dramatically affect the timeliness of postdetonation nuclear forensics. They would not only reduce the amount of time it takes to tie the forensics analysis results to an origin, but also the amount of time to analyze the material. Radiochemistry labs could do specific analyses that looked only for the presence or absence of the spe-

17. For an example of one of the few taggant projects that has been funded, see M. J. Kristo, M. Robel, and I. D. Hutcheon, “Nuclear Forensics and Attribution for Improved Energy Security: The Use of Taggants in Nuclear Fuel,” Lawrence Livermore National Laboratory, April 2007.
pecific elements used in taggants and their ratios. By using tags, nuclear forensics analysis and attribution could occur in approximately one or two weeks, which would be significantly more beneficial in a postdetonation scenario than the currently speculated time of one to several months (see table 1 above).

Taggants could fit into an international system designed to hold states accountable for their nuclear material by adding an additional avenue to attribute material. Tags could be introduced within the context of the multilateral fuel cycle initiatives that have recently gained significant support in the Nuclear Non-Proliferation Treaty (NPT) and the IAEA. Several states gave statements supporting multilateral fuel cycle initiatives at the 2012 NPT Preparatory Committee meeting. In December 2010, the IAEA’s Board of Governors voted to create an IAEA Low-Enriched Uranium (LEU) Fuel Bank. The bank will be managed by the IAEA and provide assurance of fuel supply to IAEA member states in case their fuel supply is disrupted. The bank currently has the financial resources for approximately three fuel loads for a 1,000-MWe light water reactor. Donors include the European Union, Kuwait, Norway, the United Arab Emirates, the United States, and the Nuclear Threat Initiative. Most of these donors have nonproliferation as a high-priority political objective. Therefore, initially, it may be less politically controversial to introduce taggants into the context of the IAEA LEU Bank than in the context of fuel from the international market. Introducing the idea of taggants to the international community in a smaller-scale, relatively uncontroversial project like the IAEA LEU Bank may help taggants gain political acceptance and support for more wide-scale use later on. Even without tags in all material, introducing them into some material would still aid in attribution by helping reliably assure what material was not used.

Taggants have not been discussed much in the international community, so they do not carry with them some of the political baggage associated with international databases. They do have several technical challenges that could most likely be overcome if funding were to support basic research initiatives to develop tags that could track with weaponsusable material throughout the fuel cycle. Tags are also challenging because they would be used in nuclear fuel. There may be additional practical, logistical, and technical barriers before fuel manufacturers would be willing to add them to fuel. Nuclear forensics analysis equipment is extremely sensitive; therefore, it is likely that only very small, trace amounts would need to be added to the fuel. Further research on the economic implications of adding tags to nuclear fuel would be necessary. Table 3 outlines some of the political and technical challenges associated with taggants.

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18. The author attended the 2012 NPT Preparatory Committee meeting in Vienna from April 30 to May 11, 2012.

Table 3. Political and Technical Challenges to Taggants

<table>
<thead>
<tr>
<th>Practical and Political Challenges</th>
<th>Technical Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication issues and misunderstandings because tracer isotopes are technically complex</td>
<td>Very little R&amp;D in the area</td>
</tr>
<tr>
<td>Possible lack of willingness by vendors and fuel manufacturers to integrate into fuel</td>
<td>Lack of knowledge about how various isotopes or molecules would behave through fuel cycle</td>
</tr>
<tr>
<td>Need to outline policy goals for what material taggants would follow through the nuclear fuel cycle</td>
<td>Lack of data about how taggants would behave during nuclear detonation</td>
</tr>
<tr>
<td></td>
<td>Need to identify taggants that would follow UF6 through enrichment and Pu through reprocessing</td>
</tr>
<tr>
<td></td>
<td>Lack of data of how taggants would affect fuel performance</td>
</tr>
</tbody>
</table>

Conclusions

The role of nuclear forensics in postdetonation attribution is currently limited by the amount of information a state has about the nuclear material, processes used in fabrication, and device design. In the case of nuclear terrorism, this information may not be known. Therefore, to ensure that the United States has a credible capability to identify the source of nuclear material, which could put pressure on nations to enhance their nuclear security and deter states from intentionally transferring nuclear material to non-state actors, the U.S. government should work to establish the international framework that would support the current technical nuclear forensic capabilities. This international framework could include international databases or libraries, taggants, or a combination of both.

The United States should revisit the idea of an international database and further explore both the practical and technical aspects of taggants. Specifically, the United States and the rest of the international community should continue to discuss an international framework for databases and/or libraries despite the political challenges. Effort should be made to establish the logistic infrastructure for a voluntary, confidential database that could house less politically sensitive data (i.e., uranium ore) but have the capability to be expanded if the political climate for sharing information and establishing a more robust accountability system in the future changes. Discussions should include details such as who would house the database (e.g., the IAEA), specifically what data or information it would contain, how measurements would be taken, how data would be stored, and the legal details binding the use of the information.

Additionally, the United States and the international community should also put effort into the research and development of taggants as a potentially more politically feasible alternative to a database that would provide a more credible assurance of attribution than the current system while potentially strengthening the deterrence that accompanies that assurance. Taggants would considerably reduce the amount of time required to attribute the material and also significantly increase the probability that nuclear material
could be tied back to a particular origin. The United States should begin discussing the framework to include taggants in the IAEA LEU Bank within the context of the IAEA and the NPT and through Track II dialogue with nations that support multilateral fuel cycle initiatives. As stated in the 2010 Nuclear Forensics and Attribution Act, “In order to identify special nuclear material and other radioactive materials confidently, it is necessary to have a robust capability to acquire samples in a timely manner, analyze and characterize samples, and compare samples against known signatures of nuclear and radiological material.” International databases and taggants would help create this robust capability.
Stewarding a Nuclear Stockpile of Varying Size
Michael S. Johnson¹

The United States depends on its Nuclear Weapons Complex to maintain a safe and reliable nuclear stockpile. Ideally, the size of the nuclear stockpile would be optimized to reflect stewardship abilities, reliability, safety, cost, and the like. But a perfectly optimized stockpile size is not realistic. Furthermore, the optimized value would likely change even before it could be realized. This necessitates the ability to steward different sizes of stockpiles. Every time the stockpile’s size changes, certain elements and factors need to be analyzed to ensure its vitality and future. Some of these elements will change significantly as numbers decline; others will remain more constant and are even needed if the numbers go to zero. It is vital that these necessary elements are not permitted to atrophy as numbers decline. At any stockpile size, the most important of these elements is the ability to maintain expert personnel. A second element that should always remain is the ability to conduct surveillance and maintain the health of the stockpile. Another necessary factor is to maintain a production capability in order to react and respond to unpredictable events.

The United States has turned to its Nuclear Weapons Complex (NWC) for nuclear weapon design, development, production, maintenance, surveillance, refurbishment, and dismantlement since the NWC’s inception in 1942. Several events since then have altered the focus of the NWC. The most notable of these was the end of the Cold War and the events that followed. More recent events also point toward future changes in the scope of the NWC.

When the majority of the nuclear weapons were being designed and built (1942–1992), the flexibility and reliability of the U.S. nuclear deterrent force was ensured by having a large quantity and variety of weapons, with frequent (10–15 year) replacement of aging designs.² During this time, the U.S. government opened 27 design/production sites as a part of the NWC. Also, an additional 21 test sites and 5 prototype research reac-

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¹. Michael Johnson works for Sandia National Laboratories as part of the Surety Assessment, Engineering, and Analysis Center. The views expressed in this paper are those of the author and do not necessarily reflect the views of Sandia National Laboratories.

tors were opened. Then, the Cold War ended and focus shifted. By the end of 1994, 20 of the 27 NWC design/production sites, 19 of the 21 test sites, and all research reactors had been closed.

Global strategic environments and policies also changed. In the early 1990s, all new nuclear weapons production was more or less halted. This meant that all development engineering activities for current nuclear weapons systems were canceled. This marked the first time that there were no active nuclear weapon development programs at the NWC. During this same year, the United States began a moratorium on yield-producing nuclear weapon tests. These changes presented new challenges to maintaining a safe, secure, and reliable nuclear weapons stockpile. There was a fundamental shift in the emphasis of the NWC with respect to the stockpile: Instead of quantity and frequent replacement, the focus moved to enhancing the reliability and longevity of the current stockpile.

President Barack Obama’s 2009 speech in Prague outlined his vision of a world without nuclear weapons. If this vision ever becomes reality, some would say that the NWC could effectively be eliminated and its resources could be reallocated to other areas. Others argue that it must be maintained on some level in case a need to rapidly rebuild it might ever arise. Either way, there has been a continued trend toward stockpile reduction (even if zero is never reached). The latest step in these shrinking numbers took place with the ratification of New START in February 2011. President Obama’s vision, and recent policies enacting deep stockpile reductions potentially place the NWC on the cusp of another shift in the future. It also presents policymakers with the increasingly complicated question of what is the optimal number of weapons to ensure that the stockpile meets the nation’s objectives. Decisions made today will determine if the nature of the NWC acts on or reacts to the dynamic future of global nuclear weapons policy.

Optimization of a Dynamic Stockpile

What is the optimal number of nuclear weapons in the stockpile? It is human nature to optimize. This is especially true of scientists and engineers. In mathematics, optimization of a function nearly always occurs in a particular domain. When considering very elaborate (often nonlinear) multivariable functions, optimization can be a futile task un-

4. Ibid.
5. Ibid.
6. Ibid.
til the domain is changed to a subset of the whole, greatly simplifying the problem.\textsuperscript{9} The catch is that the optimization of a function can change dramatically across different domains. Further exacerbating the difficulty of optimization is that choosing the focal subset can quickly become subjective in nature. The optimizer often cares more about the functional response due to certain variables and inherently places more weight on these arguments than others. What is more important in the eyes of one is often less significant for another. This can quickly transform stockpile optimization into more of a debate than a science.

Optimization of the size of the stockpile is an impossibly difficult, nonlinear, multi-variable problem in constant flux. Trends and fluctuation in stockpile size shape the structure of the NWC and nuclear weapon policy. The debates are very politically charged and under significant scrutiny due to a perceived small margin of error and potentially unforgiving ramifications. There are a significant number of variables influencing the problem. Trade-offs between reliability, safety, maintenance, deterrence, surveillance, and cost, along with the perception of society, potential political gain, international relations, and so on all must be taken into consideration. The importance and weight of each varies for different countries, governments, organizations, and individuals. Treaties and numbers are negotiated to establish better, not best, cases.

Due to the nature of this complex task, reduction often focuses symbolically on reaching seemingly arbitrary round numbers, such as 1,000, 500, or even zero weapons. These round numbers seem to please the masses, causing policymakers to strive to achieve them. This leads to a quasi-backward approach of deciding on a final value and only then figuring out how to make it happen—as opposed to using needs, analysis, and capability to determine a more optimal stockpile size. Although this approach is not wholly ideal, the complexity of the problem necessitates it on some level.

A perfectly optimized stockpile size is not realistic. Furthermore, the optimized value would likely change even before it could be realized. This necessitates the ability to steward different sized stockpiles. Every time the stockpile size changes, certain elements and factors need to be analyzed to ensure its vitality and future. Some of these elements will change significantly as numbers decline; others will remain more constant and are needed even if the numbers go to zero. It is vital that these necessary elements are not permitted to atrophy as the numbers decline. First and foremost, at any stockpile size the most important element is the ability to maintain expert personnel. The second element that remains for a stockpile of varying size is the ability to conduct surveillance and maintain the safety and reliability of the stockpile. And third is the ability to react and respond to serious events that may require a return to previous number levels.

The remainder of this paper attempts to outline the necessary elements of stockpile stewardship and what it means for the NWC. The paper also ventures to address future actions for further deep reductions and to suggest future analysis that may become necessary.

Expertise

Experts have always been the most valuable asset to the stockpile and the NWC. From the beginning, the best and brightest minds in the United States were necessary to develop the first nuclear weapons. Experts in science, engineering, systems management, and manufacturing were needed to accomplish this goal. It would not have been possible otherwise. The need for and supply of able personnel continued during the Cold War to enable America to hold onto its technological edge. Even though no new weapon designs have been introduced in decades, experts are still relied upon for stockpile surveillance and maintenance as unforeseen problems arise.

The current stockpile is maintained through Life Extensions Programs (LEPs), targeting Cold War era designs. But with each passing year the NWC says goodbye to more and more of the experts who designed these weapons. These experts are being replaced by a new generation with significantly less experience in nuclear weapons. One prominent example is the reality that those who participated in underground testing are becoming rare. This dwindling experience is somewhat complicated due to the classified nature of nuclear weapons. One cannot get an education or degree in nuclear weapon design or study the nuances of weapon testing and development in school. This problem is compounded by the difficulties in transferring this valuable knowledge from one generation to the next (even within the classified world of the NWC). The ability to and ease of transferring this knowledge and understanding are greatly overestimated.

Also, with the current approach of maintenance through LEPs, there is the risk that cascading small changes to Cold War-era designs could produce unpredictable and unforeseen changes in weapon reliability and safety. Those most capable of predicting these changes are the ones who made the original design, but they are on their way out the door. Without the proper expertise, no amount of resources would be sufficient to produce a confident solution to these unforeseen problems. Some argue that this could be mitigated with advancements in simulation codes and models. Sufficiently sophisticated and accurate models could allow less knowledgeable people to evaluate problems and produce solutions. However, relying on models becomes an unnerving proposition. Simulations and models are shaped around assumptions, our existing knowledge, and known test data. This limits them due to our biases and known failure scenarios, and does not allow them to accurately predict cases outside our current knowledge base.

As is discussed in more detail below, a corresponding drop in hedge numbers will most likely change the way surveillance and maintenance are conducted. Current surveillance relies heavily on destructive (nonnuclear) testing of hedge weapons. Identify-
ing problems in nuclear weapons is not trivial (especially considering that they cannot be fully tested at this time), nor are the problems and their associated solutions. New, nondestructive surveillance methods would likely be incorporated into stockpile stewardship. But the development of these methods would require an uptick in necessary personnel and weapon experts.

Taking this situation one step further, deep reductions in stockpile numbers (hundreds to zero) may require a completely newly designed weapon(s) that will need subject matter experts on electrical, mechanical, chemical, and nuclear levels as well as system-level management and manufacturing. In 2008, the secretary of defense, Robert Gates, warned that “to be blunt, there is absolutely no way we can maintain a credible deterrent and reduce the number of weapons in our stockpile without either resorting to testing our stockpile or pursuing a modernization program.” Deep reductions will almost certainly need modernization or underground tests, or both. Either way, there will be a pressing need for nuclear weapon experts. Some see the move toward zero weapons in the future as inevitable. If that is truly the case, it would be very beneficial to consider a fully modernized design sooner rather than later when generations of expertise have left the NWC.

Another difficulty is attracting the experts of tomorrow. From personal experience, the current trend of “no new designs” yields an associated perception among many recent graduates that careers in nuclear weapons are not sustainable. Even experienced scientists and engineers may perceive jobs in the NWC as poor long-term career choices that are not challenging or interesting given the lack of development and design. It also appears that those who do end up working for the NWC tend to not stay as long as they used to.16

There is a fallacy among many weapon critics and analysts that as numbers go down, the necessary quantity of capable personnel goes down with it. It is necessary that the United States realizes that there is no longer a proportional relationship between the size of the stockpile and the number of experts needed for proper stewardship. In fact, it is likely inversely proportional as stockpile levels decline.17 A 50 percent reduction in stockpile numbers cannot be maintained by a 50 percent reduction in personnel. The relationship may have been linear in the early days of nuclear weapons, but given the political stance on weapon design and testing this is no longer the case. As numbers continue to decline, it will soon arrive at a point (if it has not already) where any reduction in stockpile size will have little if any effect on the necessary manpower to maintain the stockpile.18

One of the most important methods of ensuring that experts remain connected to the NWC is continued research and development, which will need to be increased and take place alongside nuclear weapon stewardship in order to maintain experts and entice new employees to join the fold.\(^{19}\) As research efforts continue to bridge the gap between cutting-edge technologies and their potential application to the weapons world, the NWC will be able to maintain the necessary expertise and attract capable personnel from across the nation. A breakup in the relationship between cutting-edge technologies and nuclear weapons could potentially result in a hemorrhage of top minds from the complex. Given the current economic scene, public and political pressures to persuade the nation to slow funding to these research efforts are becoming more common.

All future decisions regarding the NWC should keep in mind that a stockpile of any size needs people who can identify, evaluate, diagnose, and fix problems that may arise and, if necessary, design, produce, and modernize the stockpile of tomorrow. Capable personnel are by far the most valuable asset to the stockpile, more valuable even than the stockpile itself. Given time, resources, and the right people, the stockpile could be reproduced. But no amount of time and resources would be sufficient without the expertise. When expertise is lost, efforts to bring it back to its previous state are difficult and costly. It may not even be possible to obtain an equivalent level of the previous understanding. A lapse in knowledge of nuclear weapon design, even for seemingly trivial components, could have lasting effects. The NWC must always have access to the outstanding minds in the nation.

Surveillance

Complex systems never stay in the same state. They require constant attention to maintain. A nuclear weapon combines electrical, mechanical, nuclear, and chemical aspects, making it one of the most complex systems ever developed. Thus, radiation, aging effects, degradation, and obsolete/limited-life components make it necessary to constantly monitor the nuclear stockpile.\(^{20}\) No matter the future stockpile size, aside from zero, there must be a way to evaluate the state of health of the weapon(s). In the beginning, this was done in Trinity fashion. A weapon in question was taken out and tested in full capacity. This continued throughout the Cold War with atmospheric, underwater, and underground testing. The dangers of atmospheric testing were soon realized, and all testing was relegated to underground. Soon after the Cold War ended, underground testing also ceased in the United States. Since then, the stockpile stewardship program has evaluated the state of weapons through “no-yield” component and system testing as well as materials experimentation with a newfound focus on simulation and modeling.\(^{21}\)

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19. Ibid.
Much of the current evaluation and surveillance relies heavily on ground testing at the Weapons Evaluation Test Laboratory (WETL) and nonnuclear full weapon Joint Test Assemblies (JTAs) flight tests. Surveillance using JTA flights and testing at the WETL facility involve weapons taken from the active and inactive stockpiles. These weapons are often destroyed in the testing and evaluation process.

WETL is a state-of-the-art facility capable of extensive testing of system-level electrical, mechanical, and environmental situations, including, but not limited to weapon interface signal simulation, radar-over-target simulation, live detonator firing, detonator simultaneity measurement, energy measurements, impact simulation, pullout simulation, altitude/depth simulation, linear or rotary force application, dynamic parachute deployment, and explosive component actuation. During a JTA flight, the nuclear explosives package is removed and the weapon is fitted with diagnostics to monitor its mechanical and electrical systems. The weapon is then deployed in live fashion and is scrupulously analyzed and scored.

These evaluations are paramount to understanding the state of an aging stockpile. They also depend heavily on the size of the inactive stockpile. The destructive nature of the testing necessitates that this hedge be established such that weapons in a state, more or less, identical to those in the active stockpile can accurately represent aging and other trends of the active stockpile.

The major risk with future stockpile surveillance is being able to maintain these methods as numbers decline. Particular interest is given to hedge numbers. As long as there are sufficient hedge numbers, this type of testing is ideal in the absence of underground tests. It allows experts to analyze the state of the stockpile and directly diagnose any nonnuclear issues that arise. This type of testing establishes the safety and reliability of the stockpile in order to assure the nation that the stockpile can be properly handled and deployed. It also establishes the effectiveness of the stockpile’s deterrent effect by proving the reliability of weapons for the nation and demonstrating to the adversary that U.S. weapons remain capable.

Even if active stockpile numbers approach zero, the size of the inactive stockpile would make it possible to continue surveillance of this nature. If hedge numbers decline in parallel with the active stockpile, there will come a point when a transition to a different type of surveillance would need to take place. If not, the nation would destructively test itself out of a stockpile altogether.

Developing the surveillance methods of tomorrow is a difficult endeavor, both technically and logistically. It would almost certainly make the expertise mentioned above all the more important. There are some who disagree, and it has been suggested that at low weapon numbers there would be a seamless and even practical change in surveil-

25. Ibid.
lance techniques. They are of the opinion that stockpile evaluation would no longer need to be test-based and destructive but would evolve to be a thorough investigation of the weapon systems, subsystems, and components in a bench-top environment. In this process every device, electronic board, and mechanical part would be evaluated individually. In short, this approach would be to open up every weapon in the stockpile and test every component in a rotational manner and to then replace the parts that need replacing. Those in favor of these methods have indicated that surveillance of this nature could go on indefinitely without ever having a need to produce new weapons or designs. Hedge numbers could be eliminated. But there are huge risks with this type of surveillance. Before something like this could be considered, many huge hurdles would need to be overcome. Cost, complexity, assessing system reliability, and part obsolescence are just a few of the major obstacles.

With regard to cost and complexity, it is naive to assume that surveillance of this nature would be simple and cost-efficient. Dissecting a nuclear weapon and checking all its components to see which have degraded and then replacing those that are near failure is a daunting task. Even at small stockpile numbers, this would be an astronomically huge effort with high upstart costs of establishing a test cycle rotation, training personnel, developing test equipment/techniques, establishing acceptance/rejection requirements, and so on.

In addition, the task of proving system reliability numbers to ensure that military requirements are met must be completed. System-level analysis is difficult via subsystem/component testing. Parts of a whole may function correctly by themselves but fail when combined. Proving that the weapon, as a whole, is healthy would become a statistical nightmare without high-level tests. Reliability requirements would likely need to be reduced. Furthermore, there exists a misguided assumption that one does not damage the weapon during the surveillance process. It is very difficult to examine components and subsystems for functionality without destroying them (or at the very least reducing their lifetime) due to human factors and the nature of each individual part. All these things would need great consideration in order to implement a program such as this.

The obsolescence of components and parts is another continuous problem, even with today’s modernization efforts. An excellent example of the impact of part obsolescence is that of vacuum tubes. As technologies have advanced, the vacuum tube has been all but replaced by semiconductor-based transistors in electrical systems. They perform very similar functions, but a transistor cannot directly replace a vacuum tube without significant changes being made to the system. Vacuum tubes do not last forever, and they are no longer being produced, so a system using vacuum tubes cannot be maintained. All

27. Ibid.
28. Ibid.
“modern” parts eventually become extinct. The idea of indefinite stockpile maintenance without continually modernizing weapon components/systems through LEPs is not realistic unless NWC production facilities are capable of designing and producing all the components necessary for nuclear weapons.

Some may suggest that surveillance and testing of weapons gravitate toward simulations and models. Simulation and modeling are valuable tools that should continuously be advanced, but they will never be enough, by themselves, to evaluate the complete state of nuclear weapons.\(^{30}\) As stated above, relying completely on models is impossible because they are based on our incomplete perceptions of reality and lean upon assumptions drawn from these perceptions. This makes them excellent at predicting known trends but limits their ability to anticipate the unpredictable issues.

Ideal surveillance, from a reliability standpoint, would be based on full scale underground nuclear testing. But this is not likely to happen, so it is becoming more apparent that surveillance techniques will need to change if deep reductions in stockpile numbers continue to occur. Considerations must be taken to ensure that numbers are not reduced beyond the capability to evaluate the health and reliability of the stockpile. Future reductions in hedge numbers will quickly bring us to a decisionmaking point regarding surveillance.

### Production Capability

The main risk with regard to the production of nuclear weapons is the loss of capability. It is easy to fall into the mindset of “if we did it once, we can do it again.” Building thermonuclear weapons is not like riding a bike. Reestablishing production facilities and capabilities would be an astronomical effort, both financially and logistically. Often, highly specialized abilities can never be fully brought back to their previous state once they have lapsed. Regardless of future stockpile size, great care should be taken to ensure that these abilities are maintained on some level.

The stockpile will not last forever, and simple maintenance requires the ability to manufacture weapon-related products. This is evident from the dynamic nature of the stockpile. As long as zero weapons are not achieved, components will need to be reproduced, replaced, or repaired at some point. A peer review study performed by the JASON group at Los Alamos National Laboratory and Lawrence Livermore National Laboratory on the aging of plutonium, released in unclassified form in November 2006, concluded that the minimum expected lifetime of plutonium pits in U.S. nuclear weapons is 85 years.\(^{31}\) That is a long time, but the day will come when primaries and secondaries will need to be replaced. The same goes for every component of a nuclear weapon. None of them last forever, due to degradation and aging effects. Many components in


nuclear weapons are produced by commercial suppliers and, as mentioned above, they may become unobtainable or obsolete in the future. All these concerns point to the necessity of maintaining production capabilities.

There is always the concern of unexpected reliability or safety issues discovered in routine surveillance. All weapons have related materials and components. A significant common-mode failure could cripple the stockpile. Having the expertise and surveillance techniques to identify these problems is not enough. There must also be an accompanied ability to manufacture solutions to the problems and to restore the stockpile to a satisfactory state.

In the future, there may be a need to bolster weapon numbers due to unforeseen technological or political events. Technological breakout should always be a concern. Over the centuries, there have been notable war-related technological leaps ranging all the way from gunpowder to thermonuclear weapons. These breakouts have all drastically altered the way we approach war and international relations. Since the atomic bomb was developed, there have been large advancements in technologies with fighter jets, unmanned air vehicles, satellites, and so on, but none of these has had the same impact as the development of nuclear weapons. It would be careless to assume that an enemy could never produce a next-generation weapon. If that were ever to occur, it would be vital for America to maintain the ability to react.

Stating that capabilities need to be maintained is the easy part. How can this be done when so few weapons are being produced and there is a shrinking stockpile? Low-rate constant production is difficult, but many believe it to be the best solution. The ability to produce weapons would be maintained by constant production at an equal rate to that of the natural weapon attrition caused by surveillance, dismantlement, replacement, and so on. Measures would be necessary to evaluate how production capacities of specific components and materials must be sized to maintain the stockpile through this type of steady-state, continuous production. Achieving any sort of steady-state, low-rate production would be difficult in the near term as a result of the extended period of very limited production that has occurred since the Cold War. For this to be fully established, it may become necessary to revitalize weapon designs and NWC facilities. Sustainment of a smaller more advanced stockpiles would likely be more cost-effective in the long term. The transition to an established production of modern, high-margin, high-reliability warheads would surely increase costs during a transition period but would almost certainly translate into long-term budgetary savings. But spending now to save in the long run is often seen as political suicide. Nevertheless, from the standpoint of expertise, surveillance, and production, this would be an ideal solution. If continuous, low-rate production were fully implemented, stockpile stewardship resources would likely shift to a design, research, and surveillance emphasis with established production capability.

33. Ibid.
It is important to remember that if significant and deep stockpile number reductions occur, the demonstrated ability to ramp up production may be the most powerful deterrent.

Future Considerations

Many questions were briefly touched on or alluded to in the previous sections. As stockpile numbers continue to decline, policymakers will need to find real answers to these and many other questions. It is useful to briefly review them.

Should a High-Margin/High-Reliable Weapon Design Be Readdressed?

To ensure that those who know more about weapon development are still around to participate in the design of a new warhead sooner would be the better course.35 This is especially important considering that the design will most likely never be fully tested. An effort such as this would be a huge undertaking with long lead times. The length of time for full implementation of a new warhead could make the development outlast its critical need date. Producing a high-margin warhead design based on previously tested principles would likely help assure reliability, ease of surveillance, and production. It would also likely lower long-term budgetary commitment. And it is important to keep in mind that the undertaking of a new weapon design in the midst of diminishing arsenal trends would raise domestic and international political concerns.

Should NWC Facilities Be Consolidated and/or Upgraded?

Decisions on the desired future capabilities of the stockpile must be made in the near term to appropriately size and equip the NWC. For instance, new production infrastructure—such as the Chemistry and Metallurgy Research Replacement facility and the Uranium Processing Facility—were originally sized for a specific annual production capacity.36 These production capacities will likely decrease during the lifetime of the facilities’ production but could also increase given unforeseen political events. Similar to a weapon redesign, very-large-scale facility upgrades would also raise questions among international nuclear powers.

At What Point Will the Nature of Surveillance and Stewardship Need to Change?

Stockpile numbers can only go so low, given current stewardship techniques. The United States must ensure that a decision on stockpile/hedge size does not overstep the capability to produce safe and reliable weapons and conduct extensive evaluation of the stockpile. If weapon requirements on reliability and confidence were relaxed, other options could become available, but safety can never be compromised. Ensuring that hedge


numbers remain high through low-rate continuous production would ensure the viability of current surveillance techniques, even with deep active stockpile reductions; but this would likely cause significant political angst.

Should the Number of Types of Weapons Be Reduced? Should the Triad Be Reduced?

The threat of common-mode failures requires multiple overlaps in capability. If an unexpected failure eliminated a particular weapon, the integrity of the triad would likely remain, given this overlap. But as numbers decline, at some point it becomes impractical to maintain this level of overlap. Furthermore, the necessity of a full triad is always being debated. That debate will become more heated as stockpile numbers are reduced.

Summary

The nation depends on the Nuclear Weapons Complex to maintain a safe and reliable stockpile. It has been over 20 years since a new design has entered the stockpile. Over this time frame, the number of weapons in the stockpile has decreased dramatically. With the ratification of New START, the active stockpile will reach numbers below 2,000 for the first time since the 1950s. Even though President Barack Obama outlined a goal of zero, many observers who are knowledgeable about nuclear weapon policy would say that this is more of a dream than a goal. Future deep reductions would require a shift in the approach of the NWC with regard to stockpile management. The problem is complicated when technical and political hedging strategies are considered. At low numbers, hedging could be provided by a responsive infrastructure that is continually in low-rate production and constantly exercising design capabilities. Other concerns could be mitigated via the deployment of a modern, high-margin warhead design and production facilities capable of designing and producing all nuclear weapon components. Regardless of the future of the NWC and the stockpile, certain factors should remain constant when it comes to proper stewardship. The most important of these factors are expertise, the ability to conduct surveillance, and the ability to maintain production capabilities.

The Pivot and Extended Deterrence: Options to Reassure South Korea
James Mazol

The United States plans to bolster elements of national power in the Asia-Pacific region as part of its “rebalancing” strategy. The United States and its key regional allies likely face an emerging Asia-Pacific security environment increasingly characterized by uncertainty, great power rivalry, broad military and economic competition, and crises generated by misperceptions and colliding interests. This security environment presents implications for U.S. bilateral relationships and extended deterrence commitments offered to key regional allies, including South Korea. In the future, the United States must continue to reassure Seoul or risk deleterious outcomes such as South Korea’s pursuit of more security independence; in a worst-case scenario, Seoul could damage regional strategic stability and undermine global nonproliferation goals by developing an indigenous nuclear weapons program. The United States should examine options to reassure Seoul that are cost-effective and likely to sustain the support of South Korean political and security elites and its public. In the near-term, enhancing the existing bilateral strategic security dialogue—institutionalized in the U.S.-ROK [South Korea] Extended Deterrence Policy Committee—represents the most promising way to enhance reassurance at reasonable cost and with substantial elite and popular support.

Pivoting into the Asia-Pacific Region

In reaction to “the great power shift of the twenty-first century,” the United States plans to “pivot” more of its national power into the Asia-Pacific region. In November 2011, President Barack Obama stated that the “United States is turning our attention to the

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vast potential of the Asia-Pacific region,” and “as a Pacific nation, the United States will play a larger and long-term role in shaping this region and its future, by upholding core principles and in close partnership with our allies and friends.”

3 New U.S. Department of Defense (DOD) strategic guidance outlines the military thrust of the “pivot” strategy: “While the U.S. military will continue to contribute to security globally, we will of necessity rebalance toward the Asia-Pacific region.”

4 This “rebalance” of U.S. forces and capabilities may present implications for the U.S. regional extended deterrence posture. Key Asia-Pacific allies rely on U.S. military power to stabilize the region, deter aggression, and assure their defense and security. Under the so-called nuclear umbrella, these allies require U.S. nuclear weapons—extended nuclear deterrence—to provide the ultimate security guarantee. Despite talk of “global zero,” the evolving Asia-Pacific security environment might increase the salience of nuclear weapons in security strategies.

The United States–led Asia-Pacific order was created largely to counter Soviet regional influence after World War II. Mutual defense treaties signed in the early 1950s produced a bilateral alliance structure that differed from NATO’s collective security arrangement for Western Europe. Treaty-covered countries include Australia and New Zealand (1951), the Philippines (1951), South Korea (1953, following the Korean War Armistice), Thailand (1954), and Japan (1951, revised and strengthened in 1960). This system helped institutionalize a relatively stable Asia-Pacific security environment. From a U.S. military perspective, the existing regional order remains characterized by a favorable balance of conventional military power, access to strategic lines of communication, long-standing alliances with formidable economic powers, tens of thousands of U.S. troops deployed forward, and close intelligence and counterterrorism cooperation with some countries.

The United States’ extended deterrence helps reassure critical allies of American commitments to their security and survival. Extended deterrence includes the nuclear umbrella, which both reassures certain U.S. allies and “prevents them from pursuing independent nuclear options.”

5 The U.S. concern with nuclear disarmament, however, has “reduced attention to the salience and role of nuclear weapons in national security policies and strategies.”

6 President Obama’s vision of world “free of nuclear weapons” comes at the same time that a relatively secure Asia-Pacific regional order may become less stable against a backdrop of “great power competition, unresolved territorial disputes, and, in some cases, intensely antagonistic historical relations.”


6 Ibid., 5.

If the emerging Asia-Pacific security environment is increasingly characterized by military competition, perceived insecurity, and rivalry, then key allies may desire enhanced or new methods for the United States to demonstrate the credibility of extended deterrence—particularly the nuclear umbrella. This paper focuses on South Korea because it (1) officially relies on U.S. nuclear weapons for its overall deterrence strategy; (2) remains politically sensitive to changes in U.S. extended deterrence posture; and (3) possesses an elite and population more willing to consider a wide range of options compared with other protected Asia-Pacific allies, including indigenous development or deployment of U.S. nuclear weapons on its territory. This analysis evaluated courses of action to bolster the credibility of U.S. extended deterrence to Seoul at sustainable financial cost and with the support of South Korean elite and public opinion. Based upon this evaluation, this paper recommends that the United States should better leverage the existing U.S.-ROK Extended Deterrence Policy Committee framework to increase bilateral cooperation and tailor U.S. extended deterrence posture toward South Korean demands.

The Evolving Asia-Pacific Security Environment

Following its current trajectory, China’s long-term defense modernization could produce (1) a credible second-strike nuclear weapons capability and (2) antiaccess/area-denial (A2/AD) capabilities and tactics to blunt the effectiveness of U.S. and allied conventional forces. In turn, these simultaneous developments might generate new extended deterrence requirements—including heavier emphasis on nuclear weapons. By 2015, DOD projects that the Chinese People’s Liberation Army (PLA) will deploy enhanced silo-based CSS-4 (DF-5) intercontinental ballistic missiles (ICBMs) and additional CSS-10 (DF-31A) mobile ICBMs. In addition to more mobile ICBMs, deployment of the Jin-class nuclear ballistic missile submarine (SSBN) and associated JL-2 submarine-launched ballistic missiles (SLBM) will further increase the number and survivability of Chinese nuclear forces. Continued ballistic and cruise missile development programs will increasingly threaten U.S. and allied forces deployed near China (e.g., South Korea and Japan) and complicate power projection operations into the region. As the 2011 DOD China Military Power report summarizes:

China has prioritized land-based ballistic and cruise missile programs. It is developing and testing several new classes and variants of offensive missiles, forming additional missile units, upgrading older missile systems, and developing methods to counter ballistic missile defenses.

China’s military buildup also encompasses “a major shift toward investments in asymmetric, network-centric warfare and A2/AD capabilities that are intended to deny

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9. Ibid., 34.
10. Ibid., 2.
elements of the modern battle space to potential enemies.” The A2/AD strategy helps explain the PLA’s interest in fielding cyberwarfare and space warfare capabilities to render an enemy “deaf, dumb, and blind” during the opening phase of conflict.

While China is an emerging peer competitor, North Korea represents a perpetual challenge to Asia-Pacific stability. North Korea continues to develop and test nuclear weapons and ballistic missile capabilities despite international sanctions and pressure. In May 2009, a small nuclear test confirmed Pyongyang’s status as a “fully fledged nuclear power” with “nuclear weapons,” according to the International Atomic Energy Agency (IAEA). In April 2012, North Korea conducted a proxy test for Taepodong-2 long-range ballistic missiles. Beyond missile and nuclear testing, Pyongyang also torpedoed the South Korean warship Cheonan and shelled Yeonpyeong Island in March and November 2010, respectively. South Korea is threatened by North Korean forces deployed near the Demilitarized Zone, including thousands of short-range rocket and artillery systems, some potentially armed with chemical/biological payloads.

Unresolved territorial disputes are sources of instability and potential military flashpoints, particularly in the South China Sea. In addition to Taiwan, projected resource wealth near disputed territories has increased the stakes in competition for their control. South China Sea sovereignty disputes are potential military flashpoints; skirmishing and brinksmanship over control could escalate into armed conflict that involves U.S. allies and partners. History suggests that other “spoiler” states could emerge to further upset the status quo. From 1957 to 1966, an assertive Indonesia caused much consternation among U.S. allies, especially Australia, until a coup brought in a new pro-Western government; the decade-long reign of Indonesia’s aggressive President Sukarno demonstrates that “spoilers” can dramatically effect perceptions of security among U.S. allies.

**Extended Deterrence: Theory and Practice**

The trends and scenarios described above could prompt South Korea (among other U.S. key allies) to demand reinforced assurance of U.S. extended deterrence commitments, particularly if North Korea continues provocations and testing. Extended deterrence means “providing protection to an ally or security partner via comparable deterrent threats—threats of punishment and/or threats of denial, also known as threats of opera-

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11. Ibid., 22
14. A recent example is the April 2012 China/Philippines dispute over the Scarborough Shoal, where both countries claim sovereignty; see Agence France-Presse, “U.S. to Boost Military Aid to Philippines,” *Taipei Times*, May 6, 2012, http://www.taipeitimes.com/News/world/archives/2012/05/06/2003532138.
Credible extended deterrence postures must assure protected countries and deter aggressors so they can “(1) resist intimidation and (2) refrain from seeking [their] own nuclear capabilities.” As Keith Payne notes, assurance means “easing of allies’ fears and sensitivities.” Michael Wheeler argues that security partners are most influenced by “overall perceptions of America’s nuclear posture and of the political will to maintain and use it if necessary.” The overall value of extended deterrence commitments is determined by the perceptions of protected countries, not just the capability and willingness of their protectors.

Given this theoretical context, how does U.S. extended deterrence operate in practice? The process of maintaining credibility is fundamentally interactive—a give-and-take between the United States and protected allies. Maintaining treaty-bound commitments and an effective nuclear arsenal is not enough; other methods are implemented to reinforce commitments to protected allies. These methods could include:

- Strengthening the overall relationship, to include enhancing economic interdependence, cultural connections, diplomatic interaction, and military-to-military cooperation;
- Reiterating, strengthening, clarifying and/or adding new commitments to official statements;
- Conducting joint consultations, information exchanges, and assessments;
- Sharing planning responsibilities and/or operational control of weapons;
- Forward deploying conventional and nuclear forces; and
- Conducting joint exercises and operations.

The security environment helps determine the relative importance of each method. During periods of crisis or uncertainty, key allies have sometimes questioned the credibility of U.S. commitments. Perceived vulnerability and a fear of U.S. abandonment has sometimes led important allies to explore acquiring nuclear weapons, despite Nuclear Non-Proliferation Treaty (NPT) commitments, U.S. opposition and pressure, and hostile domestic public opinion. Repeated and significant crises calling into question U.S. commitments to Asia-Pacific allies occurred during two periods: first, during the period surrounding the NPT negotiations, which included a Chinese nuclear test in 1964 and the Nixon administration’s “Guam Doctrine” declaration in 1969; and second, from the

start of North Korean nuclear and missile testing from 1993 to the present day, which includes North Korea breaking its Agreed Framework commitments. Also see box 1.

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**Box 1. Nuclear Weapons Exploration in South Korea**

South Korea not only explored, but actually committed to a clandestine nuclear weapons program on-and-off until 1979. Like Japan, South Korean anxiety was generated by a “combination of perceived relative weakness and fear of abandonment,” a process that “fostered a strong desire for American reassurance in words and deeds.”¹ Beginning in 1957, the United States armed certain U.S. Forces Korea units with tactical nuclear weapons. The circumstances surrounding the United States’ withdrawal from Vietnam played a significant role in prompting Seoul to consider (and eventually begin) a clandestine nuclear weapons program. Seoul questioned the United States’ willingness to enter another Asian land war after the Vietnam experience. In 1969, the Nixon administration’s promulgation of the so-called Guam Doctrine called for U.S. allies to take more responsibility for their defense, further denting perceptions of U.S. credibility in some capitals. President Nixon’s decision to withdraw an American division from South Korea without consulting Seoul led South Korean president Park to call for a program of “self reliant national defense.”² In late 1973, President Park initiated a clandestine nuclear weapons program—soliciting reprocessing plants and core designs from France—as part of increasing self-reliance. Despite ratifying the NPT in 1975, Seoul continued a nuclear “cat-and-mouse” game with American intelligence until the late 1980s, and South Korea actually completed nuclear fuel fabrication facilities.³

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³  Choi and Park provide an overview of South Korea’s clandestine program; see Choi and Park, “South Korea,” 374–379.
The Relevance of Extended Nuclear Deterrence

While extended deterrence is vital, is its nuclear component still relevant in the Asia-Pacific, or is the nuclear umbrella conceptually passé and, possibly, even an obstacle to achieving U.S. nonproliferation and disarmament goals? Some analysts conclude that U.S. nuclear commitments are hollow rhetorical promises and, thus, are not credible.19 In a crisis, some doubt that the United States will risk potential nuclear attack on its homeland to defend allies with nuclear weapons. Indeed, during the Cold War many questioned if the United States would really “trade Washington for Paris (or Berlin, London, etc.)” and risk a Soviet nuclear attack on the homeland. Despite these persistent concerns, South Korea has consistently and publicly noted the importance of U.S. extended nuclear deterrence and, in some cases, requested that the United States explicitly highlight the nuclear umbrella.

In September 1991, the implementation of U.S. Presidential Nuclear Initiatives removed deployed land- and sea-based tactical nuclear weapons—including the U.S. Force Korea’s tactical arsenal on the Korean Peninsula. North Korea quickly violated the ROK-DPRK [North Korean] Denuclearization Declaration; neither the Agreed Framework of 1994, multiple rounds of Six Party talks, nor sanctions have stopped North Korea’s missile and nuclear program. South Korea has increasingly demanded a reiteration of specific U.S. nuclear deterrence commitments. After North Korea’s first nuclear test, the 2006 U.S.-ROK Security Consultative Meeting (SCM) communiqué stated: “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.”20 The specific commitment to U.S. “extended deterrence” using the “nuclear umbrella” or “nuclear capabilities” has been repeated in all subsequent SCM communiqués. South Korea reportedly insisted that the SCM statement “specifically reaffirmed extended deterrence with a nuclear dimension.”21 Reissued in 2011, the 2009 U.S.-ROK Joint Vision Statement declared:

We will maintain a robust defense posture, backed by allied capabilities which support both nations’ security interests. The continuing commitment of extended deterrence, including the U.S. nuclear umbrella, reinforces this assurance.22

The inability to provide nuclear reassurance may push South Korea to pursue more strategic independence and diminish U.S. influence in a region of tremendous impor-


tance. In a worst-case scenario, South Korea could pursue nuclear weapons acquisition programs. South Korea has an extensive nuclear infrastructure—including over 20 functioning reactors—but no independent means for enrichment or reprocessing. Indigenous proliferation would undermine U.S. nonproliferation goals, introduce instability into the region, and possibly cause arms races.

Addressing New Deterrence Requirements: Course of Action and Evaluative Criteria

How can the United States bolster the credibility of its extended nuclear deterrent in a way tailored to South Korea’s particular concerns? Any successful course of action must meet three criteria: First, it must enhance South Korea’s perception of U.S. credibility. Second, it must be sustainable at reasonable financial cost. Third, it must receive support from South Korea’s political and national security elites and public. Possible courses of action include:

- Strengthening official statements;
- Deploying new conventional offensive forces and/or missile defenses to complement or substitute for nuclear forces;
- Enhancing deterrence posture committees;
- Instituting “dual key” sharing arrangements (e.g., the “NATO model”); and
- Forward deploying U.S. nuclear weapons.

Strengthening Official Statements

Official speeches, communiqués, agreements, and other statements publicly announce a government’s intentions and commitments at the highest levels. Following the second North Korea nuclear test, President Obama declared: “So long as these nuclear weapons exist, the United States will maintain a strong and effective nuclear deterrent that guarantees the defense of our allies—including South Korea and Japan.” The 2009 “U.S.-ROK Joint Vision Statement” and repeated SCM communiqués reaffirmed U.S. extended nuclear deterrence commitments to South Korea. The United States could continue to reiterate nuclear commitments in official statements and/or strengthen the language to clarify that the United States will respond to nuclear (and/or weapons of mass destruction) attack on South Korea with nuclear weapons:


24. Current projections suggest that the U.S. defense budget will be increasingly constrained for at least the next decade. Therefore, this paper assumes that the pressure for defense budget reductions means that the United States will probably need to enhance reassurance and credibility in extended deterrence without committing to new and expensive weapons systems.

■ **Credibility:** The public nature of official statements makes it difficult for the United States to back down without generating a “crisis of confidence” among all allies. Commitments at the highest levels of government send a clear signal of intent. Conversely, official statements are ultimately words on paper and meaningless without the willingness to carry out commitments. Some analysts argue that official statements should not provide confidence to protected allies. Jeffrey Lewis argues that “there is no such thing as ‘the nuclear umbrella.’ The United States does not have specific commitments to aid allies under nuclear attack; . . . nor does the United States have any obligation to use nuclear weapons in a particular circumstance.”

■ **Cost:** Relative to fielding and sustaining weapons systems and deploying forces, the long-term financial costs of issuing and reiterating official statements are very low.

■ **Elite and public opinion:** Following North Korean nuclear testing, elites in South Korea insisted upon reiterations of U.S. security guarantees, which specifically mention nuclear capabilities. Seoul’s insistence suggests that elites generally associate importance to official statements regarding extended deterrence and, specifically, the nuclear umbrella.

■ **Evaluation:** Official statements are relatively low cost and desired by South Korean elites. Given the forceful and explicit existing commitments already provided to South Korea, however, it would be difficult to further strengthen the existing language. Further tinkering and reiteration is unlikely to reassure Seoul.

### Deploying Conventional Offensive Strategic Forces

The threshold for employing nuclear weapons use is higher than for conventional means (and some conventional weapons can credibly hold at risk many nuclear targets). One could argue that U.S. nuclear deterrent threats are not credible except in limited circumstances. To the extent that conventional can substitute for nuclear, deploying more capable conventional offensive retaliatory forces could presumably enhance the credibility of extended deterrence. In other words, Seoul may desire the United States to shift the “mix” of extended deterrent capabilities toward conventional strategic forces to complement (but not substitute for) U.S. nuclear weapons. If this posture is more reassuring to Seoul, then the United States could modify existing strategic nuclear delivery vehicles to carry conventional payloads (e.g., conventionally tipped Trident II SLBMs) or field alternative types of conventional prompt global strike (CPGS) platforms:

■ **Credibility:** As a complement to nuclear forces, conventional offensive strategic forces increase the credibility of extended deterrence because allies perceive the threshold for use is lower than for employing nuclear weapons. In a crisis, the United States might hesitate to escalate to nuclear use. CPGS offer retaliatory options against hidden and relocated targets at strategic distances, which could

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26. Lewis, “Extended Deterrence.”
enhance credibility, particularly in situations where A2/AD tactics prevent the United States from employing regional assets or moving forces in-theater. Conversely, shifting the “mix” too far could damage credibility, if Seoul perceives that nuclear retaliatory threats are hollow and aggressors believe they can escalate to nuclear attacks without the United States responding in kind.

- **Cost:** The United States could bolster its conventional offensive strategic forces in two ways: (1) modify existing assets for the extended conventional deterrence mission and/or (2) develop new CPGS capabilities. In 2006, Congress eliminated a DOD proposal to modify Trident D-5 SLBMs to carry conventional payloads. DOD requested about $500 million over five years to modify 24 D-5s and develop assigned conventional warheads. Despite the elimination of Trident D-5 conversion, DOD continues to have a robust CPGS program. DOD’s fiscal year 2013 budget submission requests about $1.1 billion over five years for CPGS “design, development, and experimentation of boosters, payload, delivery, vehicles, non–nuclear warheads, guidance systems, and mission planning and enabling capabilities.”

- **Elite and public support:** High-level national security statements demonstrate that South Korean elites view nuclear weapons as a “vital” but not the “sole” component of extended deterrence. South Korea recently emphasized conventional weapons in its central deterrence strategy against North Korea, suggesting that elites perceive utility in conventional weapons for deterrence. Days after Pyongyang’s April 2012 missile test, Seoul publicly confirmed its Hyunmoo cruise missile deployment, a move “meant to send a message to the North, and its own people, as tensions mount over fears the North will stage a third nuclear test.” South Korea also wants to renegotiate a 2001 agreement with the United States that bans South Korean development of missiles with ranges exceeding 300 kilometers. Recent press reports indicate that the renegotiated agreement will permit South Korea’s missiles to have ranges of at least 800 kilometers.

- **Evaluation:** Conventional strategic strike could provide prompt, precise, and powerful retaliatory options from out-of-theater and without escalating to nuclear

27. Amy Woolf notes that CPGS could fulfill the mission set in conflict scenarios where “bombers may be too slow to arrive and too vulnerable to air defense systems, sea-based or air-launched cruise missiles may also be too slow to arrive and of too short a range to reach remote targets, and sea-based systems, with the exception of long-range ballistic missiles, may also be too far away to reach priority targets.” See Amy Woolf, Conventional Warheads for Long-Range Ballistic Missiles, Congressional Research Service Report RL 33067, January 2009, 20.

28. Ibid., 9.


use. The high cost associated with fielding more capable conventional strike systems—particularly CPGS—diminishes their attractiveness. Assuming continued congressional opposition to conventional Trident, CPGS development costs at least $1 billion (not including the costs of procurement and sustainment). In direct response to North Korean missile and nuclear testing, Seoul’s pursuit of longer-range missiles demonstrates that elites believe in conventional deterrence at some level. Yet South Korea might resist more U.S. emphasis on conventional extended deterrence if China indicates that CPGS will undermine strategic stability.

**Enhancing Missile Defense Cooperation**

Missile defenses “deter-by-denial” through imposing costs on aggressors, complicating attack planning, and limiting the damage of offensive strikes. Missile defenses help assure by offering options to defensively respond to attack beyond simply retaliating. Extensive system testing also gives South Korean assurance that these systems will actually prove effective if employed. South Korea participates in U.S. missile defense exercises and will deploy U.S. terminal-phase interceptor batteries by 2015.\(^\text{32}\) The United States could increase cooperation through undertaking joint development projects, providing upgrades to South Korea’s systems as requested, and better integrating launch detection and missile tracking capabilities:

- **Credibility:** Missile defenses enhance the credibility of extended deterrence in three fundamental ways. First, they deny aggressors the certainty of successful strikes and, thus, dissuade attacks in the first place. Second, active defenses offer flexibility of response before (or in conjunction with) escalation to retaliatory offensive strikes. Third, defenses demonstrate immunity to reprisal, thus rendering irrelevant uncomfortable questions about U.S. resolve to trade Washington for Seoul.\(^\text{33}\)

- **Cost:** Missile defenses are relatively expensive and the “cost-per-shot” disparity between interceptors and adversary ballistic missiles will probably widen, particularly vis-à-vis hit-to-kill missile defenses. The costs of deploying sufficient interceptors to defeat salvo attacks are prohibitive; fielding “limited” defenses is also relatively expensive. Incremental hardware/software upgrades for Aegis ballistic missile defense systems on in-service U.S. warships cost about $45-55 million per ship. The estimated procurement cost of Standard Missile-3 (SM-3) Block IB and IIA are $12–15 million and $20–24 million per interceptor, respectively (not including operations and maintenance costs).\(^\text{34}\) Clearly, developing and deploying missile defenses is an expensive proposition.

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\(^{33}\) Murdock et al., *Exploring the Nuclear Posture Implications*, 2.

- **Elite and public opinion:** South Korea deploys Patriot missile defense batteries to defend population centers. Until recently, South Korea balked at cooperation on advanced systems citing fears of upsetting China. Of particular importance, the 2009 South Korean–U.S. SCM communiqué agreed to joint missile defense cooperation, including arming Korean destroyers with SM-2 interceptors. More recently, the United States reportedly agreed to help South Korea analyze its ballistic missile defense requirements and to combine air defense and surveillance systems on the Korean Peninsula. These commitments to long-term projects indicate that South Korean elites value credible missile defenses. Watanabe Takeshi notes that South Korean public opinion largely drove South Korea’s hesitant defense elites into greater missile defense cooperation with the United States.

- **Evaluation:** Enhanced U.S.–South Korean missile defense cooperation is increasingly popular among South Korean elites and publics, but hesitancy at undermining strategic stability vis-à-vis China remains an important obstacle to further cooperation. Fielding and sustaining these systems, however, is relatively expensive and cannot provide more than a limited defense. Therefore, the United States should continue to enhance its land- and sea-based missile defense cooperation with South Korea to strengthen a vital component of extended deterrence posture. While joint development of interceptors is expensive, other cooperative methods are cheaper, including conducting threat and requirements assessments, sharing information, and, potentially, access to existing U.S. systems that monitor North Korea. Like conventional strike, shifting the extended deterrence mix of capabilities too far toward defensive capabilities will undermine the posture’s overall credibility. Long-term missile defense cooperation is a necessary but not sufficient condition for bolstering the credibility of extended deterrence commitments.

**Enhancing Deterrence Posture Committees**

Deterrence posture committees increase joint understanding, input, and coordination on U.S. extended deterrence. South Korea perceives some reassurance value from the existence of institutionalized deterrence dialogues or committees. In 2010, the 42nd ROK-U.S. SCM created the ROK-U.S. Extended Deterrence Policy Committee (EDPC) to “improve the effectiveness and reliability of extended deterrence” but did not specify the EDPC’s responsibilities. The 43rd SCM communiqué stated U.S.–South Korean intentions to “further develop” the EDPC, endorsed the EDPC’s Multi-Year Work Plan,

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and “decided to develop a tailored bilateral deterrence strategy.”\textsuperscript{40} The United States could enhance the EDPC and, potentially, multilateralize deterrence policy committees to include other key covered allies:

- **Credibility**: Deterrence posture committees can increase credibility through “enhancing transparency and expertise” and building trust among allies.\textsuperscript{41} These mechanisms help the United States tailor assurance strategies by helping determine each ally’s unique security needs. As Clark Murdock and Jessica Yeats note, “meaningful consultations means knowing more than what an ally wants—it means knowing why they want it.”\textsuperscript{42} Deterrence posture committees are not helpful if they are merely “talking shops” that resemble high-level deterrence seminars.

- **Cost**: The monetary costs associated with staffing deterrence posture committees are relatively low compared with fielding and sustaining offensive and defensive capabilities. Sustained dialogues will always be cheaper than building weapons systems.

- **Elite and public opinion**: The EDPC demonstrates the desire of South Korean elites to have some formal mechanism in place to discuss U.S. extended deterrence. To the extent that such consultative mechanisms are considered part of “strengthening the alliance,” public opinion seems largely supportive of such efforts.

- **Evaluation**: Deterrence posture committees are low-cost means of bolstering assurance through sustained, detailed dialogue and refined tailoring of extended deterrence posture to meet an ally’s requirements. The United States should enhance the EDPC and, potentially, consider multilateral options to include other key Asia-Pacific allies. The EDPC should cover areas such as allied concerns about both the security environment and American commitments, joint threat assessments, explanations of posture changes, detailed reviews of U.S. capabilities, and planning for U.S. responses to specific scenarios.

### Implementing Nuclear-Sharing Arrangements

Dual-key arrangements offer protected countries much more participation and insight into all aspects of posture planning, but they also require sharing the responsibilities of sustaining credible day-to-day deterrence. Under the NATO “dual-key” model, the Nuclear Planning Group (NPG) develops and makes collective decisions on NATO’s nuclear policy, and a High-Level Group regularly meets on NATO’s nuclear issues. NATO institutionalizes nuclear operations sharing through stationing dual-capable aircraft (DCA) and U.S. B-61 nuclear gravity bombs on the territory of five Allies—Belgium, Germany, Italy, Turkey, and the Netherlands. Without forward deploying nuclear weapons, the United States could implement nuclear sharing by establishing a bilateral


\textsuperscript{41} Murdock et al., Exploring the Nuclear Posture Implications, 3.

\textsuperscript{42} Ibid.
NPG-like posture planning committee with collective decisionmaking. In other words, Seoul would be fully integrated into an NPG decisionmaking body, but the United States would keep operational control and possession of all assigned nuclear forces:

- **Credibility:** “Dual-key” arrangements enhance credibility by “coupling” the security of the United States and covered allies, conveying the will to defend allies at all costs, and forcing all to share the risks and burdens of security.

- **Cost:** The monetary costs associated with sustaining the dual key posture (e.g., maintaining the delivery systems and personnel necessary for the nuclear mission) are relatively high; these costs include training and maintaining personnel; production, transportation, and storage of weapons; and procurement and sustainment of delivery systems. If the United States chose to retain sole control of existing forces assigned to extended nuclear deterrence, then the costs would decrease substantially.

- **Elite and public opinion:** Given its support for EDPC, South Korea’s elite would likely support an NPG-like structure because it offers the maximum amount of transparency. In light of historical concerns regarding upholding strategic stability with China, the South Korean elite would probably hesitate to accept nuclear deployments. The public, however, is much more enthusiastic about nuclear weapons. In 2011, almost 70 percent of South Koreans wanted nuclear weapons; 67 percent of South Koreans want the United States to redeploy tactical nuclear weapons on the peninsula.\(^\text{43}\)

- **Evaluation:** Nuclear sharing arrangements bolster credibility through creating a common and jointly sustained deterrence culture that spreads the costs and responsibilities of sustainment and operations to other members (even if some are only involved at the planning level).\(^\text{44}\) Such a system “implicates” participating allies in nuclear deterrence along with the United States. The financial costs of this option, however, are high, particularly compared with strengthening official statements or institutionalizing effective deterrence posture committees. The South Korean public favors a redeployment of U.S. tactical nuclear weapons (though a strong minority opposes this policy).

The United States could conceivably pursue a limited (and much cheaper) sharing arrangement that excludes stationing nuclear weapons or delivery systems in South Korea. In this scenario, South Korea would be like Spain or Canada in NATO nuclear sharing—participating in the policy discussion, but not maintaining weapons or delivery systems assigned to the NATO nuclear mission. This policy would take the EDPC to its fullest level of cooperation. While this “bilateral NPG option” would offer reassurance to South, the United States should probably avoid

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\(^{44}\) Yost, “U.S. Extended Deterrence,” 17–18.
it because consensus-based decisionmaking allows participating allies vetoes over extended deterrence posture.

Redeployment of U.S. Tactical Nuclear Weapons

The United States deployed hundreds of tactical nuclear weapons in South Korea beginning in 1958. Under the Presidential Nuclear Initiatives, the United States removed all tactical nuclear weapons from the Korean Peninsula by December 1991. In February 2011, Obama administration weapons of mass destruction coordinator Gary Samore said that the United States would probably favorably respond to a South Korean request for redeployment; the White House promptly disavowed Samore’s comments—stressing the U.S commitment to peninsular denuclearization. As passed by the House of Representatives, the fiscal year 2013 National Defense Authorization Act (NDAA) called for redeploying tactical nuclear weapons to the Western Pacific. Forward deploying U.S. nuclear weapons can reassure protected allies through its visible and in-theater presence. Writing in the context of NATO nuclear sharing, the DoD Nuclear Weapons Management Task Force report noted: “Much of the deterrent value of NATO’s DCA deployment is derived from their in-theater presence, demonstrating and maintaining the capability to employ them.” In other words, in-theater presence helps add credibility to an extended deterrence posture. The U.S. extended nuclear deterrent is not visibly forward deployed into the Asia-Pacific theater:

- **Credibility:** Forward deployments seem to enhance credibility through their visibility, availability, and in-theater nature. They add to reassurance through serving as “important political and psychological symbols” and, thereby, “linking” or “coupling” security.

- **Cost:** Redeploying tactical weapons would be expensive, considering that costs associated with production (or refurbishment) and transportation of weapons and building the facilities for storing, securing, and handling the weapons. Forward deployment would also incur high sustainment costs for the weapons. For example, the B-61 Life Extension Program will cost at least $4 billion.

- **Elite and public opinion:** Conservative South Korean defense intellectuals, parliamentarians, and ministers sometimes call for U.S. redeployment, but South Korean

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48. B-2 and B-52 squadrons deploy on training rotations to Guam; while some U.S. SSBNs patrol the Pacific, these assets are invisible to allies.
national policy has consistently maintained the denuclearization commitment. In response to the above-mentioned fiscal year 2013 NDAA provision, South Korea denied any planning or need for redeployment. The public is much more favorable to the notion of both indigenous development and redeployment, with solid majority backing. Of particular importance, a fierce minority opposes any nuclear weapons and would likely launch major protests in the event of redeployment.

- **Evaluation:** Forward deployment enhances credibility through symbolic and psychological reassurance that is qualitatively different from conventional capabilities and more tangible than strategic nuclear forces invisible to ally and adversary. The cost of regenerating the necessary facilities and sustaining weapons/delivery systems and supporting personnel units to secure, handle, and employ tactical weapons would probably be tens of billions of dollars. Despite persistent public majorities in favor of nuclear weapons, the subject of redeployment is taboo among the South Korean elite. Unless the security situation dramatically deteriorates, the United States should pursue lower-cost means of reassurance before considering redeployment.

**Recommendations**

Enhancing the deterrence policy committees is the best option to enhance reassurance at reasonable cost and with South Korea’s elite and public support. In June 2012, the U.S.–South Korean “2+2” meeting (foreign and defense ministers) communiqué stated: “Ministers expect the EDPC to continue its current efforts for developing a practical and tailored bilateral extended deterrence policy.” The Korea-U.S. Integrated Defense Dialogue (KIDD) encompasses the EDPC and other strategic bilateral fora. While the inaugural KIDD meeting was held in late February 2012, the EDPC has already met three times since it was established in 2010. The success of the EDPC depends on its ability to build trust between the United States and South Korea and to translate increased confidence into practical cooperative steps. Therefore, discussions should avoid high-level and general deterrence, focusing instead on specific South Korean concerns, and produce joint coordination on threat assessments, requirements generation, operational planning, and exercises to simulate responses to numerous contingencies. Discussions should similarly avoid undue focus on nuclear deterrence and also include deterrence in the cyber and space domains. And it is particularly important that KIDD/EDPC continues beyond the proposed transfer of the Combined Forces Command operational control to South Korea in 2015.

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51. “Majority of South Koreans Want Atomic Bombs.”
Taiwan’s Nuclear Conundrum
Combining the Models of Nuclear Decisionmaking
Emily Cura Saunders

What are the driving factors behind whether a state develops a nuclear weapon or not? Several models have been proposed, including norms, domestic issues, and security threats. This paper proposes a fourth model: that of confidence in the United States’ extended nuclear deterrent. These models can also be combined in order to better explain a state’s decisionmaking process. The paper looks at these decisionmaking models in light of Taiwan, proposing a combination of how these models interacted during Taiwan’s reported exploration of fuel cycle technology.

Both President Barack Obama and Secretary of State Hillary Clinton have recently made claims that it would behoove the United States to refocus its foreign policy agenda on the Asia-Pacific region. This “Pacific pivot,” as it has been deemed in political circles, will begin by solidifying America’s relationships with its allies in the region and continuing to assert itself economically and militarily on the Asia-Pacific stage.

There is little doubt that important issues will come to the fore as the United States makes this pivot. One of the main issues will be stemming the tide of a potential nuclear arms race in the region. Both China and North Korea possess nuclear weapons, and South Korea, Japan, and Australia are covered under the so-called nuclear umbrella of the United States. This umbrella does not guarantee that any of those states will not “go nuclear,” but it does provide U.S. allies with a commitment that there should be no need to develop independent nuclear deterrents. For decades, the United States’ nuclear umbrella has served as a nonproliferation tool for its allies in East Asia.

While South Korea, Japan, and Australia have clear-cut and transparent security guarantees from the United States, Taiwan does not. For the past 30 years, the United States has more or less maintained a posture of “strategic ambiguity” when it comes to Taiwan relations. Given that Taiwan has a rich history in terms of security decisionmaking models, why does Taiwan stay a nonnuclear state in such a tough neighborhood?

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What makes a state like Taiwan choose a nuclear path in the first place? Is there anything U.S. policymakers can do to prevent this choice?

This paper begins by examining some of the generic decisionmaking models for nuclear proliferation. These existing frameworks attempt to address the question of why states proliferate, looking at issues of security threats, perceived norms, and the domestic political landscape. The paper then proposes a new model of extended nuclear deterrence as a tool for state nuclear decisionmaking. After proposing a hypothesis of how these models are likely interconnected, and not mutually exclusive, the paper tests the model in light of Taiwan’s nuclear ambitions.

The Existing Framework

There has been much speculation about why states do or do not develop nuclear weapons. In his article “Why Do States Build Nuclear Weapons? Three Models in Search of a Bomb,” Scott Sagan identifies three models: international security, domestic politics, and norms. While Sagan offers policy implications for the United States, here I extend his theory to include U.S. security guarantees as a model, rather than a policy tool to be used within his existing models. While other scholars—such as Etel Solingen, Natasha E. Bajema, and Jacques E. C. Hymans—have also speculated about various models of state decisionmaking, they leave out the effect that the United States’ security guarantees can have on a country’s nuclear decisionmaking process. Often, U.S. extended deterrence is seen as a result of the models and a way to deter states from proliferating, rather than a model at play when a state is deciding whether to proliferate nuclear weapons.

To begin, it is important to briefly explain the three existing models. The security model is heavily laced with realist international relations theory. Sagan explains that according to this theory, “states exist in an anarchical international system and must therefore rely on self-help to protect their sovereignty and national security.” This fits relatively well into the idea that if a state possesses nuclear weapons, a rival state will proliferate to balance its adversary and develop its own independent deterrent. It is a fairly intuitive notion that if a state feels threatened, it will try to balance that threat by developing nuclear weapons.

The idea of extended nuclear deterrence, whereby a nuclear state brings another state under its “nuclear umbrella,” is a concept that is not well explained by realist theory. That being said, and as Sagan rightly notes, it is not as if a country that wishes to possess a nuclear weapon could just do so; there are of course budgetary constraints, research shortcomings, and international treaty agreements to consider.

As Sagan claims, “from a realist’s perspective, nuclear restraint is caused by the absence of the fundamental military threats that produce positive proliferation decisions.” He goes on to explain that a way to counter the security problem is for the United States

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3. Ibid., 57.
4. Ibid., 61.
to maintain nuclear commitments.\^5\ Using this as a policy implication is reasonable, but it should be extended into a model of its own, as this paper demonstrates.

Natasha Bajema explains how “the deficiencies of the security model for explaining the dynamics of nuclear proliferation . . . arise primarily from the neglect of domestic-level variables in neorealist theory.”\^6\ This brings us to the second explanation of why states proliferate: the domestic politics model. As Solingen explains, “identifying core models of political survival underlying the domestic politics of nuclear aspirants provides a systematic tool, portable worldwide, with premises backed by important evidence.”\^7\ Sagan claims that “whether or not the acquisition of nuclear weapons serves the national interests of a state, it is likely to serve the parochial bureaucratic or political interests of at least some individual actors within the state.”\^8\ The model, as proposed by Sagan and Solingen, seeks to examine the domestic factors of nuclear decisionmaking. As one can imagine, this is a large tent, and it is necessary to examine several domestic variables—such as regime type, regime transitions, economic standing, and status of markets (open or closed). Both scholars also recognize that these issues are intertwined with regional and global issues.

The last model this paper examines before proposing a new model is the norms model. This model “focuses on norms concerning weapons acquisition, seeing nuclear decisions as serving important symbolic functions—both shaping and reflecting states’ identity.”\^9\ Sagan draws upon sociology to question whether nuclear weapons could be seen as similar to a flag or a national airline, something that is a part of “what modern states believe they have to possess to be legitimate, modern states.”\^10\ Sagan does not neglect the political science literature, however, noting “that such symbols are often contested and that the resulting norms are spread by power and coercion, and not by the strength of ideas alone.”\^11\ In terms of norms, one can point to the attempted abolition of chemical and biological weapons; in fact, the widely accepted norm is such that said weapons are unacceptable for a state to possess, making the norm the lack of such weapons.

While all these models make mention of the United States’ nuclear posture as a driver in a state’s decisionmaking, none explain that the posture itself could be a stand-alone model. In the 2010 Nuclear Posture Review, the Obama administration solidified the United States’ posture, explaining that it will continue security guarantees with allies:

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5. Ibid., 60.
9. Ibid., 73.
10. Ibid., 74.
11. Ibid., 76.
Such security relationships are critical not only in deterring potential threats, but can also serve our non-proliferation goals—by demonstrating to neighboring states that their pursuit of nuclear weapons will only undermine their goal of achieving military or political advantages, and by reassuring non-nuclear U.S. allies and partners that their security interests can be protected without their own nuclear deterrent capabilities.\footnote{12}

This security policy insinuates that a way to keep states from proliferating is to assuage their threat perception with the extension of a security guarantee from the United States. While the United States cannot control the norms, domestic issues, or security threats that a country faces, it does have control over its security guarantees, and it could use these guarantees to assist in nonproliferation efforts and to influence a state’s decisionmaking process.

Perhaps it is worth taking this one step further and looking at extended deterrence as a model itself. There are several cases where a state under the nuclear umbrella has considered developing an independent deterrent when it has felt that the U.S. commitment has waned. For example, both South Korea and Japan had reactionary responses to the Nixon Doctrine with regard to their homegrown nuclear capability. While neither country pulled the nuclear trigger, both have had serious concerns over the U.S. commitment in the past and both have considered an independent nuclear option as a result.

Using a U.S. extended deterrence commitment as a state decisionmaking tool is a worthwhile exercise, and likely another piece of the decisionmaking criteria that states use. This is especially pertinent given that the United States is toying with the idea of using security guarantees to help stem a potential nuclear arms race in the Middle East. Looking at the past proliferation activities of and the level of confidence in the United States’ extended deterrent commitment to any given state could shine some light on whether the variables are connected.

That being said, these models are not mutually exclusive, and, as Sagan points out in his conclusion, “some of the policy recommendations derived from the models are quite compatible: for example, many of the diplomatic tools suggested by the domestic politics model, which attempts to reduce the power of individual parochial interests in favor of nuclear weapons, would not interfere with simultaneous efforts to address states’ security concerns.”\footnote{13} As can be seen in figure 1, each of these models could lead to the development of a nuclear capability, but each of them could also add to another model to lead to a weapons program, and thus the norms model could inform the security model and so on and so forth; they are not mutually exclusive, and in fact they probably work together in tandem on some level.

Another way to look at figure 1 would be to think about the models in terms of the relative weights of the various decisionmaking criteria. For some countries, perhaps security is the most important, and that could be reflected in the size of the circle.


\footnote{13} Ibid., 86.
Figure 2 demonstrates a spatial way of looking at these models. This model would reflect a country for which norms were not a major factor in the decisionmaking process, and for which domestic politics played a slightly more important role. This figure insinuates that security played a relatively large role in the decisionmaking process, but the biggest factor was confidence in the United States’ extended deterrent. This is a simple figure, but it can be helpful when thinking through state nuclear decisionmaking models. The second section of this paper examines Taiwan’s nuclear conundrum in light of these models. It seeks to answer what was Taiwan’s nuclear decisionmaking model in the 1960s, and again in the 1980s.

**History**

Before delving into the models of nuclear decisionmaking for Taiwan, it is useful to briefly explore some security history. After World War II, China found itself in the midst of a civil war and Mao Zedong’s Communist Party took over, forcing General Chiang Kai-shek to retreat to Taiwan. This retreat set in motion a 30-year dispute over who holds legitimate power in China. The United States was initially conflicted over which side to support, Mao’s People’s Republic of China (PRC) or Chiang’s Republic of China (ROC); after the PRC sided with North Korea in the Korean War, the United States aligned itself with the ROC. In 1954, the United States and Taiwan signed a mutual defense treaty, not unlike the treaties signed with South Korea and Japan. This alliance
lasted almost 30 years, until the United States, under President Nixon, normalized relations with Mao’s Communist Party and recognized the PRC.

President Nixon’s trip to China in 1972 was the beginning of the end of official U.S. relations with Taiwan, and culminated in 1979 when President Carter severed diplomatic ties with Taiwan. Congress then passed the 1979 Taiwan Relations Act (TRA), which ambiguously provided a legal basis for unofficial relations between the two countries. This also marked the beginning of the U.S. Congress’s hand in guiding United States–Taiwan relations, a point that should not be overlooked, and will be a variable later in this paper upon examining the U.S. posture toward Taiwan.

While this serves as a brief overview of the diplomatic history of Taiwan, there is also a nuclear history, which deserves attention. In 1956, like much of the world, Taiwan opened a research reactor. Nuclear energy at the time was the new frontier, so it was not particularly alarming that reactors were being built and developed all over the world. That being said, what does set off alarm bells is when such reactors are placed in the hands of the military rather than civilian energy companies. In Taiwan, nuclear research was under the military, and thus was cause for concern when in 1967, the Ministry of Defense reportedly published a $140 million proposal to develop nuclear weapons. Throughout the 1970s, Taiwan skated the line between civilian and military programs, having the two operate side by side, leaving the international community guessing as to the intentions of their research.

The International Atomic Energy (IAEA) and the U.S. government were integral in helping to stop these research ambitions. After the discovery of potentially questionable behavior in terms of its research reactor, and with pressure from the United States, Taiwan “agreed to convert the reactor to a new core that used both low-enriched uranium oxide and natural uranium fuel assemblies.” The United States also insisted that the spent fuel be shipped to the United States. The IAEA also was instrumental in curbing the Taiwanese program. One of its major contributions was that of increasing transparency. It took several steps to encourage a more open program, including “installing additional cameras as the Taiwan research reactor (TRR), examining plutonium-laden irradiated fuel from the TRR, and carefully verifying Taiwan’s declarations.”

This history, though brief, serves as a foundation for the following section, which looks at the Taiwan nuclear program in light of the aforementioned models, and considers whether the United States’ commitment could have been a driver in the country’s nuclear decisionmaking.

15. Ibid., 59.
16. Ibid., 59.
Applying the Models

In light of this history, it is important to examine which model, if any, Taiwanese decisionmaking fits. This could be a useful tool as the nonproliferation regime tries to regain traction and sustain a world with only limited nuclear states.

Taiwan and the Security Model

There is little doubt that Taiwan continues to face major security threats, as it has throughout its history. The ROC began with a civil war between the mainland Chiang’s people and the army, and thus they fled to Taiwan. The threat did not stop then, however. Taiwan has had a long history of feeling threatened by the PRC. There have been several scuffles over the Taiwan Strait, and much of the PRC’s military advancement is seen as a threat to Taiwan.

While the PRC has been advancing militarily for some time, no advancement could rival the shock of the 1964 nuclear weapons test. As a reaction to the test, in 1967, the Ministry of Defense in Taiwan “floated a $140-million proposal for developing nuclear weapons.”18 There is a clear correlation between mainland China’s nuclear ambitions and Taiwan’s nuclear research response.

More recently, Taiwan has used nuclear rhetoric in response to a perceived threat from the PRC. In 1995, the PRC test-fired several missiles near Taiwan. This was reported as “an unwelcome sign of increasing Chinese belligerence in a region that hopes to avoid conflict with Beijing.”19 Shortly after these missiles were fired, “President Lee Teng-Hui told the national assembly: ‘We should restudy the question [of nuclear weapons] from a long-term point of view.’”20 This rhetoric is often withdrawn days after comments like this, but nevertheless, there is the idea that a Taiwanese nuclear deterrent could be seen as useful by some within the government as a counter to the PRC’s aggression. There is much evidence that Taiwan’s nuclear decisionmaking fits the security model.

Taiwan and the Domestic Model

Taiwan became a democratic state in 1996. According to the domestic model, this has the potential to be a significant event with regard to nuclear decisionmaking. Solingen explains that moves to reverse a nuclear program can entail “a domestic evolution toward internationalization.”21 If a state wants to become a player on the international stage, it may likely see a nuclear program as a hindrance rather than a way to obtain credibility. She goes on to state that “only leaders and ruling coalitions advancing their political survival through export-led industrialization undertook effective commitments to denuclearize.”22 Theoretically, Taiwan would want to become an export industrial

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22. Ibid., 43.
state, for once a country sheds the chains of autocracy, it will most likely want to advance economically. The fact is, in a democratic society, leaders cannot survive without economic advancement, lest they be unelectable.

Sagan points out that in the domestic model, some actors within the state would likely benefit from the development of a nuclear weapons program, and this appears to have been the case in Taiwan. There is much speculation that Chiang’s son, Chiang Ching-kuo, who would later become premier upon the death of his father, was, along with other high-ranking government officials, a major driver in the nascent days of Taiwan’s nuclear research.⁴³

Solingen is quick to point out that these issues do not exist in a vacuum—of course, there are regional concerns and concerns regarding a country’s progress in its nuclear program. That said, a clandestine nuclear program is less likely to get traction in a democracy. There is too much inherent transparency to undertake such a large and expensive program without constituents, political adversaries, and the media finding out about it. It is a reasonable assumption that Taiwan’s democratization today makes a clandestine nuclear program likely untenable; however, at the time of its proliferation activity, there were certain domestic actors pushing the program through in an autocratic society.

**Taiwan and the Norms Model**

The norms model is perhaps the most interesting of the models in this case, due to Taiwan’s ambiguous status on the international stage. There was a 30-year period of ambiguity over who actually controlled China, and during this period, the Chinese Nationalist Party, the Kuomintang (KMT) under Chiang signed international treaties. At this time, the KMT was seen as the legitimate party in China. In fact, it was the KMT that signed the Nuclear Non-Proliferation Treaty, which is widely considered the norm of nonproliferation in the international arena; thus Taiwan was actually adhering to the norms of nonproliferation.

According to Sagan, the norms model means that states’ decisionmaking is partly based on the idea that nuclear weapons legitimize a state. If there were ever a state that needed to prove its legitimacy, it would be Taiwan, especially after the international community recognized the PRC as the legitimate sovereign in 1971. But there is little evidence that legitimacy drove Taiwanese research.

**Taiwan and the Confidence Model**

Taiwan and the United States have a rich history of contradictory feelings of assurance and abandonment. As was noted above in the historical analysis, the United States was squarely on the side of Taiwan until the split in the 1970s. This split led to feelings of abandonment, but even before the official severing of ties, Taiwan had such feelings that contributed to the spurring of its nuclear program. In 1964, China tested its first nuclear weapon, posing an extreme threat to Taiwan. As tensions in the Taiwan Strait rose, “the absence of U.S. military action to neutralize the Chinese nuclear arsenal, combined with

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⁴³ Albright, “Taiwan,” 58.
America’s preoccupation with Vietnam, spurred the Taiwanese defense ministry . . . to propose an effort to develop a secret Taiwanese nuclear arsenal.”\(^{24}\) By the 1970s, President Nixon’s trip to and subsequent recognition of China were seen as undermining the previous commitments to Taiwan, “thereby strengthening internal arguments for an independent nuclear capability.”\(^{25}\)

The confidence issue is still very much salient today. As has been the case since the TRA was passed, the U.S. Congress has a major hand in the Taiwan issue. This is unique in that, when it comes to other states under the U.S. nuclear umbrella, it is usually the executive branch that deals with such foreign policy issues. The TRA was passed in such a way that it is veto-proof, in order to solidify the concept that presidents would have the power to sell arms to Taiwan. The U.S. Congress has voted time and time again to make sure Taiwan is well-armed. This is significant because, should a U.S. president falter on this commitment, Taiwan could appeal to the U.S. Congress, and through it, an entire constituency of support. According to the confidence model, this should theoretically assure Taiwan enough to deter an independent nuclear program.

**Taiwan and the Collective Model**

Based on the above information, it is reasonable to assert that the collective decision-making model for Taiwan could look like figure 3. Norms seem to have played the smallest role in its decisionmaking. While, according to the norms model, nuclear weapons could legitimize a state, there is very little evidence that this was a driver in Taiwan’s decisionmaking. Domestic issues did play a role in Taiwanese decisionmaking, as there were several high-ranking officials who were interested in nuclear advancement. Today, however, it is likely that the international community will have to wait to see how domestic issues affect current decisionmaking, but from the past, it is clear that Taiwan reversed its program before it became democratic; therefore, it can be assumed that democratization does play a role in this case. Taiwan’s current state as a strong democracy could make it unlikely that it would develop a clandestine program, but that does not rule out the idea of an open program, should threats become imminent enough.

That brings us to our third decisionmaking criteria, the security model. With the PRC nuclear test, Taiwan clearly felt the threat. It is clear from Taiwanese rhetoric and actions that threats from the mainland were a major driver in Taiwan’s decisionmaking process, most likely the heaviest weighted piece of their decisionmaking puzzle. Taiwan also faces major perceived security threats today. In fact, in June of 2012, the *Taipei Times* cited a report that China could have as many as 1,800 nuclear warheads, as opposed to the 300 it was previously believed to have had.\(^{26}\) The security model was very much salient in the 1970s and 1980s, and it remains so at this very moment, which leads to our last model, the confidence model. Taiwan has reacted to feelings of abandonment


\(^{25}\) Ibid., 544.

in the past by attempting to develop an independent nuclear deterrent; it is not unreasonable that if Taiwan felt abandoned again, it could continue with its hedge. The confidence model for Taiwan is today and was in the 1970s and 1980s very important. A research extension to this theoretical hypothesis would be to look at these issues quantitatively. A project that could be pursued further would be to delve deeper into proliferation activities and code them to explore more firmly the correlation and connection to the decisionmaking models that have been outlined.

Conclusion

The decisionmaking models described above are all interconnected, and none are mutually exclusive. Just because a state does not see nuclear weapons as normalizing does not mean that it will not succumb to domestic pressure, external threats, or feelings of abandonment by whomever is providing it extended deterrent. This model is also not just applicable to Taiwan. One could easily use subject matter experts to game this out with other states. In a time when various policy makers are making claims about extending the U.S. deterrent to the Middle East, applying this model to those countries may be a worthwhile exercise. By trying to think about decisionmaking factors, policymakers can know and understand how much weight each model holds and plan accordingly. If there were a state for which confidence issues played little role, how could the United States encourage certain domestic policies toward nonproliferation? Or how could the international community reinforce the notion that nuclear weapons do not make a state legitimate? Or how could it mitigate regional security threats?

These models are also ever changing. When a country democratizes and liberalizes its economy, it most likely will change its domestic model of nuclear decisionmaking; when a neighbor gains nuclear weapons, it will most likely increase its security bubble; and so on and so forth. Thinking through these issues can be helpful with regard to how the international community can continue to stem the tide of nuclear proliferation and for understanding the drivers behind a given state’s nuclear decisionmaking process.
A Proliferation Cascade in the Middle East?
Iran’s Nuclear Program, the Middle Eastern Nuclear Renaissance, Fukushima, and Implications for Nonproliferation
David Vielhaber

A nuclear domino scenario of accelerated proliferation of nuclear arms in the Middle East has been a widely predicted, yet mostly theoretical, potential consequence of Iran’s continuing pursuit of at least a nuclear weapons option. Proponents of this theory have pointed toward the increased, though mostly rhetorical, interest of Middle Eastern countries in civilian nuclear energy, describing this behavior as “hedging” (i.e., the establishment of a latent nuclear capability that could be transformed into a weapons capability in the future). This paper explores the plausibility of such a scenario in the context of heightened concerns over nuclear safety triggered by the Fukushima nuclear crisis, focusing on how Fukushima has affected plans for civilian nuclear energy expansion in the Middle East, and using those findings to reexamine the Iranian nuclear program’s purported role as the primary motivational factor for such plans. In doing so, this paper pays particular attention to three countries commonly suspected of “hedging” against a nuclear Iran: Saudi Arabia, Turkey, and Egypt. Findings do not support worst-case assessments of an impending proliferation cascade in the Middle East. While Fukushima has had a limited impact on nuclear power programs in the Middle East, it does not appear to have affected nuclear decisionmaking in these three countries. However, given their scope and pace of implementation, it is arguably implausible to consider these nascent nuclear programs as part of a hedging strategy. There is also some evidence that Fukushima may complicate the attempted future implementation of hedging strategies by leading to higher construction costs and rising public opposition to nuclear power.

Conventional wisdom holds that if Iran was to acquire a nuclear weapon at some unspecified point in the future, and particularly if Tehran was to declare this capability with a spectacular demonstration such a nuclear weapons test, then a race for the bomb, involving an unknown but significant number of actors, would surely commence im-

1. David Vielhaber is a research associate with the National Consortium for the Study of Terrorism and Responses to Terrorism at the University of Maryland.
mediately. Various terms have been used to describe this phenomenon of rapid reactive proliferation, including proliferation cascade, domino, or avalanche. In fact, this race for the bomb might already be under way. Proponents of this notion have argued that the upsurge in interest of Middle Eastern countries in civilian nuclear power, sometimes called the “Middle Eastern nuclear renaissance,” is not motivated by the benefits of generating electricity but rather by the more sinister objective of developing expertise in nuclear technology that could be exploited for a future nuclear weapons program. This strategy is known as nuclear hedging. Theories of proliferation cascades and hedging strategies have become the target of criticism for their alleged inaccuracy. The technology of nuclear power has become the target of criticism for its alleged insecurity in the aftermath of the Fukushima nuclear crisis in Japan in March 2011.

This paper is an attempt to explore if and to what extent Fukushima has affected the motivation and ability of countries in the Middle East to develop civilian nuclear infrastructure. Has the Fukushima crisis affected nuclear decisionmaking in the Middle East? If so, what does this reveal about the validity of the much-cited claim that countries in the region seek nuclear power as a security hedge against Iran? Or has Fukushima complicated the development of nuclear power by increasing construction costs and public opposition, making hedging strategies more difficult to implement? If the hedging narrative holds true, no fundamental changes in nuclear decisionmaking could be expected. After all, the underlying security imperative has not decreased, but rather increased as Iran keeps developing its fuel-cycle capabilities.

The paper starts by gauging the interest of countries in the Middle East in civilian nuclear power before the outbreak of the nuclear crisis in Fukushima in March 2011. This is followed by an examination of the hedging narrative, taking into account both its advocates and its critics. The paper then turns to a detailed analysis of the pre-Fukushima nuclear plans of the three actors that are commonly identified as the most likely to acquire nuclear weapons if Iran does so: Saudi Arabia, Turkey, and Egypt. The next section examines different projections about the Fukushima effect on the future of civilian nuclear power. Finally, the paper analyzes Fukushima’s actual impact on nuclear decisionmaking in the Middle East, contrasts this impact with other factors, such as political unrest and economic considerations in the region, and scrutinizes the post-Fukushima developments in Saudi Arabia, Turkey, and Egypt. The paper concludes that the crisis in Japan has had a very limited impact on nuclear decisionmaking in the region. The primary hedging candidates are moving ahead with their programs, at least for now. However, the pace at which these programs are being implemented still casts considerable doubt on the validity of the hedging narrative. Fukushima may still have a long-term impact on the feasibility of nuclear hedging by increasing public opposition to nuclear power. Evidence of such trends can be observed in both Egypt and Turkey.

2. It might be noted here that the term “renaissance” is inaccurate because there is no existing civilian nuclear energy infrastructure that could be revived.
A Nuclear Renaissance in the Middle East?

Since 2006, there has been a remarkable upsurge in interest in civilian nuclear power in the Middle East. Between February 2006 and January 2007 alone, 13 Middle Eastern countries announced their intention to pursue or at least explore civilian nuclear energy. Altogether, 18 out of 24 countries in the region had nuclear energy aspirations by the time of the outbreak of the Fukushima nuclear crisis in March 2011. However, the degree of interest varied widely. In some cases (e.g., Sudan, Yemen, and Qatar), such aspirations consisted of not much more than the initial avowal of interest, some exploratory activities and negotiations with foreign suppliers, and the announcement of vague target dates for the first operational plant that in most cases will almost certainly be missed. Others (e.g., Algeria and Morocco) began the establishment of regulatory frameworks for a future program and commissioned feasibility studies.

The increased interest in nuclear power throughout the region also led to a flood of memorandums of understanding and cooperation agreements signed with potential suppliers. However, the nuclear industry is renowned for the stark gap between rhetoric and reality, and the signing of cooperation agreements and the announcements of target dates are notoriously unreliable indicators for the seriousness of the effort. More likely than not, many if not most of the announced projects would never have seen the light of day. Nevertheless, some countries made a serious push for nuclear energy. The United Arab Emirates had concrete plans for the construction of four reactors, selected a South Korean consortium to implement the plans, and had established the necessary regulatory framework. Turkey had designated sites for the construction of two plants with a total of eight units, signed a contract with Russia for the construction of the first one, and had plans to construct more plants. Jordan made a serious effort as well. Amman had plans for a total of six reactors, designated a site for the first plant, and short-listed three foreign reactor vendors. Saudi Arabia had announced ambitious plans to construct dozens of reactors but had only taken modest steps toward implementation. Egypt had passed a national nuclear law in 2010, announced plans to construct four plants by 2025, and designated a site for the first one.

On the surface, this leaves a large number of countries that could be seeking nuclear power as a security hedge against Iran. However, few concerns have been raised about the United Arab Emirates seeking nuclear energy for a future weapons program. Abu Dhabi surrendered its right to acquire enrichment and reprocessing technologies, rati-

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3. Mark Fitzpatrick, ed., Nuclear Programmes in the Middle East: In the Shadow of Iran (London: International Institute for Strategic Studies, 2008), 7. This number refers to new programs, and thus excludes Iran. Countries include Algeria, Bahrain, Egypt, Jordan, Kuwait, Libya, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, the United Arab Emirates, and Yemen. For more information on nuclear energy in the Middle East, see Charles Ebinger et al., Models for Aspirant Civil Nuclear Energy Nations in the Middle East (Washington, D.C.: Brookings Institution Press, 2011).
4. The scope of the Middle East for this paper is based on the definition used by the IAEA plus Turkey. Countries with declared interest in nuclear power until March 2011 include Algeria, Bahrain, Egypt, Iraq, Israel, Jordan, Kuwait, Libya, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, Turkey, the United Arab Emirates, and Yemen.
fied the Comprehensive Nuclear Test Ban Treaty (CTBT), and concluded an Additional Protocol (AP) with the International Atomic Energy Agency (IAEA). While Jordan’s refusal to rule out enrichment and reprocessing raised some eyebrows, few commentators could imagine Amman attempting to acquire nuclear weapons. Jordan ratified the CTBT and concluded an AP with the IAEA. Likewise, the modest nuclear aspirations of the small Gulf nations of Qatar and Kuwait caused little alarm despite the fact that both countries have had an antagonistic relationship with Tehran for decades. However, three other countries—Egypt, Saudi Arabia, and Turkey—have appeared in the top spots of every observer’s list of reactive proliferators. The nuclear ambitions of these countries were thus invoked as evidence for the much-cited narrative of nuclear hedging in the Middle East.

The Hedging Narrative

Scholars and pundits have written a vast literature on the topic of nuclear hedging (i.e., a country’s development of civilian nuclear infrastructure to create the foundation for a potential future nuclear weapons program). The hedging narrative has become the most popular explanation for the increased interest of Middle Eastern countries in civilian nuclear power and is commonly invoked in the context of making the case for a potential avalanche of nuclear weapons proliferation that could hit the region.5 The notion that proliferation begets proliferation, a concept coined by scholar Scott Sagan, provides the theoretical foundation for this narrative.6 In this view, states seek nuclear weapons to balance the security threat posed by a rival’s superior conventional or nuclear capabilities, become security threats to other states in the process, and thus inevitably create conditions for further proliferation. In the Middle East, Iran’s nuclear program would be the spark to start such a chain reaction. Saudi Arabia would seek nuclear weapons to counter Iran, prompting Turkey and Egypt to follow suit. A 2007 study by the International Institute for Strategic Studies put it this way: “What they [countries in the Middle East] want is the human and technical infrastructure associated with nuclear-energy programmes in order to provide a counterbalance to Iran, both laying the ground for a possible future security hedge and bestowing national prestige in the context of historic rivalries.”7


scholar Jack Caravelli expressed similar sentiments: “Some Muslims nations almost certainly see commercial nuclear development, because of the dual use nature of the technology, in their nations as providing, inter alia, a hedge against a future nuclear armed Iran.” However, hedging does not equal acquisition. A broad selection of domestic and international factors influences states’ nuclear decisionmaking, and hedging does not, as frequently implied, necessarily equal a political decision to obtain nuclear weapons. While some observers have therefore only raised the possibility that an Iranian bomb could cause further proliferation, others have described this as certain, sometimes describing the consequences in apocalyptic terms of widespread proliferation and instability in the Middle East and possibly even beyond.

Others have criticized this narrative as overtly pessimistic, simplistic, ignorant of historical facts, and out of touch with reality. One critic is the scholar John Mueller, who referred to the forecasting of worst-case proliferation scenarios as “cascadology” and called its advocates “cascadologists”: “Not only has proliferation progressed at a far more leisurely pace than generations of alarmists have routinely and urgently anticipated, but the diffusion that has actually transpired has proven to have had remarkably limited, perhaps even imperceptible, consequences.” There is indeed little empirical evidence to substantiate claims of an impending proliferation avalanche in the Middle East. Analysts concerned about such a scenario have thus invoked the hedging narrative; pointing to the actual or expected spread of nuclear technology throughout the Middle East as “evidence” that rapid proliferation would transpire if Iran acquired the bomb. However, such reasoning might be more indicative of a “grasping at straws” mentality than unbiased factual analysis. The scholar Jacques Hymans put it this way: “Therefore, any shred of evidence that a country is interested in nuclear technology is taken as proof positive that the country is building a ‘nuclear weapons capability,’ after which point it will be only a matter of time before it builds nuclear ‘weapons.’”

Saudi Arabia

Saudi Arabia is widely believed to be the most likely candidate to acquire nuclear weapons if Iran did so. Riyadh has sent unambiguous signals to encourage speculations to this end. The British Guardian reported in 2003 that Riyadh had embarked on a strategic review that considered the acquisition of nuclear weapons as a deterrent. In June 2011, former Saudi intelligence chief and member of the royal family Prince Turki al-Faisal reportedly stated that Saudi Arabia would be compelled to acquire nuclear weapons if Iran

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did so.\(^{13}\) He made similar remarks at a security conference in Riyadh six months later.\(^{14}\) In February 2012, the *Times* of London reported that it had learned that Saudi Arabia would immediately launch a twin-track nuclear weapons program if Iran successfully tested a nuclear device. Riyadh would purchase an assembled weapon from abroad, most likely from Pakistan, to gain an immediate deterrent vis-à-vis Iran. Simultaneously, Saudi Arabia would upgrade its civilian nuclear program to include a military dimension.\(^{15}\) In May 2012, a former senior U.S. diplomat reportedly said that King Abdullah of Saudi Arabia had explicitly stated in a meeting that Riyadh would obtain nuclear weapons if Iran did so.\(^{16}\) However, the credibility of such statements has been questioned. On the one hand, Riyadh has the necessary resources to launch and sustain a nuclear weapons program and also possesses an arsenal of Chinese CSS-2 missiles that, for lack of accuracy, have little utility except when equipped with a nuclear warhead. Furthermore, Saudi Arabia has neither signed the CTBT, nor has it concluded an AP with the IAEA. On the other hand, Riyadh’s lack of experience with nuclear technology has led some to believe that such announcements are not much more than controlled leaks aimed at exerting pressure on the West to prevent Iran from getting the bomb.

Saudi Arabia has partnered with the Gulf Cooperation Council to explore the development of civilian nuclear power in the Gulf region since 2006. In 2009, Riyadh expressed interest in an independent nuclear program, citing the country’s rapidly increasing demand for electricity as justification. Until March 2011, Riyadh had only taken modest steps to advance this agenda. The Saudi government had established the King Abdullah City for Nuclear and Renewable Energy to implement the program and contracted with a consulting firm to conduct a feasibility study. Saudi Arabia’s complete lack of nuclear infrastructure means that Riyadh would have to rely heavily on foreign partners. It therefore signed cooperation agreements with the United States (2008) and France (2011).

**Turkey**

Turkey is the second candidate suspected of seeking civilian nuclear power as a security hedge against Iran. Ankara has justified its civilian nuclear energy plans with Turkey’s rising demand for electricity over the next decades. While Ankara has a less openly antagonistic relationship with Tehran than Riyadh, Turkey’s concerns over Iran’s nuclear program are fueled by Ankara’s fears of losing ground to Tehran in its quest for

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regional hegemony and concerns about regional instability that could have an impact on Turkey’s economic development. Turkey has attempted to play the role as mediator between the West and Iran, has defended Tehran’s right to enrich uranium, has helped broker an ultimately unsuccessful “fuel swap” deal, voted against United Nations Security Council Resolution 1929 (2010)—which imposed additional sanctions on Iran—and has refrained from issuing semiofficial announcements regarding possible nuclear weapons aspirations. In the Turkish case, “confirmation” of a possible interest in nuclear weapons has been mostly confined to reports of closed-door meetings, during which Turkish officials have allegedly acknowledged that their country’s nuclear power plans are at least partly motivated by concerns over Iran. In this context, Turkey’s refusal to forsake its right to enrichment and reprocessing technologies has been portrayed as an additional “indicator” of a possible future weapons program. However, Turkey’s NATO membership and the deployment of U.S. tactical nuclear weapons at the Incirlik Air Base are strong disincentives for an independent nuclear capability. Also, Turkey has excellent nonproliferation credentials. Ankara ratified the CTBT as an Annex II state and concluded an AP with the IAEA.

Turkey has been attempting to develop a civilian nuclear program since 1970. However, planning and financing issues prevented the program from making much progress until Ankara reinvigorated its push for nuclear power in the mid-2000s. After further delays and a troubled tender process, Turkey reached an agreement with a state-owned Russian company, Atomstroyexport, for the construction of four units at Akkuyu, located on the country’s Mediterranean coast. Construction is scheduled to begin in 2013, with the first unit expected to go online in 2018. Although Turkey possesses some nuclear infrastructure, including two research reactors and several research institutions, Ankara will have to rely on foreign partners in its quest for nuclear power. Turkey has concluded cooperation agreements with the United States (2008) and with South Korea (2010).

Egypt

Egypt, the third candidate suspected of seeking civilian nuclear power as a security hedge, has been in a state of constant political turmoil since the overthrow of the Hosni Mubarak government in January 2011. Before the revolution, ambiguous statements made by Egyptian officials fueled suspicions about Cairo’s intentions and reinforced the notion that Egypt was seeking nuclear energy as a security hedge. For instance, then-Egyptian ambassador to the United Nations, Maged Abdel Aziz, said in an interview in June 2010: “But if others will acquire nuclear weapons—and if others are going to use these nuclear weapons to acquire status in the region of the Middle East—let me tell

17. For an overview of Turkish nuclear policies, see The Turkish Model for Transition to Nuclear Energy, edited by Sinan Ülgen (Istanbul: Center for Economics and Foreign Policy Studies, 2011).
you, we are not going to accept to be second-class citizens in the region of the Middle East.”

Six months later, in December 2010, a leaked U.S. diplomatic cable quoted Mubarak telling U.S. officials in 2009 “that Egypt might be forced to begin its own nuclear weapons program if Iran succeeds in those efforts.” Such statements leave room for interpretation. On the one hand, they could be an attempt to not only convey Cairo’s grave concerns over an Iranian bomb to the United States but also to increase pressure on Israel to come clean about its nuclear capabilities and join regional efforts to establish a zone free of weapons of mass destruction. On the other hand, they could indicate genuine deliberations among Egyptian elites about the perceived necessity to acquire nuclear weapons. Egypt has explored the possibility of obtaining nuclear weapons in the past and has always ranked high on the list of potential proliferators. Cairo’s refusal to sign the CTBT or to conclude an AP with the IAEA, along with irregularities in its declarations to the IAEA as part of its comprehensive safeguards agreement regarding unreported activities relating to uranium conversion and reprocessing experiments in 2005, have fueled lingering suspicions about Egypt’s nuclear intentions.

Egypt has been exploring civilian nuclear energy with varying degrees of interest since the mid-1970s. However, a lack of financing and Egypt’s questionable stance on proliferation have hampered the development of a civilian nuclear program. The Mubarak government revived Cairo’s interest in nuclear power in the mid-2000s, citing the country’s increasing demand for electricity, and announced plans to construct the first reactor within 10 years. In 2010, Cairo expanded the plans to four reactors by 2025. The Mubarak government had made some progress in advancing its plans, including signing a cooperation agreement with Russia (2008), contracting an Australian energy services providers for site and selection studies, requesting assistance from the Korea International Cooperation Agency to train Egyptian engineers, and designating a site called El Dabaa on the Mediterranean coast in Northern Egypt as the location for the first plant. However, Cairo had not yet selected a foreign vendor to construct the plant, and it seems questionable if it would have been able to secure financing for the project.

Although Egypt possesses a fairly advanced nuclear infrastructure, at least by Middle Eastern standards, including two research reactors and various other facilities related to

the nuclear fuel cycle, Cairo would need to rely on foreign partners for the plant’s construction and initial operation.

The Fukushima Effect

The narrative of a global nuclear renaissance was a matter of contention even before the outbreak of the crisis in Fukushima. Advocates pointed not only to the rapid expansion of nuclear power in Asia and the widespread interest in nuclear energy throughout the Middle East but also to planned new-build projects and life-cycle extension programs in established nuclear energy countries in Europe and North America. Opponents countered that this narrative was more fiction than fact, arguing that most nuclear new-build projects never made it past the planning stage. Not surprisingly, the skeptics saw Fukushima as another nail in the coffin of a dying industry. For instance, the 2011 edition of the annual, antinuclear *World Nuclear Industry Status Report* asserted: “If there was no obvious sign that the international nuclear industry could eventually turn empirically evident downward trend into a promising future, the Fukushima disaster is likely to accelerate the decline.”

Some countries’ reaction to Fukushima supported this view. Germany suspended its entire reactor fleet, shut down 8 of 17 units permanently, and passed a law to phase out nuclear power completely by 2022. Voters in Italy rejected nuclear power in a national referendum. However, as time passed, it became clear that the effect of the Fukushima crisis on the future of nuclear energy was much more ambiguous. On the one hand, although a few countries decided to phase out nuclear energy, shelved plans to expand nuclear energy, or abandoned plans to possibly pursue nuclear energy, most countries continued their programs. On the other hand, Fukushima might still have a long-term adverse effect on civilian nuclear power by raising construction costs for new plants due to strengthened safety criteria and increasing public opposition to nuclear power to a point where nuclear new-build projects would be politically costly or unfeasible. A February 2012 study by the MIT Center for Energy and Environmental Research came to a more balanced assessment: “We are surprised that public acceptance has not been shaken more by the accident at Fukushima and, if further lessons learned from Fukushima do not increase the political backlash, the same factors that influenced the future trajectory of nuclear generation pre-Fukushima are likely to continue to dominate.”

According to the supporters of the hedging narrative, Iran’s nuclear program was the most important of these pre-Fukushima factors.

Fukushima and Nuclear Hedging in the Middle East

On the surface, interest in nuclear energy in the Middle East has declined since the Fukushima crisis. Bahrain, Israel, and Kuwait scrapped their plans for nuclear power.


The efforts of a number of other countries, including Tunisia and Syria, have stalled. This alone does not allow for the conclusion that Fukushima was the sole dissuasive factor that caused countries to either scrap their plans or not pursue them with much urgency. Did Fukushima fundamentally alter the perceptions of key decisionmakers regarding nuclear energy, or was it just the last straw that broke the camel’s back? Does the ongoing political turmoil in the region, which has resulted in the formation of new governments and changing alliances and power structures, offer a more convincing explanation? Did governments come to the conclusion that the financial and environmental burdens of nuclear power are too high? Or did they move ahead regardless because the perceived threat posed by Iran’s nuclear program was the primary consideration from the beginning? Before examining the effect of Fukushima on the three primary hedging candidates (Egypt, Saudi Arabia, and Turkey), it is useful to first consider nuclear-related developments in other countries in the region. Similarities and differences in nuclear decisionmaking between the “hedgers” and “nonhedgers” could provide clues if the hedging narrative holds true.

Judging by statements made by political decisionmakers, the abandonment of nuclear power by Bahrain, Israel, and Kuwait was a direct consequence of the events in Japan. In March 2011, Israeli prime minister Netanyahu stated that his country probably would not pursue nuclear energy in the coming years, citing the Fukushima crisis as the reason. In July 2011, Kuwaiti deputy prime minister and foreign minister Mohamad Al-Sabah declared that Kuwait was no longer interested in nuclear power. In February 2012, Bahrain’s energy minister, Abdulhussain Mirza, announced that his country had abandoned plans to adopt nuclear power as an alternative energy source. In the case of Israel, it appears doubtful that it would have advanced its plans with much enthusiasm due to the discovery of major natural gas deposits off the country’s northern coast in November 2010. As for Kuwait, there seems to be a more direct connection. The Kuwaiti government has repeatedly voiced concerns about the safety of Iran’s Bushehr plant, a major radiation release at which could potentially have a substantial impact on several Gulf States. The Fukushima crisis seems to have amplified such concerns considerably,
contributing to the decision not to pursue nuclear power further.\textsuperscript{32} In the case of Bahrain, concerns over financing and ongoing unrest in the country seem to have been much more decisive factors than Fukushima. The political turmoil in the region also explains why countries such as Tunisia, Yemen, and Syria have not advanced their nuclear aspirations. Tunisia is in the middle of a transition process to a new government after the overthrow of the Ben Ali regime, the al-Assad regime in Syria is on the brink of collapse in the wake of the civil war raging in the country, and Yemen is battling regional autonomy militias and Al-Qaeda militants to prevent the disintegration of the country. Jordan’s nuclear future also appears doubtful, albeit Amman remains committed. Concerns over financing and escalating costs, a parliamentary vote to suspend the program in May 2012, growing public opposition and doubts about the accuracy of government estimates of the country’s uranium reserves have cast a shadow on Jordan’s nuclear future.\textsuperscript{33} At the very least, it is likely that Amman will not be able to start the construction of its first plant as scheduled in 2013. The nuclear plans of the United Arab Emirates have been largely unaffected by Fukushima. Despite a safety review and assurances that the mistakes made in Japan would not be repeated in the Emirates, public skepticism remains high. However, this has not swayed Abu Dhabi’s commitment to move ahead. In July 2012, construction commenced at the Barakah site.

Fukushima has caused a substantial increase in public opposition to nuclear power in countries presumed to have nuclear aspirations for other reasons than as a security hedge. In some countries (e.g., Jordan), this has led to the emergence of antinuclear movements not unlike other such civil society pressure groups that have had a considerable influence on nuclear decisionmaking in several European countries. However, with the exception of Kuwait, political unrest in the region and financing concerns are far more plausible explanations for the fading enthusiasm for nuclear power. Nevertheless, the hedging narrative suggests that the nuclear power plans of Saudi Arabia, Turkey, and Egypt could be expected to have remained largely unaffected by such considerations.

There is a strong case to be made that Fukushima had no discernable adverse impact on Riyadh’s nuclear energy plans. In fact, preparatory activities seem to have accelerated, and there is little evidence of a public protest movement. In June 2011, Saudi Arabia announced plans to construct 16 units by 2030, and three months later it hired an Australian energy services provider to select potential sites and compare foreign vendors interested in constructing the plants.\textsuperscript{34} Riyadh also concluded three more cooperation agreements with

cleID/158727/reftab/149/t/Kuwait-concerned-over-Iran-s-Bushehr-nuclear-plant--/Default.aspx.
Argentina (2011), with South Korea (2011), and with China (2012). On the surface, Saudi Arabia’s intensified efforts to develop nuclear power after Fukushima buttress the hedging narrative. Also, the political turmoil in Middle East has left Riyadh feeling more insecure than ever. However, as of July 2012 the Kingdom’s plans still lack concreteness, and it appears doubtful that Riyadh has made the final decision to go ahead. At the very least, the construction of 16 units by 2030, with the first two to be completed by 2021, seems ambitious if not unrealistic. Given this apparent lack of urgency, it might arguably seem implausible to describe Saudi Arabia’s nuclear behavior as hedging. However, if Riyadh in fact has the option of acquiring nuclear weapons from Pakistan on short notice, the pace of implementation might not necessarily be indicative of the Kingdom’s intentions.

Turkish officials have stated repeatedly that Fukushima would not affect Ankara’s nuclear energy plans. Preparations to begin construction at Akkuyu continue, as do talks with foreign partners for the Sinop plant. Turkey also signed two more cooperation agreements with Japan (2012) and China (2012). Ankara appears set to go ahead, albeit the scope of the program will almost certainly be smaller than announcements by the Turkish government indicate. Turkey’s minister of energy, Taner Yildiz, said in June 2012 that Turkey would have twenty-three units by 2023, a plan that seems highly ambitious. 35 While Fukushima does not appear to have influenced political decisionmaking, events in Japan have reinforced antinuclear sentiments in an already skeptical populace. Turkey has seen the rise of an activist antinuclear movement that could cause trouble for Ankara’s plans in the future. As of July 2012, given Turkey’s nonproliferation credentials, the determined but not rushed development of its civilian nuclear plans, and the heavy reliance on foreign vendors, it is hard to make a case that Ankara is pursuing a strategy of nuclear hedging against Iran. However, the outbreak of the civil war in Syria has led to a marked deterioration in Turkish–Iranian relations. 36 Tehran has been particularly incensed by Ankara’s decision to host an early-warning radar on its territory as part of NATO’s missile shield, prompting half-concealed threats that Iran would bomb the installation if attacked. 37

Because Egypt’s political future remains uncertain as of July 2012, an assessment of Egyptian nuclear weapons aspirations, possible hedging strategies, and the impact of Fukushima must be regarded as preliminary. Representatives from the Egyptian Atomic Energy Authority (EAEA), a subsidiary of the Ministry of Electricity, stated that there was no technical reason for the crisis in Japan to affect Egypt’s plans. 38 Although Egypt officially suspended its program in 2011, support in the bureaucracy for nuclear power appears to...
remain strong. The EAEA has continued with preparatory activities, including drafting an action plan for implementation that the authority was reportedly preparing to submit for political approval in July 2012. However, the uncertainty regarding Egypt’s future power structures makes it seem questionable if Egypt would be able to implement a program even if a political decision to do so was taken. The political instability in the country and the ascendance of the Islamist Muslim Brotherhood (MB) would likely deter foreign investors from becoming involved in long-term, hugely expensive energy infrastructure projects. Fukushima has further complicated the potential implementation of a nuclear program by contributing to the emergence of a nationwide activist movement against nuclear power.

In one incident in January 2012, violent protests broke out at El Dabaa, the site designated for Egypt’s first nuclear power plant. The demonstrators, who rallied against forced resettlements and the demolition of houses by government forces to clear the construction site, demanded the termination or relocation of the project. The clashes reportedly also involved the theft of low-level radioactive sources from a laboratory at the site.

At the time of writing, it is hard to make a case for ongoing nuclear hedging in Egypt. Fukushima has complicated the pursuit of such a strategy in the future. However, developments in post-Mubarak Egypt are hard to predict. If the Supreme Council of the Armed Forces can maintain its position as the country’s ultimate power base, Egypt could likely be expected to proceed with caution and restraint on the nuclear issue. If, however, the Islamist MB becomes the strongest faction in the new Egypt, the equation could change. Before the revolution, MB’s leaders repeatedly called openly for an Egyptian nuclear deterrent against Israel. Although MB’s leaders have recently tuned down their rhetoric, the organization’s uncertain stance on the nuclear issue remains a reason for concern. The political adoption or dismissal of the EAEA’s implementation plan could provide further indications regarding Egypt’s alleged nuclear hedging against Iran, especially if Cairo would continue its opposition to the conclusion of an AP with the IAEA and the surrender of its right to enrichment and reprocessing.


44. Ibid.
Conclusion

There is little evidence to date suggesting that the nuclear crisis in Japan has had a strong impact on nuclear decisionmaking in the Middle East. With the exception of Kuwait, while Fukushima may have contributed to the abandonment or postponement of some programs, continuing political unrest in the region and financing issues are more plausible explanations.

The hedging narrative suggests that Saudi Arabia, Turkey, and Egypt could be expected to continue their push for nuclear power despite Fukushima. On the surface, this seems to be the case. Saudi Arabia has even intensified its preparatory activities post-Fukushima. While this lends some credence to the hedging narrative, it does not prove its validity. If the perceived threat from Iran’s nuclear program is indeed the primary motivational factor for those countries’ civilian nuclear power programs, why are they not implementing them more urgently in light of continuing Iranian progress in developing the fuel cycle and especially enrichment technology? This is a question that the proponents of the hedging narrative will have to answer. The current pace of nuclear development in the region hardly backs up claims of an impending proliferation cascade.

Fukushima has had more of an impact on civil society than on political elites. Rising public opposition to nuclear power and activists’ protests against pursuing it could make hedging strategies more difficult to implement. This is particularly true for Egypt and to a lesser extent for Turkey. In the Saudi case, public opposition does not appear to be a factor.
North Korea’s Compellence Strategy
A Case Study in Nuclear Latency
Tristan Volpe

North Korea provides a useful case to study the international security implications of nuclear latency. Why did Pyongyang use its nuclear fuel cycle—specifically plutonium reprocessing, and later uranium enrichment—as an independent strategic capability? This paper argues that changes in the post–Cold War security environment drove North Korea to pursue a strategy of compellence with the nuclear fuel cycle. The explanation is presented in five sections. The first analyzes the security situation that North Korea faced during the Cold War, and the second links this environment to Pyongyang’s decision to focus on conventional military power. The third section examines the structural changes that North Korea confronted at the end of the Cold War, and the fourth explains why this new environment caused Pyongyang to adopt a joint security posture that combined conventional deterrence with nuclear fuel cycle compellence. The final section posits that North Korea currently faces a dilemma between continuing to use its nuclear program as a means of compellence and the gradual solidification of nuclear deterrence over time. Failure to resolve this quandary will soon push North Korea into a danger zone of crisis instability with the United States.

As the Cold War entered its final phase in 1989, North Korea began construction on an industrial-scale plutonium-reprocessing plant at the Yongbyon nuclear research complex. Within three years, work on the facility reached a terminal stage. The United States worried that the huge plant could soon be used to separate significant quantities of weapons-grade plutonium from spent fuel irradiated by a modest reactor at Yongbyon. Although party to the Nuclear Non-Proliferation Treaty, North Korea did not place the reactor or the reprocessing facility under international safeguards. As a result, North Korea acquired the latent capability in 1991 to threaten other states with the acquisition of nuclear weapons in the near future. Over the next decade, Pyongyang used this opaque nuclear fuel cycle posture to compel material resources and other concessions from the United States.

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North Korea provides an apt case to study the international security implications of nuclear latency. Given the security benefits of nuclear deterrence, why did Pyongyang use its nuclear fuel cycle as an independent strategic capability? This paper argues that changes in the post–Cold War structural environment drove North Korea to pursue a strategy of compellence with the nuclear fuel cycle. This explanation contributes to the burgeoning literature on North Korea and nuclear proliferation. North Korea’s conventional military balance, nuclear weapons program, and sensitive nuclear technologies have received extensive analytic treatment. Yet less attention has been paid to Pyongyang’s use of its nuclear fuel cycle as an instrument of compellence. The case study advanced here draws from a more general theory of nuclear latency to fill this gap.

This paper proceeds in five main sections. The first analyzes the security situation that North Korea faced during the Cold War. The second section links Pyongyang’s Cold War environment to its choice of strategy and means. Although nuclear deterrence appeared optimal, the structural situation drove North Korea to rely on conventional military power as a means of denial and offense. The third section examines the rapid and significant structural changes that North Korea confronted at the end of the Cold War, specifically the meteoric rise of South Korea and the loss of patronage from the Soviet Union and China. The fourth section explains why the post–Cold War environment caused North Korea to adopt a new joint security posture that combined conventional deterrence with nuclear fuel cycle compellence. The final section highlights areas of ongoing research and policy implications. In particular, the conclusion probes the contemporary trade-offs that North Korea faces between continuing to use its nuclear program as a means of compellence and the gradual solidification of nuclear deterrence over time.

North Korea’s Severe Structural Environment during the Cold War

During the Cold War, North Korea faced a severe security environment. At the structural level, it confronted a dangerous material and informational situation with its primary adversaries: the United States and South Korea. As a superpower in a bipolar world, the United States was much stronger than North Korea along every possible index of power, and it had forward-deployed tactical nuclear forces on the Korean Peninsula to deter future aggression. A history of repeated nuclear threats exacerbated this relative power asymmetry. During the Korean War, Truman and Eisenhower threatened to bring nuclear capabilities to bear against North Korean and Chinese troops. In the subsequent decades of stalemate, North Korean intransigence prompted the United States to mobilize its nuclear-capable naval and air forces into the Sea of Japan to compel acquiescence on three separate occasions. North Korea therefore found itself in direct confrontation with a nuclear-armed superpower throughout the Cold War.

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The balance of power between North Korea and its primary regional adversary in the South changed over time. South Korea remained much weaker than its Northern adversary until the 1970s, when investments in economic, industrial, and military capability started to shift the regional power balance in favor of the South. South Korea also relied on the extended nuclear deterrent umbrella provided by the United States. Nonetheless, the South attempted to deploy a nuclear fuel cycle posture under the hard-line rule of General Park Chung-hee in the early 1970s. Although Park never decided to produce a South Korean nuclear weapon, “he was determined to acquire the technology and capability to do so on a few months’ notice,” and he thus requested French assistance to build an industrial-scale plutonium-reprocessing plant in 1972. The United States threatened to sever its alliance commitments if South Korea did not forgo the transfer of reprocessing technology, and Park canceled the French contract. In sum, as South Korea evolved into an economic power with nuclear fuel cycle ambitions, the material constraints on North Korea grew more severe at the regional level.

The informational relationship further compounded the severity of North Korea’s security situation. Even though North Korea initiated the Korean War, Pyongyang believed that the United States and South Korea wanted to unify the peninsula through force. The pattern of bellicose interaction among these adversaries solidified a mutual perception that each side held revisionist motives. North Korea frequently attempted to achieve offensive and revisionist policy objectives, from numerous assassination and terrorist operations against civilian and military targets, to a concerted campaign to pressure American withdrawal from the peninsula in the 1970s. To the North Koreans, conversely, the extensive strategic bombing campaign during the Korean War, repeated nuclear threats from the United States, and the desire of hard-line South Korean leaders to invade the North constituted strong evidence that they faced greedy adversaries.


Pyongyang’s Cold War Strategy and Means

The severe structural environment created three core security objectives for North Korea. First, North Korea needed to dissuade coercive threats from the United States. A deterrent posture based on an assured threat of nuclear retaliation would be the most efficient choice for the relatively weak and small regional state to a superpower from aggression. Second, North Korea wanted to mitigate proximate threats from South Korea. The adoption of a nuclear deterrent posture would also create an asymmetric strategic advantage for North Korea over the nonnuclear South Korea, thereby dampening the threat of proximate invasion from the South. Third, the North desired to unify the Korean Peninsula by annexing the South. A nuclear deterrence posture may have given the North some leverage to compel territorial demands and alter the regional status quo. As a result, nuclear deterrence was an optimal posture for North Korea as it sought to achieve these objectives in a highly constrained environment.

Despite the benefits of nuclear deterrence, North Korea instead adopted a strategy of deterrence by denial, and it deployed extensive conventional forces to deny the United States and South Korea the ability to perform successful military missions. The foundations of this denial posture emerged in the aftermath of the Korean War. As North Korea focused on reconstruction, the United States forward-deployed ground forces with tactical nuclear weapons in South Korea, thereby augmenting its ability to attack the North. In the 1960s, North Korea began to prepare for a war that included the serious contingency of nuclear strikes, and it thus built extensive hardened defenses. From 1972 to 1980, the North built up enough conventional military power to acquire major defense-in-depth and offensive capabilities vis-à-vis the United States–South Korea allied force. While North Korean forces also threatened punishment against value targets in the South, the primary emphasis was on deterrence by denial during the Cold War.

However, a denial strategy suffers from two limitations that make it a puzzling choice for North Korea relative to deterrence by punishment with either nuclear or conventional capabilities. First, a weak regional defender often cannot build up the conventional forces sufficient to deny its superior rivals the ability to perform military missions. Although the unique geography of the Korean Peninsula favors defense, the North still needed an

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7. Throughout the 1970s, North Korea “emphasized the commitment of scarce resources, development of industry, and military expansion” to create a military force capable of both defense and an offensive “Two-Front War” against South Korea. The war plan envisioned that a very large conventional force would destroy South Korean forward forces along the Demilitarized Zone and envelop the peninsula. At the same time, North Korean special operation forces (SOF) would infiltrate deep into the South Korean rear to neutralize the U.S.–South Korean command, control, and communication infrastructure. To build such a military, North Korea devoted “between 32 and 38 percent of central government expenditures” to defense, began a major “reorganization and modernization of its ground forces,” and dramatically increased SOF personnel strength from 15,000 in 1970 to 80,000 by 1984. See Andrew Scobell and John M. Sanford, North Korea’s Military Threat (Carlisle, Pa.: Strategic Studies Institute, U.S. Army War College, 2007), 9, 21, 32, 43; Hayes, Pacific Powderkeg, 133.
expensive defense-in-depth capability coupled with the ability to perform counterforce missions. Second, a denial strategy relinquishes the risk and cost calculus of attack to the adversary. The rival will selectively engage when the probability of success is high, and it is able to absorb the costs associated with overcoming the opponent’s defensive forces. Given the asymmetry in power relative to the United States and eventually South Korea, such a strategy required significant and continual investments in North Korea’s economic power base and military capabilities. North Korea opted to deploy an expensive and risky conventional force posture against its adversaries.

Three factors drove North Korea to mitigate and accept the costs/risk calculus of deterrence by denial. First, North Korea could not produce nuclear weapons within a time frame sufficient to deter imminent aggression. North Korea had to develop de novo the scientific and technological capacity to produce nuclear weapons with assistance from abroad, and it turned to the Soviet Union to help lay the foundation. North Korean scientists started to train at the United Institute for Nuclear Research near Moscow in the 1950s, and Soviet assistance was instrumental in bringing the research reactor at the Yongbyon nuclear complex, along with a radiochemical laboratory and auxiliary technical facilities, to fruition in the 1960s. The Soviets, however, opposed an independent North Korean nuclear deterrent, and they did not transfer more sensitive technology. North Korea would have to pursue a clandestine program so as not to alienate its key source of nuclear technology and support, which could take decades without the transfer of enrichment or reprocessing technology. Since North Korea feared a looming attack from the South, it could not depend exclusively on the future acquisition of nuclear deterrence.

Although North Korea emphasized the primacy of conventional military power and civil nuclear cooperation with the Soviet Union, the beleaguered state did attempt to acquire nuclear weapons from China, and ultimately initiated an indigenous military program. In 1964, Kim Il Sung requested that Mao Zedong “share the atomic secret” with North Korea after the successful Chinese nuclear weapon test. In response to South Korea’s nuclear fuel cycle program, Kim sent another request in 1974 for nuclear weapons technology and military assistance. China refused both inquiries. Unable to acquire the requisite capabilities from the Chinese, Kim decided in the late 1970s “to initiate

10. The Soviet Union helped in the design and construction of the hot-cell facility, but did not transfer industrial scale reprocessing technology. See Zhebin, “Political History,” 32–34.
11. Hayes, Pacific Powderkeg, 162.
a nuclear weapons program, which was to include a rapid expansion of the Yongbyon facilities.”  

13. Work began in 1980 on a 20- to 30-megawatt reactor at Yongbyon that was well suited to the production of weapons-grade plutonium in the spent fuel.  

14. By 1984, the reactor’s core, smokestack, and control building were complete, though the North Koreans needed Soviet assistance to finish the project.  

15. In 1985, Moscow induced Pyongyang to accede to the Nuclear Non-Proliferation Treaty in return for technical assistance, and reactor operations began one year later.  

16. Consequently, the severe security environment did drive North Korea to pursue a secondary nuclear deterrent option alongside its primary conventional security posture, and these facilities were ostensibly built to produce an eventual military capability. Yet North Korea also understood that it could not acquire a nuclear deterrent quickly enough to mitigate immediate Cold War threats, and it therefore devoted defense resources to building a conventional capability.

The second driver of North Korea’s denial strategy stemmed from the risk- and cost-accepting nature of South Korea. Although the nuclear route did not meet North Korea’s immediate security needs, the conventional retaliation option would also be risky and difficult. As demonstrated during the Korean War, the North could rapidly counterattack a frontal U.S.-South Korean assault and lay siege to Seoul. Yet even this threat of severe punishment against the South Korean capital city may not have been enough to dissuade several hard-line South Korean leaders from launching a military unification campaign. The United States feared entrapment in a second Korean war for several decades, and the nascent United States–South Korea alliance may not have been enough to restrain the bellicosity of Syngman Rhee or General Park. If either leader believed it acceptable to strike the North and unify the peninsula at the cost of Seoul, then deterrence by punishment was bound to fail. North Korea needed a denial strategy to dissuade South Korea from attack.

Third, powerful allied patrons offset and buttressed the power asymmetry between the North and its adversaries. Alliances with the Soviet Union and China mitigated the costs and risks intrinsic to deterrence by denial. Although the North swung between its


15. The U.S. Central Intelligence Agency determined that North Korea still needed “to develop advanced engineering techniques to master the remote control operations that are necessary for handling highly radioactive materials.” See U.S. Central Intelligence Agency, “North Korea: Nuclear Reactor Under Construction,” April 20, 1984, 2.


two patrons to extract maximum material support, the Soviet Union remained the main source of economic assistance, and it thus “continued to fuel North Korea’s economy and military machine throughout the Cold War.” The Soviets transferred massive quantities of commercial goods, energy imports, and industrial-military technology. These subsidies allowed the North to choose both guns and butter during the Cold War.

In addition, a mutual defense treaty between Moscow and Pyongyang helped assuage the nuclear threat from the United States by increasing the risk that a conflict on the peninsula would escalate into general war between the two superpowers. Moscow’s security umbrella, combined with North Korea’s conventional denial and counterforce capabilities, obviated the pressure to develop an immediate nuclear arsenal, and may have prevented the conspicuous deployment of enrichment or reprocessing assets early in the Cold War. As with most alliances, the relationship between Moscow and Pyongyang was strained at times. North Korea lost confidence in the security commitment after witnessing the Soviets acquiesce to the United States during the Cuban Missile Crisis in 1962. The alliance then slumped into a nadir during the mid-1960s, when the USSR suspended military and economic assistance for three years. The fear of abandonment only drove Pyongyang to further build up and modernize its conventional capabilities once Moscow turned the aid spigot back on in 1965. Despite the occasional schisms that emerged throughout the Cold War, allied patronage and extended deterrence constituted an important element of North Korea’s deterrence by denial strategy.

The North Korean decision to deploy a posture of conventional deterrence by denial during the Cold War matters in the context of nuclear latency for three reasons. First and foremost, the posture committed North Korea to continually building up its conventional force capabilities as the central means to practice deterrence on the Korean Peninsula. Conventional military power became the “crux of the Korean confrontation.” As a result, North Korea entrenched itself as a garrison state and “perhaps the most militarized society in the world” by the 1970s. Second, North Korea’s relative power asymmetry necessitated a dependence on foreign assistance from the Soviet Union and China to build the military it needed. Patronage sustained conventional military power and therefore became a central tenant of North Korean strategy. Finally, North Korea laid the foundations for its future nuclear fuel cycle posture, albeit with the intent to produce a nuclear deterrent in the future. The creation and expansion of Yongbyon was not tied


Structural Changes in the North Korean post-Cold War Security Environment

As the Cold War ended, North Korea’s structural power situation changed along three dimensions. First, the collapse of the Soviet Union left the United States as the lone superpower. The international system transformed into a unipolar power structure, with North Korea’s Cold War rival at the center. Second, South Korea’s juggernaut economy grew at a rapid pace to eclipse North Korea as the dominant regional power. Economic statistics paint a bleak picture. South Korea’s gross national product (GNP) was more than seven times that of the North by 1988. Even though North Korea spent between 20 and 25 percent of its GNP on defense, South Korea’s military budget was roughly double, at a mere 5 percent GNP allocation. A vibrant export market in consumer and industrial goods generated a trade surplus with double-digit growth rates for South Korea. In desperate need of economic assistance, the Soviet Union reversed its policy toward South Korea to normalize diplomatic and trade relations. China followed Moscow, and trade between South Korea and North Korea’s primary Cold War sponsors burgeoned into a multi-billion dollar market by 1991. At the international and regional level, North Korea faced a massive and growing disparity in power with its Cold War rivals.

The third dimension concerned the loss of allied patronage from the Soviet Union and China. These states buttressed North Korea’s economic and military power, and they thus constituted an important part of the material situation that Pyongyang faced during the Cold War. Moscow subsidized the majority of North Korean energy imports, military hardware, and consumer goods, while China provided the rest. Yet the change in the international distribution of power drew these countries into a close relationship with South Korea and a concomitant deep freeze with North Korea. In 1991, the Soviet Union terminated the traditional concessional system and demanded hard currency for exports at market value to North Korea. China subsequently followed Moscow’s lead, and North Korea found itself with a devastating shortfall in energy imports that crippled its economy. The loss of Soviet and Chinese sponsorship exacerbated North Korea’s decline in relative power.

26. In 1988, Moscow exported $1.9 billion in goods to North Korea, but only imported $0.9 billion in return. The Soviets thereby provided Pyongyang with “an increasing quantity of oil and gas, weapons, and a variety of other goods on easy credit and concessional terms,” and constituted “nearly 3/5 of North Korea’s total trade turnover.” When the sponsorship ended in 1991, North Korea’s energy imports fell by 75 percent from the 1990 level. China did not make up this
The structural parameter of nuclear weapons did not change significantly in the new unipolar world. South Korea remained a non–nuclear weapon state, albeit with a sophisticated civil nuclear energy sector sans enrichment or reprocessing technology. The United States continued to maintain a robust nuclear strike capability against North Korea. As part of an international initiative, the United States withdrew all ground-based tactical nuclear weapons from the Korean Peninsula in 1992. But the basic nuclear–non-nuclear relationship between the United States and North Korea endured as the Cold War came to an end. North Korea soon found that the potential to acquire nuclear weapons and upset this asymmetric balance generated an important threat vector against the United States.

Although North Korea faced dire changes in the material power situation, the informational relationship with the United States and South Korea became much more benign. Most important, South Korea’s behavior as the Cold War ended signaled that it was most likely a security seeker. The domestic political situation in South Korea faced a watershed moment in 1987 as the country shifted from decades of authoritarian rule to democracy. This transition had a profound impact on foreign policy. South Korea eased its traditional hard-line anticomunist stance and launched historic public and secret negotiations with North Korea’s leaders. While South Korea’s meteoric rise posed a threat to the North, the fledgling democracy valued regional stability as the sine qua non condition of continued growth and international commerce. Unification of the peninsula remained important, but the costs to South Korea under any scenario were staggering. South Korean leaders no long viewed the use of military force to annex the North as a rational or desired option.

North Korea’s perception of United States’ motives also improved, though oscillatory behavior introduced considerable uncertainty. In 1988, the United States established the first “mutually authorized, direct channel for diplomatic business” with North Korea. Yet the annual Team Spirit joint military training exercise between U.S. Forces Korea and the Military of South Korea continued apace, with over 200,000 person-

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27. See Kang et al., “South Korea’s Nuclear Surprise”; Hersman and Peters, “Nuclear U-Turns.”


30. Oberdorfer, Two Koreas, 196.
nel and nuclear-capable delivery vehicles participating in the 1988 and 1989 rounds. North Korea contended that Team Spirit was preparation for an invasion of the North, and perceived the exercises “as deeply threatening.” Despite the continuation of Team Spirit, North Korea faced a precarious situation without allied sponsorship: “The fact that there was no socialist ally on which North Korea could rely for its security and survival pushed Pyongyang to approach the only superpower, the United States.” North Korea gambled on the United States as a security seeker.

In sum, North Korea faced rapid and significant changes in its structural situation at the end of the Cold War. The rise of South Korea and the loss of communist sponsorship created an acute disparity in power that threatened the state’s survival. Yet Pyongyang also confronted a very different risk-averse Seoul driven by security-seeker motives and dependent on economic growth. The United States still posed an existential threat, but North Korea came to perceive the superpower as a potential source of foreign assistance. As the next section demonstrates, North Korea consequently manipulated the threat of nuclear arsenal acquisition to compel material resources from these adversaries and support conventional deterrence.

The Joint Security Posture: Conventional Deterrence and Nuclear Fuel Cycle Compellence

North Korea developed a joint security posture to achieve two main security objectives in the post-Cold War environment. First, North Korea needed to deter much stronger adversaries from unacceptable aggression. Deterrence by punishment with an assured conventional retaliation capability allowed Pyongyang to achieve this core objective. Second, North Korea also required new sources of foreign assistance to buttress its conventional posture. As a result, Pyongyang adopted a concomitant strategy of compellence and deployed an opaque nuclear fuel cycle posture to accomplish this end. This section explains why North Korea turned toward such a unique duality in strategy and means.

North Korea’s first objective focused on the deterrence of potential aggression from far superior adversaries, especially regionally dominant South Korea. The new material power situation undermined the efficacy of traditional deterrence by denial. To maintain such a capability, North Korea needed to achieve substantial economic growth and deploy modern military technology commensurate with U.S.–South Korean capabilities. The massive gap in power and technological capability made it very difficult for North Korea to meet these requirements. The Sino-Soviet freeze on patronage compounded the power asymmetry to make deterrence by denial an untenable strategy. North Korea

31. B-52 nuclear bombers and nuclear-capable Lance long-range missile systems were introduced into Team Spirit during the 1970s. See John F. Farrell, “Team Spirit: A Case Study,” *Air and Space Power Journal* 23, no. 3 (Fall 2009).
34. Scobell and Sanford, *North Korea’s Military Threat*, 32–33.
could no longer deny its adversaries the ability to perform missions; nor could it accomplish counterforce missions without inviting total defeat. As a consequence, North Korea shifted to a posture of deterrence by punishment with an assured conventional retaliation capability.  

Conventional deterrence by punishment was an optimal choice because North Korea solved two important limitations with the posture. First, a regional power will often find it difficult to perform a counterstrike retaliatory mission against a superpower. Indeed, North Korea lacked the force projection capability to threaten mainland targets in the United States. Yet the operational requirements for deterrence on the Korean Peninsula stipulated that North Korea only needed military forces sufficient to absorb an attack from a combined U.S.–South Korean force, and then counterstrike value targets beyond the initial battlefield, such as civil and industrial centers in South Korea. North Korea therefore focused on reconfiguring its conventional forces to achieve a virtual assured retaliation capability against Seoul and other United States assets in East Asia. With regard to Seoul, this necessitated the deployment of hardened long-range artillery and multiple-rocket launcher systems with credible command and control. Consequently, the United States faced a high-probability threat of punishment against targets it valued.

Conventional deterrence poses a second limitation for the defender if the adversary believes it can accomplish objectives before the cost of punishment become too great. North Korea believed that South Korea held such a deterrent calculus under the leadership of Rhee and Park, and it therefore focused on denial during the early Cold War. But North Korea perceived two changes to South Korea’s calculus in the post–Cold War environment. Foremost, Seoul could not escape rapid and tremendous punishment from North Korea’s reconfigured forces. The capital city and central nervous system of South Korean power lay a mere 40 kilometers from the Demilitarized Zone (DMZ). In the late 1980s, North Korea moved “roughly 65 percent of its total units and up to 80 percent of its estimated aggregate firepower” within 100 kilometers of the DMZ and concentrated on hardening its artillery strike force along the western front near Seoul. 

Basic artillery assessments conclude that Seoul would accrue significant human and infrastructural damage in a very short period of time, even with sophisticated U.S.–South Korean counterstrike measures. Since South Korea was now a security seeker whose prosperity and power were tied in large part to Seoul, the threat of assured conventional punishment provided North Korea with an effective posture relative to its traditional reliance on denial.

Of course, the forward disposition of forces along the DMZ could support an offensive invasion of South Korea. Some specialists posit that North Korea aimed to reunify the peninsula, and the concentration of military power near the border served as a means to accomplish this long-term goal. While these forces also generated an effective deterrent against aggression, they may have been organized and deployed to retake the South. As one proponent of this perspective concluded, “North Korea’s military strategy is offensive and is designed to provide a military option to achieve reunification by force, employing surprise, overwhelming firepower, and speed.” This proposition is controversial. Under most engagement scenarios, North Korea would not be able to accomplish the military missions necessary for unification. Even if North Korea used a surprise attack to overwhelm South Korean defenses, it could not hold territory in the face of a combined U.S.–South Korean counterstrike; nor does it have the political and economic acumen necessary for the long-term occupation and pacification of South Korea. Given the asymmetry in power that developed in the late 1980s, North Korea’s end game “changed from one of hegemonic unification to basic survival.” Thus, in the post–Cold War environment, reunification of the peninsula was no longer an achievable security objective.


41. See Defense Intelligence Agency, North Korea, 3–4; Hodge, “North Korea’s Military Strategy,” 68–70; Scobell and Sanford, North Korea’s Military Threat, 23–26; Minnich, North Korean People’s Army, 68.


43. For a good overview of the disagreement, see Andrew Scobell, North Korea’s Strategic Intentions (Carlisle, Pa.: Strategic Studies Institute, U.S. Army War College, 2005), 3–13; Victor D. Cha and David C. Kang, “The Debate over North Korea,” Political Science Quarterly 119, no. 2 (2004): 229–254.

44. See Beldecos and Heginbotham, “The Conventional Military Balance In Korea,” 1–9; O’Hanlon, “Stopping a North Korean Invasion,” 135–170. Many analysts doubt North Korea’s ability to conduct such an operation. “South Korean acquisition of military hardware (both quality and modern), significantly improved weapon and sensor technology, and urbanization—coupled with presence of U.S. forces, precision munitions, counterbattery fire, and bunker-buster bombs—has diminished North Korea’s chances of a military reunification.” Scobell and Sanford, North Korea’s Military Threat, 32–33.

The second security objective for North Korea was to compel material resources from foreign governments. The post–Cold War posture of conventional deterrence promised to ensure the external survival of the state against superior adversaries at less cost than the traditional denial strategy. Yet the loss of sponsorship from the Soviet Union and China severely shocked North Korea’s fragile and stagnant economy, and even the new force posture required significant capital investments. Without foreign assistance, North Korea could not sustain its autarkic economy and the conventional capabilities necessary for deterrence. It thus needed to find new patrons to provide resources in lieu of its former communist sponsors. But because no states volunteered to sponsor it, it adopted a strategy of compellence to manipulate material concessions from involuntary patrons.

The compellence of material resources from other states is not a strategy unique to North Korea. As Byman and Lind adroitly point out, the manipulation of foreign governments is a standard tool used by dictatorial regimes to ensure survival: “External governments can be used as a source of financial aid, enabling a regime to gain resources without having to make concessions at home.”

46 The internal logic of selectorate economic distribution in North Korea stipulates that the ruling Kim regime maintained a select group of elites to stay in power, and thus only needed enough foreign assistance to sustain the military and cultivate this elite selectorate. Since “the health of the overall economy is less important than the regime’s ability to bribe elite supporters,” the total level of material resources needed to ensure the survival of North Korea’s state apparatus is a manageable demand for most powerful states to meet. Most important, these material concessions dwarf the massive costs that would stem from the implosion of the regime, through internal revolution, external military action, or any other scenario of Korean unification. Acquiescence to such a strategy of compellence becomes quite a rational option for cost-averse target states.

49 Before North Korea could craft an appropriate means of compellence, it needed to select a primary target. Three candidates existed. Within the region, South Korea and Japan could provide North Korea with “large infusions of cash and technology,” but domestic and international factors in both countries constrained their international


47. On selectorate theory, see Bruce Bueno de Mesquita et al., The Logic of Political Survival (Cambridge, Mass.: MIT Press, 2003). On the political, economic, and social structure of North Korea, see Oh and Hassig, North Korea through the Looking Glass, 65–67, 96–102, 133–135; Noland, Avoiding the Apocalypse, 59–142; Bechtol, Defiant Failed State, 186–187.


49. North Korea also conducts overt and covert funding operations—conventional weapon sales, arms technology transfers, narcotics and counterfeit money production, etc.—to maintain a flow of hard currency to the Kim regime. Much like the foreign compellence strategy, these operations “provide essential support for the survival of North Korea as a sovereign state.” See Robert D. Wallace, Sustaining the Regime: North Korea’s Quest for Financial Support (Lanham, Md.: University Press of America, 2006), 1; and Victor Cha, The Impossible State: North Korea, Past and Future (New York: Ecco, 2012), chaps. 4–5.
behavior toward Pyongyang and posed risks to long-term regime survival. The United States was the primary target for two reasons. First, the United States could coordinate the behavior of its East Asian allies in response to North Korea’s compellence process. South Korea and Japan still became enmeshed in the dynamic as important sources of material concessions, but North Korea always focused on the United States. Second, the material costs of acquiescence were relatively low for the lone superpower. The United States possessed abundant capital and technology, but also the military capability to resist North Korea’s demands. If Pyongyang’s means of punishment did not exact direct kinetic damage against the United States, then the costs of resistance—especially military action—would far outweigh the cost of giving up a relatively small slice of material resources. In an ironic twist, the preeminence of American power made it a ripe target for Pyongyang’s compellence strategy.

With the United States as the primary target, North Korea crafted a means of indirect punishment with the nuclear fuel cycle. Throughout the Cold War, North Korea used limited conventional provocations, special operation missions, and acts of terrorism to coerce and compel the United States, South Korea, and Japan. North Korea eschewed its traditional reliance on these kinetic capabilities and used nuclear fuel cycle assets to practice the new strategy of compellence. Four factors drove this unique choice of means.

First, the nuclear–nonnuclear structural asymmetry between the United States and North Korea allowed Pyongyang to use the fuel cycle as an indirect means of punishment. North Korea configured the reprocessing facility at Yongbyon to threaten the United States with the capability to acquire nuclear weapons in the near future. Yet Pyongyang’s conventional retaliation force could already exact unacceptable punishment against targets Washington valued in East Asia. So why would the prospect of nuclear acquisition pose a threat? North Korea’s nuclear fuel cycle assets endangered the asymmetric nuclear relationship with the United States by moving Pyongyang closer toward


54. In line with the stipulated logic of target selection, Pyongyang already held Seoul in virtual hostage with conventional capabilities, so the threat of nuclear acquisition was directly against the United States.
an eventual assured nuclear retaliation capability against mainland American targets. If North Korea ever reached this distant nuclear force point, then the calculus of deterrence would expand beyond the Korean Peninsula to include tremendous direct costs against the United States. Since nuclear deterrence favors the defender, the United States would also suffer a loss in relative military capability vis-à-vis a nuclear North Korea. A steady decrease in the time to North Korean nuclear arsenal acquisition thereby generated a dynamic threat vector against the core security interests of the United States.

Second, the nuclear fuel cycle is an optimal means to compel material resources from a superior target. Under most scenarios, the nuclear fuel cycle is prone to fail as a means of compellence. For example, when the coercer makes high-stake demands, such as a territorial concession or unconditional surrender, the dynamic threat process is likely to provoke the target to resist with competitive political and military reactions. Yet North Korea confronted a different calculus because it wanted to compel relatively low-cost resources from the United States. Pyongyang could decrease the time lag to arsenal acquisition with its nuclear fuel cycle and commit to freeze development or implement maximum visibility once the United States gave up the resources. Given the above-mentioned structural relationship between North Korea and the United States, the costs of potential nuclear acquisition far outweighed the cost of material concessions for the superpower. The United States might resist the compellent threat through a preventive military strike, though this option entailed huge intrinsic costs given the deterrence calculus on the peninsula. To dampen the preventive motivation for war, North Korea’s demands needed to be clear and consistent, and tied to a credible commitment to cease punishment with the fuel cycle. If Washington believed that Pyongyang’s promise to stop punishment was credible, then the logic of compellence with the nuclear fuel cycle would heavily favor North Korea.

Third, the change in the informational environment North Korea faced after the Cold War had a significant impact on the probabilistic efficacy of this compellence calculus with the nuclear fuel cycle. If North Korea were certain that the United States (or South Korea) held revisionist motives, then compellence would not be a rational option. The dynamic latent threat of acquisition would catalyze a preventive strike, as actual nuclear weapons acquisition in the future would severely limit the revisionist state’s ability to perform offensive military missions against the defender. Thus, as a security seeker, South Korea no longer wanted to incur the high costs of fighting and the loss of Seoul that stemmed from a preventive strike. The situation was more risky with the United States. North Korea gambled on the superpower as a security seeker. Indeed, Pyongyang almost lost the bet in 1994 when Washington seriously contemplated a preventive strike. In the end, the stable logic of deterrence mitigated the risk that the United States was greedy and willing to incur massive costs to prevent North Korea from acquiring a nuclear arsenal.

Fourth, North Korea already had the infrastructure in place to deploy a nuclear fuel cycle posture. The decision to initiate a nuclear weapons program in the late-1970s and expand the facilities at Yongbyon laid the foundation necessary for a plutonium reprocessing capability. After the second reactor came online in 1986, North Korea quickly
developed the techniques necessary for the front end of the fuel cycle. In 1989, the United States released intelligence that indicated North Korea was building a huge “factory-like building near the Yongbyon reactor that appeared to be a reprocessing plant,” as well as a third reactor in the 50–200 megawatt class. By 1991, “a ‘steady trickle’ of new intelligence had suggested that several new installations at Yongbyon were nearly complete, including the suspected reprocessing plant.” The decision to build the reactor and reprocessing capability most likely originated in the severe security environment of the Cold War as a means to acquire nuclear weapons. But as North Korea’s structural situation changed, the Yongbyon infrastructure intended for nuclear deterrence was available to practice compellence with the nuclear fuel cycle.

Conclusion

Major changes in North Korea’s security environment drove the deployment of the nuclear fuel cycle as an independent strategic capability in 1991. The opaque configuration of the unsafeguarded plutonium reprocessing facility gave Pyongyang an instrument to directly threaten and punish the United States without the use of military force. A strong temporal relationship exists between the deployment of this latent capability as a means of compellence and the shift in North Korea’s structural situation. In the post–Cold War environment, a joint deterrence–compellence posture promised to maintain the status quo against challenges from much stronger adversaries and buttress the relative power position of a weak state bereft of superpower patronage.

The explanation of why North Korea pursued nuclear fuel cycle compellence sets the foundation to examine how this latent nuclear posture had an impact on its ability to achieve security objectives. Ongoing research addresses this second question and posits that different nuclear fuel cycle postures have very different effects on the success of compellence. For example, Pyongyang’s initial deployment of the plutonium-reprocessing capability during the first North Korean nuclear crisis from 1991 to 1995 and the subsequent confrontation in 2002 over uranium enrichment technology provide two comparative cases to test the impact of different choices on the dynamics of compellence with the United States. In turn, this work on North Korea contributes to a more general understanding of why and how other states—for example, Pakistan during the 1980s, Italy in the 1970s, and perhaps Iran today—use sensitive nuclear technology to practice compellence.

55. “North Korea pursued the concurrent development of the reactor, research facilities, road and rail nets, power grids, housing, etc.” See Bermudez, “North Korea’s Nuclear Programme,” 408.
56. Construction of the reprocessing facility began sometime during late 1988 or early 1989, while construction on the 50–200 MW class reactor most likely started in 1984. See ibid., 409; and Richelson, Spying on the Bomb, 348, 357.
57. Richelson, Spying on the Bomb, 358; Mazarr, North Korea and the Bomb, 62.
The analysis of North Korea’s compellence strategy points toward a final contemporary dilemma for Pyongyang. Compellence with the nuclear fuel cycle rests on the ability to threaten another state with the acquisition of nuclear weapons in the near future. In the wake of the 2006 and 2009 nuclear weapons tests, North Korea now faces a trade-off between continuing to use its nuclear program as a means of compellence and the gradual solidification of nuclear deterrence. Nuclear weapons are very effective instruments of deterrence, but they have limited coercive utility. If North Korea continues down the path that eventually leads to a direct nuclear deterrent relationship with the United States, then it must fundamentally rethink how to practice compellence. Failure to resolve this emerging dilemma between compellence and deterrence will eventually push North Korea into a nuclear danger zone of crisis instability vis-à-vis the United States.