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Systems Resilience and Nonproliferation

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Abstract

There are growing concerns about the resilience of the nuclear nonproliferation regime. The goal of this paper is to introduce the concept of systems resilience as a new framework for thinking about the future of nonproliferation. Resilience refers to the ability of a system to maintain its vital functions in the face of continuous and unpredictable change. First, I make the case that the nonproliferation regime can be viewed as a complex system. Next, I discuss key themes from the literature on systems resilience and apply them to the nonproliferation system: the difference between resilience and stability; the need for evolution to maintain function; the importance of functional diversity; and thresholds between fundamentally different system states. I show that most existing nonproliferation strategies are aimed at stability rather than resilience and that the current nonproliferation system may be over-constrained by the cumulative evolution of strategies. According to the literature on systems resilience, this increases its vulnerability to collapse. I argue that the resilience of the nonproliferation system can be enhanced by reducing resources expended on outdated strategies; developing general international capabilities to respond to proliferation and other international security threats; increasing the diversity of nonproliferation champions; and focusing more attention on reducing the motivation to acquire nuclear weapons in the first place. To stimulate discussion, I put forth a number of ideas for moving ahead and define needs for future research. Developing a much better understanding of feedbacks among nonproliferation strategies will be essential. It will also be important to understand interactions of the nonproliferation system with other systems on larger and smaller scales.

Introduction

The goal of this paper is to introduce the concept of systems resilience as a new framework for thinking about the future of the nonproliferation regime.[1] First, I define the terms "complex system" and "resilience" and make the case that the nonproliferation regime is a complex system. Next, I discuss key themes from the literature on systems resilience and apply them to the nonproliferation system. Based on this discussion, I suggest that the resilience of the nonproliferation system can be increased by acknowledging that not all determined states can be prevented from acquiring nuclear weapons and instead focusing on 1) developing new international capabilities to respond to proliferation, 2) increasing the diversity of the champions of the nonproliferation regime, 3) reducing motivations to acquiring nuclear weapons in the first place, and 4) reducing resources expended on outdated strategies.

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Definitions

A complex system is a dynamic network of many interconnected elements, in which changes in some elements (or the relations among them) produce changes elsewhere. In addition, the properties of the system as a whole are different from the properties of its individual elements. This is referred to as "emergent" behavior. It is difficult to predict, control, or understand the effects of actions in a complex system, especially when its elements are tightly connected and disturbances propagate easily. Actions always have unintended consequences, as positive and negative feedbacks among system elements cannot be known in advance. Coherent behavior, if it occurs, arises from competition and cooperation among the system elements, and results from very large numbers of individual actions. Order is emergent, rather than pre-determined.[2]

Resilience is a measure of a system's ability to absorb continuous and unpredictable change and still maintain its vital functions. After a significant disturbance, some of the system's elements might change, or be related to each other in different ways, but if the system can adapt sufficiently so that it continues to perform its vital functions, it is resilient. In contrast to resilience, stability is a measure of a system's ability to resist change and to bounce back to its original configuration after a perturbation.

The concept of systems resilience has been explored extensively in the last twenty years in the context of social-ecological system sustainability.[3] Several themes are particularly relevant: 1) the difference between resilience and stability; 2) the need for evolution to maintain function in a changing environment, 3) the importance of functional and demographic diversity, and 4) the need to understand thresholds that separate fundamentally different system states.

The Nonproliferation System

The set of actors, institutions, and strategies aimed at preventing the spread of nuclear weapons can be thought of as a complex system whose emergent property is a strong international norm against nuclear proliferation. Different actors have different priorities, making it difficult to predict the impact of nonproliferation strategies in advance. For example, controlling the supply of sensitive nuclear technology raises the threshold for acquiring nuclear weapons, but it can also make such technology more desirable and increase demand, which could stimulate establishment of illicit supply networks, which are more difficult to detect and control. Military intervention to end a nascent nuclear program may act as a powerful deterrent to some states considering clandestine programs; on the other hand, it may be seen as misuse of military power by others and undermine their commitment to implementing nonproliferation norms.

Despite these complexities, decades of embracing the Nuclear Nonproliferation Treaty (NPT) and engaging in nonproliferation practices (e.g., placing civilian nuclear material under International Atomic Energy Agency (IAEA) safeguards, controlling exports, and protecting nuclear material and weapons) have created a strong international norm against the spread of nuclear weapons. Although its strength is difficult to measure, I suggest that maintaining this international norm is the most important function of the nonproliferation system.

Difference between Resilience and Stability

Strategies to promote system resilience will be fundamentally different than strategies to promote stability. Strategies for stability will emphasize avoiding danger and controlling both system elements and the external environment. They will focus on detailed plans to prevent a broad

range of hypothetical threats. Strategies for resilience will acknowledge the inevitability of change and focus on establishing general capabilities to respond to unknown hazards as they occur. Rather than avoiding danger, strategies for resilience will use an experimental approach to probe the environment: stressing the system to strengthen it.[4]

Most existing nonproliferation strategies can be classified as strategies for stability. Controls on the supply of nuclear weapons-relevant material, technology and expertise are explicitly designed to prevent additional states and non-state actors from acquiring the means to make nuclear weapons. International Atomic Energy Agency (IAEA) safeguards are intended to prevent diversion of nuclear material from civilian to military use; cooperative efforts to secure nuclear weapons and material are aimed at preventing unauthorized access or illicit transfer across and within national borders. Diplomatic strategies and sanctions seek to control the environment by offering potential proliferants a combination of carrots and sticks to dissuade them from nuclear ambitions. Military intervention has been used only occasionally, but again the aim has been to prevent or delay acquisition of capabilities to produce nuclear weapons.

Relatively little attention has been devoted to reducing motivation to acquire nuclear weapons in the first place or to developing broad international capabilities to respond to proliferation when it occurs. Security alliances address a broad range of security objectives and one outcome has been reduced motivation for states included in the alliances to develop their own nuclear weapons. There are also a number of strategies designed to provide early warning of proliferation and to enhance international response capabilities: the IAEA Additional Protocol would improve the IAEA's ability to detect clandestine nuclear activities and the Proliferation Security Initiative (PSI) aims to detect and interdict illicit shipments of proliferation-relevant material or technology. Other efforts to improve international nuclear detection and forensics capabilities are also underway.[5] Ballistic missile defense is yet another strategy to enable response, even though it has not received wide international support and most current systems are aimed at specific threats, such as Iran and the DPRK.

The Need for Evolution to Maintain Function

Systems must continuously evolve to maintain their performance in a changing environment, much less to improve. Evolution includes two types of change: strengthening existing capabilities, and developing new ones.

The current nonproliferation system has evolved in both ways over the years in response to a changing international environment. After the failure of the Baruch Plan to win international support in 1946, the primary U.S. nonproliferation strategy was classification of information related to the nuclear fuel cycle and nuclear weapons. When Soviet and British nuclear weapons tests in the late 1940s and early 1950s demonstrated weaknesses of this approach, classification guidelines were modified, but not abandoned. The IAEA was created to promote nuclear power for peaceful purposes and also to safeguard civilian nuclear material. IAEA safeguards coupled with diplomacy (mostly bilateral) were the prevailing nonproliferation strategies until the Indian nuclear test in 1974, which triggered much more intensive efforts on international export control and the formation of the Nuclear Suppliers Group. The end of the Soviet Union in 1991 and fears of unsecured nuclear weapons and material was a significant shock to the nonproliferation system and resulted in creation of a broad range of cooperative threat reduction efforts to

improve nuclear security; in the same time frame, the failure of the IAEA to detect the Iraqi nuclear program led to the IAEA Additional Protocol.

Since the shock of 9/11 and revelations about the A.Q. Khan black-market raised the specter of nuclear terrorism, many new approaches have been tried, ranging from capacity building to help developing countries implement nonproliferation obligations, to the Proliferation Security Initiative aimed at interdicting illicit shipments, to limited ballistic missile defense, to preemptive war in Iraq. The Obama administration has recently embraced yet another strategy: reducing the salience (and numbers) of nuclear weapons to demonstrate U.S. commitment to NPT Article VI and to increase support by nonnuclear weapon states for implementation of stronger nonproliferation measures.

The Importance of Diversity

Diversity is essential for resilience. For example, the resilience of ecological systems is enhanced if different organisms performing the same ecological function respond differently to environmental perturbations, thereby enhancing the likelihood that the service will be maintained throughout a wide range of conditions. [6] Loss of diversity increases the chances for ecosystem collapse. In the business world, diversity in workplace skills, personalities, and perspectives is believed to enhance creativity and innovation and to improve decision-making and problem-solving, leading to better products. A demographically diverse workforce also may have a better understanding of the demographics of the marketplace, enhancing its competitive edge.

How diverse are the strategies, institutions, and actors of the nonproliferation system? The previous discussion suggests that the current set of nonproliferation strategies lacks diversity, as most are focused on controlling supply. Traditional nonproliferation institutions, such as the IAEA and the NSG, also focus primarily on controlling supply, although the IAEA also plays an important role in facilitating international cooperation on civilian nuclear technology. New strategies and institutions are emerging, however, that could increase diversity. For example, the PSI focuses on detection and interdiction through a "coalition of the willing" rather than through a traditional (bureaucratized) international institution.

The greatest diversity of the nonproliferation system lies in its actors, in terms of both their motivations and the roles they play. Indeed, broad international support for the nonproliferation system emerges from a diverse set of motivations: some actors emphasize that security for all states is increased by limiting the spread of nuclear weapons, others support nonproliferation as a means to the elimination of nuclear weapons world-wide, some are primarily interested in maintaining existing international balance of power, yet others emphasize access to peaceful nuclear technology.

Actors in the nonproliferation system also play a number of different roles: there are the champions, the (sometimes ambivalent) participants, and the challengers. Western states and their allies are the most vocal champions of nonproliferation, with the United States the most prominent. Champions among the nonnuclear weapon states generally have advanced civilian nuclear industries and many possess the technological capability to develop nuclear weapons should they desire. Although this group is fairly uniform from the perspective of economic development, they do not all agree about nonproliferation strategies. For example, Canada and Australia both objected to U.S. attempts to restrict further acquisition of uranium enrichment

capabilities because it would have limited their options as uranium suppliers; South Korea wants to develop spent fuel reprocessing capabilities in spite of U.S. objections.

There are also many states, both with and without nuclear weapons, who participate in the nonproliferation system with varying degrees of commitment. For example, China and Russia are active participants, but see U.S. "hegemony" as a greater threat to their security than nuclear proliferation. Some, such as Brazil and Argentina focus primarily on the rights of nonnuclear weapon states to the full range of nuclear technology and resist additional nonproliferation requirements, such as the IAEA Additional Protocol. Others, such as South Africa and Egypt, emphasize the importance of NPT Article VI and consistently press nuclear weapon states to disarm. This is highly diverse group geographically, economically and politically.

Finally, there are the challengers of the current regime: states that openly defy international norms, such as North Korea, and states that are widely believed to aspire to nuclear weapons clandestinely, such as Iran.

Thresholds

A threshold is a crossing point that separates system states with completely different behaviors. Understanding thresholds and maintaining the appropriate distance from them are critical to managing system resilience.[7] Whether there are thresholds in the nonproliferation system that cannot be crossed if global norms against the spread and use of nuclear weapons are to be maintained is much debated in the context of discussions about nuclear tipping points, albeit in slightly different terms. Intuitively, the threshold between the current state (international norms against the spread and use of nuclear weapons) and a state in which pursuit of nuclear weapons was common and acceptable would depend on at least two variables: technological capability and political will.

Strategies to control supply of nuclear technology and material can be thought of as strategies for maintaining a distance from this threshold. However, more and more states have access to uranium enrichment and spent fuel reprocessing capabilities, and this number could grow with the expansion of nuclear energy world-wide. Coupled with increased accessibility of nuclear technology through illicit channels, it would be safe to assume that in the future supply side controls alone will be insufficient to avoid crossing the threshold.

However, the threshold is also determined by political will and the degree of motivation to acquire nuclear weapons. If supply side controls are no longer sufficient, much more attention should be devoted to decreasing motivation for states to pursue weapons programs. In fact, this will be the only barrier to proliferation in a world of wide-spread nuclear latency.

The Adaptive Cycle

The concept of an adaptive cycle has been developed to inform discussions of resilience in ecological systems.[8] According to this concept, resilient systems do not tend toward a stable equilibrium. Rather, they pass through characteristic phases associated with growth, conservation, release, and reorganization. The growth phase is characterized by great innovation and experimentation. As the system matures innovation and experimentation slow and it enters the conservation phase, which is characterized by specialization and high connectivity among all system elements. High connectivity and specialization increase efficiency, but at the expense of

flexibility, and the system's ability to respond to disturbance decreases. Eventually a perturbation arrives that stresses the system past its breaking point, and triggers system collapse (or release), whereupon significant changes in system elements and their relationship to each other may occur. The release phase is followed by a period of reorganization during which new ideas, policies, or species can arise. A resilient system can maintain its function over time as it passes through one or more cycles. In contrast, a non-resilient system, such as a sand-pile accumulating more and more sand until it finally collapses, cannot recover.

Looking at the nonproliferation system through the lens of the adaptive cycle, which phase is it in? An argument could be made that it is in the conservation phase and therefore particularly vulnerable to major shocks: The cumulative evolution of the nonproliferation system has resulted in an inflexible and overburdened system that is incapable of responding to the challenges ahead, challenges that certainly will require greater agility and innovation.

On the other hand, an argument could be made that the system is in the early stages of a growth phase: Although attempts to change the existing system after the shocks of 2001 have had limited success, experimentation with new approaches falling outside the traditional structure of the nonproliferation regime is vigorous and ongoing. Lessons from these experimental efforts will be taken into account as new ideas evolve.

Reality is most likely somewhere in the middle: Although many innovative ideas are now being tried, the old approaches remain and continue to burden the system. In addition, the impact of many of the newer approaches remains unknown and international support remains uncertain. The critical question is how to increase the resilience of the nonproliferation system in this transitional period.

New Approaches to Enhance Resilience

The discussion in the preceding sections suggests several inter-related themes to guide development of more resilient approaches: 1) experiment with new ideas to enhance resilience rather than continue to focus on strategies for stability; 2) increase the diversity of nonproliferation champions, 3) reduce the motivation for states to acquire nuclear weapons in the first place, and 4) reduce or eliminate resources expended on outdated strategies that contribute little to stability or to prevention; and If systems resilience is a useful framework for analyzing nonproliferation, much more work will be required to develop these ideas further and to understand feedbacks among system elements that would influence their overall effectiveness.

Experiment with New Approaches

Strategies emphasizing resilience will focus on developing general capabilities to respond to proliferation, acknowledging that not all determined states can be prevented from acquiring nuclear weapons. The effort to develop reliable, versatile missile defense is an example. However, to contribute to the resilience of the international nonproliferation system, missile defense must not be perceived as furthering the interests of just a small subset of nonproliferation actors which is how it is often characterized today. Understanding potential unintended consequences of missile defense (such as alienating China and Russia) and taking steps to reduce them will be essential to its making a positive contribution to the international nonproliferation system.

Establishing new multilateral security structures that serve a broad set of needs, but also undertake proliferation-relevant missions such as response to nuclear events and defense against the threat of nuclear use, should be explored. Exercises, such as those conducted under the auspices of the PSI, would play a critical role. Precedents exist for such security structures, such as the Cooperative Defense Initiative (CDI) that brings the United States, the Gulf Cooperation Council, Egypt and Jordan together for military coordination purposes. International Peace-Keeping also might provide useful lessons learned.

General response capabilities have value even if proliferation never occurs. Missile defense can be used against conventional threats, and new security structures can be used to resolve regional conflicts over a broad range of issues, such as disputes over territory and natural resources. In addition, the ability to respond effectively to proliferation might reduce states motivation to invest in nuclear weapons programs, if they knew in advance that their military value would be limited.[9]

Increase the Diversity of Nonproliferation Champions

Paradoxically, attempts by the United States to heighten world-wide awareness of the dangers of nuclear terrorism and proliferation, coupled with unilateralist approaches, have created an impression that nonproliferation is a U.S. issue and that taking it seriously is tantamount to giving in to U.S. demands. Although the current administration has embraced multilateralism, it has named nuclear proliferation and terrorism as the top two threats to U.S. security. This may only reinforce the perception in some countries that nonproliferation is a proxy for the U.S. agenda.

To counter this perception, the potential reactions of nonproliferation champions and ambivalent participants must be considered explicitly when making decisions about nonproliferation strategies. The diversity of motivations among the supporters of nonproliferation strengthens the system and should be maintained, even though it also introduces tension about policies and priorities. New strategies are needed that explicitly take this diversity into account. Recent commitments by the United States to reduce the numbers and salience of nuclear weapons is an example of a strategy aimed at increasing support for nonproliferation by key "ambivalent" states, although its impact is not yet clear.

Another example concerns the approach to the spread of sensitive nuclear technology. Rather than publicly seeking commitments by others not to pursue enrichment and reprocessing capabilities, states with the greatest stake in nonproliferation could lead by example and establish multinational enrichment and spent fuel reprocessing facilities. Commitments with individual states not to develop sensitive nuclear technologies could still be pursued privately as part of establishing nuclear cooperation agreements.

Reduce Motivation to Acquire Nuclear Weapons

Motivation to pursue a nuclear weapons program is generally thought to stem from a combination of several causes: national security concerns, domestic politics, and prestige derived from the symbolic value of nuclear weapons.[10] Many of the ideas discussed above are also relevant here: developing effective capabilities to respond to proliferation may change states' calculations about their security value; reducing the salience of nuclear weapons in national

security strategies could reduce both their perceived security value as well as their symbolic importance.

To the extent that security concerns are the primary motivators behind a nuclear weapons program, reducing regional tensions and increasing the number of states that are covered by security assurances could be considered.[11] Positive security assurances are widely believed to have been instrumental in preventing proliferation in Europe and Asia. However, if positive security assurances are understood to carry the promise of a nuclear response, they might inadvertently increase the perceived value of nuclear weapons as the ultimate security guarantors. In addition, unless countries such as Russia and China were included in development of new security arrangements, it could exacerbate their own security concerns.

The use of high-volume public pressure to convince countries such as Iran to give up nuclear weapons programs also should be reconsidered. Its primary result seems to be to increase domestic support for nuclear weapons programs in the face of threatening international rhetoric. Better results might be obtained by taking this debate out of the public eye and pressuring countries in private forums.

In the final analysis, however, as long as the most powerful states in the world continue to view nuclear weapons as indispensible to their security, it will be hard to convince all others that such weapons are not worth pursuing. This is why many argue that the two-tiered approach that is inherent in the existing nonproliferation system must end. As a first step, some argue for a ban on nuclear weapons use analogous to the Geneva Protocol that banned the use of chemical and biological weapons in 1925.[12] Even though it took almost seventy years to achieve the Chemical Weapons Convention that banned their production and use, the Geneva Protocol was an important first step in their de-legitimization.

Reduce Resources Expended on Outdated Strategies

Nonproliferation strategies have evolved largely through a cumulative process: new strategies are added but older strategies remain. For example, export control and classification of information continue to require significant resources, even as technology and information have become widely available in the public domain. Expending the majority of IAEA inspection resources on safeguarding Japan's civilian nuclear infrastructure because of outdated rules about allocation of resources is another case in point.

This cumulative process has a huge opportunity cost, which inhibits exploration and development of the new approaches that have arisen in the last decade. Although it would be unwise to completely eliminate classification of nuclear weapons information and export controls, these approaches need to be brought up to date with the reality of global availability of technology and information. Refocusing efforts on protecting what is absolutely essential will free up resources that could be used more productively elsewhere.[13]

Final Thoughts

Developing a better understanding of feedbacks among nonproliferation strategies will be essential to develop approaches that enhance resilience. The discipline of systems dynamics, including the development of dynamic models of a system's functions, could provide valuable tools and methodologies for exploring interdependencies in greater detail. Such models could

establish a framework for evaluating the impact of existing and new approaches on the system as a whole, rather than on just a subset of its elements.

However, it is important to keep in mind that the nonproliferation system interacts constantly with other systems on larger and smaller scales. In the United States nonproliferation traditionally has been an element of broader security policy, not necessarily the highest priority. Larger international security issues have sometimes driven policies that seem inconsistent with the strict goals of nonproliferation. The so-called U.S. / India nuclear deal that implicitly places a higher priority on a strategic partnership with India than on India's acceding to the NPT is an example. Developments in the broader international environment also have produced some of the greatest shocks to the nonproliferation system, e.g., the dissolution of the Soviet Union and the September 11 terrorist attacks.

The nonproliferation system interacts with smaller-scale systems as well, such as domestic energy policy and nuclear weapons policy. Implications of the interaction between nuclear energy policy and nonproliferation have been recognized and analyzed since the 1950s, but the latter is much less understood. For example, the 2010 U.S. Nuclear Posture Review Report states that the largest threats to U.S. national security are nuclear proliferation and terrorism, and articulates the goals of reducing numbers of U.S. nuclear weapons and their salience to U.S. security strategy while maintaining a safe, secure nuclear deterrent as long as other states possess them.[14] It also establishes ambitious goals for both nonproliferation and modernizing the U.S. nuclear weapons complex. However, modernizing the U.S. nuclear weapons complex in a way that is consistent with possible future arms control and nonproliferation requirements will be a challenge.[15] During the implementation process, much care will be needed to avoid sending the wrong message and undercutting international nonproliferation commitments.

Finally, although many worry about the repercussions of a nuclear capable Iran or developments in the North Korean nuclear program, it is impossible to predict the nature or timing of the next major challenge to the nonproliferation system. Acknowledging both the inevitability and unpredictability of future shocks, and relaxing the urge for control may be one of the most important steps to foster a climate for continued innovation that will underpin any ultimately resilient nonproliferation system.

Endnotes

[1] A previous version of this paper was published in the Fall 2010 edition of the Public Interest Report, the Journal of the Federation of American Scientists: <http://www.fas.org/pubs/pir/2010.html>.

[2] Three books have informed much of the discussion of complex systems in this paper: For discussions of complex systems, see Robert Jervis, *Systems Effects: Complexity in Political and Social Life* (Princeton, NJ: Princeton University Press, 1997); Aaron Wildavsky, *Searching for Safety* (Piscataway, NJ: Transaction Publishers, 1988); and Per Bak, *How Nature Works* (New York, NY: Copernicus Press, 1996)

[3] For a good overview see Brian Walker and David Salt, *Resilience Thinking* (Washington, DC: Island Press, 2006). For an example of the application of the concept of resilience to homeland security, see Stephen Flynn, *The Edge of Disaster*: *Rebuilding a Resilient Nation* (New York, NY: Random House, 2007).

[4] The ecologist C.S. Holling was among the first to articulate the difference between resilience and stability in his classic paper "Resilience and Stability of Ecological Systems," *Annual Review of Ecological Systems*, 1973, 4: 1-23.

In addition, Aaron Wildavsky devotes much of his book *Searching for Safety* to the difference between strategies for resilience and strategies for prevention.

[5] For example, see Jacob Goodwin, GSN: Global Security News, "DNDO wants to develop a "global nuclear detection architecture"" July 14, 2010: <http://www.gsnmagazine.com/article/21061/dndo_wants_develop_%E2%80%9Cglobal_nuclear_detection_archi >

[6] For a good discussion of the importance of diversity to resilience, illustrated with the example of Caribbean coral reefs, see Brian Walker and David Salt, *Resilience Thinking* (Washington, DC: Island Press,2006), pp. 64 – 73.

[7] For good illustrations of the concept of thresholds in social-ecological systems, see Steve Carpenter, Brian Walker, J. Marty Anderies, and Nick Abel, "From Metaphor to Measurement: Resilience of What to What?" *Ecosystems* 4 (2001) p. 765, and Walker and Salt, *Resilience Thinking*, pp. 53 – 63.

[8] This concept is developed through a series of articles and case studies in L. H. Gunderson and C. S. Holling, eds. *Panarchy: Understanding Transformations in Human and Natural Systems* (Washington, DC: Island Press, 2002). There is also a good non-technical overview in Brian Walker and David Salt, *Resilience Thinking* (Washington, DC: Island Press, 2006), pp. 74 – 95.

[9] This argument mirrors that of Stephen Flynn in *The Edge of Disaster*, where he argues that rather than invest the majority of counter-terrorism resources in preventing terrorism, the United States would be better off, for example, by investing more resources to strengthen aging infrastructure. Not only would this enhance the foundations of economic security and improving resilience to natural disasters, it would also make it a less attractive target for terrorists and reduce their motivation to attack.

[10] Scott D. Sagan, "Why Do States Build Nuclear Weapons? Three Models in Search of a Bomb," *International Security* 21 (3) Winter 1996/1997), pp. 54 – 86.

[11] See, for example, C. Paul Robinson, "Developing a Realistic Strategy to Control the Spread of Nuclear Weapons." *Nature* 432, November 25, 2004, pp. 441-442.

[12] For two discussions of this idea see Rebecca Johnson, "Nuclear Weapons: Beyond Nonproliferation," Open Democracy, April 29, 2010, < http://www.opendemocracy.net/5050/rebecca-johnson/nuclear-weapons-beyond-non-proliferation> and George Perkovich and James M. Acton, "Outlaw Use of Nuclear Weapons?" The Carnegie Endowment for International Peace, Abolition Debate Series, Part 5 or 8, April, 21, 2010, < http://carnegieendowment.org/publications/index.cfm?fa=view&id=40645>.

[13] Note that the Obama administration has recently announced that it has launched a major review of the U.S. export control system, and aims to modify both the policy for determining what commodities and technologies are subject to controls and how the federal bureaucracy will apply the new policy and operate the system. See, for example, Baker Spring, Obama's Ambitious Export Control Reform Plan, The Heritage Foundation, September 20, 2010. http://www.heritage.org/research/reports/2010/09/the-obama-administrations-ambitious-export-control-reform-plan

[14] The 2010 Nuclear Posture Review can be read at: <http://www.defense.gov/npr/docs/2010%20nuclear%20posture%20review%20report.pdf> .

[15] For an exploration of ideas for accomplishing this, see Lani Miyoshi Sanders, Sharon M. DeLand, and Arian L. Pregenzer, "Integrating Nuclear Weapons Stockpile Management and Nuclear Arms Control Objectives to Enable Significant Stockpile Reductions," *The Nonproliferation Review*, November 2010, pp. 475 – 489.