Nuclear Weapons in 21st Century U.S. National Security

Report by a Joint Working Group of AAAS, the American Physical Society, and the Center for Strategic and International Studies

December 2008

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

APS physics

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Acknowledgments

Many thanks to Linton Brooks, Ashton Carter, Henry Chiles, Christopher Chyba, John Deutch, John Foster, Raymond Jeanloz, Morton Halperin, Bruce Tarter, Amy Woolf, and Peter Zimmerman for their thoughtful comments on this paper. Support for this project was provided by the American Physical Society, the John D. and Catherine T. MacArthur Foundation through grant numbers 08-91194-000-GSS and 08-91955-000-GSS and the Richard Lounsbery Foundation.

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The American Association for the Advancement of Science (AAAS) is the world's largest general scientific society and publisher of the journal Science (*www.sciencemag.org*). AAAS was founded in 1848 and serves some 265 affiliated societies and academies of science, serving 10 million individuals. Science has the largest paid circulation of any peer-reviewed general science journal in the world, with an estimated total readership of 1 million.

AAAS participation in this report was through its Center for Science, Technology and Security Policy. The Center's mission is to provide objective, high-quality, scientific information and analysis on a wide range of security issues to the Washington policy community, by drawing on the best academic research on these issues in the nation's universities. The Center is supported by the John D. and Catherine T. MacArthur Foundation of Chicago.

Printed in the United States of America
ISBN 978-0-87168-722-7

Layout by AAAS Publication Services
Cover by Sandra Audia

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The American Physical Society was founded in 1899, with a mission of advancing and diffusing the knowledge of physics. APS is now the nation's leading organization of research physicists with more than 46,000 members in academia, national laboratories, and industry.

APS's work on this paper was overseen by the APS Panel on Public Affairs (POPA). POPA occasionally produces reports on topics currently debated in government in order to inform the debate with the perspectives of physicists working in the relevant issue areas. Indeed, APS has long played an active role in federal government with its members serving in Congress and having held positions such as Science Advisor to the President of the United States, Director of the CIA, and Director of the NSF.

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The Center for Strategic and International Studies (CSIS) is a bipartisan, nonprofit organization that conducts research and analysis to provide strategic insights and policy solutions to decisionmakers in government, international institutions, the private sector, and civil society. Founded in 1962, CSIS has grown to become one of the world's preeminent international policy institutions, with more than 220 full-time staff and a large network of affiliated scholars focused on defense and security, regional stability, and transnational challenges ranging from energy and climate to global development and economic integration.

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Executive Summary

During the Cold War, the purpose of the United States nuclear arsenal was to deter nuclear threats to the United States, primarily from the Soviet Union. Today, in the post-9/11 world, the most urgent nuclear weapon threats to the United States are not from another major power's deliberate use of them, but instead are from non-state terrorist actors or from the regional proliferation of such weapons into unreliable hands.

U.S. nuclear policy and strategy in this post-Cold War and post-9/11 security environment have not been well articulated and as a consequence are poorly understood both within and outside American borders. This situation has led to doubts and uncertainties about the roles and missions of nuclear weapons and their value against 21st century security threats, including allies' uncertainties about U.S. assurances as they relate to emerging nuclear-armed neighboring states.

Lacking a coherent and compelling rationale for U.S. nuclear strategy and policy, Congress has been unwilling to fund some Bush Administration requests for new nuclear refurbishment efforts (both stockpile and infrastructure). Meanwhile, serious strains on the human, technical, and scientific infrastructure could undermine whatever strategy is ultimately adopted. Clearly, this policy vacuum regarding our nuclear deterrent must be addressed alongside our efforts to prevent further nuclear proliferation.

The purpose of this report is to inform the next administration's decision-making on U.S. nuclear strategy, policy, posture, and related proliferation and arms control issues. Any decision that the United States makes with respect to its own nuclear stockpile and infrastructure must also address how these decisions (and perceptions of those decisions) may affect U.S. efforts to prevent nuclear proliferation and pursue lower global inventories of nuclear weapons. To address 21st century nuclear threats, and growing challenges to sustaining the U.S. nuclear deterrent, the next administration should build a package of nuclear initiatives that can attract broad support both at home and abroad. This study seeks to identify the components of a new centrist way forward to end the post-Cold War drift on U.S. nuclear strategy, policy, and capabilities.

The American Physical Society (APS), the American Association for the Advancement of Science (AAAS), and the Center for Strategic and International Studies (CSIS) collaborated in this study in an effort to bring together the technical expertise of the scientific community and the policy expertise of the security studies community. This collaborative effort was organized around a series of four workshops,[1] held in the first half of 2008, that ensured cross-fertilization across disparate disciplines and perspectives without sacrificing issue-specific depth. Despite diverse views about

the role of U.S. nuclear weapons and their importance to U.S. security, workshop attendees found they held common, though not necessarily unanimous, views on how the next administration could assemble a package of initiatives that, if taken together, could attract broad support. Throughout this report, these **commonly held views** will be expressed in **bold type**. It should be noted, however, that no participant held all of these views and that no single view was held by all attendees.

The truly pressing nuclear issues that will demand presidential attention are few in number:

- **Preventing the spread of nuclear weapons to more countries, including dealing with the nuclear proliferation threats of North Korea and Iran**
- **Securing and reducing global inventories of nuclear weapons and materials to prevent them from falling into the hands of terrorists**
- **Reversing Russia's apparent increasing reliance on nuclear weapons in its security policy through strategic engagement in an attempt to both prevent the emergence of a new 21st-century nuclear threat and gain Russian agreement to significantly lower U.S.-Russian stockpiles"**

The commitment of the president-elect to a vision of a nuclear-free world, and the continuing need to have a credible U.S. nuclear deterrent as long as nuclear weapons exist, provide the basis for a 21st-century version of a dual track nuclear arms control and refurbishment/updating policy:

- **The United States must re-establish its global leadership in nuclear nonproliferation, arms control and disarmament matters.**

AND IN PARALLEL

- **The United States must ensure a credible nuclear deterrent for as long as is needed through steps that include continuing to refurbish and update its nuclear stockpile and infrastructure as necessary without creating any new nuclear weapon capabilities.**

The components of a possible new centrist package of nuclear initiatives that address the pressing nuclear issues on a dual track include the following:

- **As part of a new strategic dialogue with Russia, the United States should reinvigorate nuclear arms talks with the Russians: first, to extend START-I (and its suite of verification measures), and then, to systematically account for total inventories of U.S.-Russian nuclear weapons and achieve deeper reductions in U.S.-Russian and global nuclear stockpiles.**
- **The United States should re-establish global leadership in nuclear nonproliferation and arms control at the 2010 Nuclear Non-Proliferation Treaty (NPT) Review Conference (RevCon).** To that end, the United States can:
  - **i. Ratify the Comprehensive Nuclear-Test-Ban Treaty (CTBT), if coupled with other interconnected nuclear initiatives described below.**
  - **ii. Address the challenge of how to manage increased global reliance on nuclear energy without increasing the risks of nuclear proliferation by promoting strategies such as an international fuel bank, advanced technical safeguards, and closing the NPT Article IV treaty proliferation loophole.[2]**
- **Both to enable deeper reductions in the total inventory and to maintain a credible nuclear deterrent as long as it is needed, the United States should continue to refurbish and update the U.S. nuclear stockpile as necessary without creating new nuclear weapon capabilities through a "spectrum of options" approach,** such that different weapons types can be kept in the stockpile with varying degrees of modification.
- **To maintain a credible nuclear deterrent, the United States should sustain the necessary human capital: as much of the existing workforce ages, experience, expertise and competence will likely decline across the nuclear enterprise including the Department of Defense (DOD), Department of Energy (DOE), and the military services. A broader mission for the nuclear weapons labs that addresses energy security as well as nuclear security interests can help recruit, retain, and sustain highly skilled and motivated scientists and engineers.**

Nuclear Weapons in 21st Century U.S. National Security

Purpose of the Study

Nuclear weapons will be a common element of many national security challenges for the next administration. Two of these nuclear-centric challenges – the denuclearization of North Korea and stopping Iran's apparent effort to join the ranks of nuclear-armed powers – will test the new president immediately. Other nuclear-related challenges are no less urgent but are longer-term in nature: reducing existing stockpiles and securing nuclear materials from diversion to non-state actors, preventing the likely growth in nuclear power from stimulating a "cascade of proliferation," and reversing Russia's apparent increasing reliance on nuclear weapons in its security policy. The need to address these urgent "external" nuclear challenges is recognized broadly in the policy community.

The "internal" challenges facing U.S. nuclear strategy, policy, and capabilities (both weapons and infrastructure), by contrast, are not as widely recognized, and the policy community is divided on how urgent these challenges are and how they should be addressed. Since the September 11, 2001 attacks on the United States, decreasing senior-level attention has been paid to U.S. nuclear issues as technical challenges to the infrastructure and stockpile have increased and competency has eroded in some operational areas. It should be noted that recent actions by Defense Secretary Gates are an important step in addressing these issues but more may be required.

The next administration, however, must recognize that its "internal" and "external" nuclear challenges are politically, if not practically, related. Any decision that the United States makes with respect to its own nuclear stockpile and technical and scientific infrastructure must address how these decisions (and perceptions of those decisions) affect U.S. efforts to prevent nuclear proliferation and pursue lower global inventories of nuclear weapons. This has always been true to some extent, but today, unlike during the Cold War when U.S. nuclear weapons were at the core of its security policy, there is no broad consensus on the importance of U.S. nuclear weapons to U.S. security. Moreover, the next administration must address these sensitive and interlocking nuclear issues at a time when, sparked by the first op-ed in January 2007 by former Secretaries of State Henry Kissinger and George Shultz, former Secretary of Defense William Perry, and retired Senator Sam Nunn (the Quartet)[3], there is revived interest, both at home and abroad, in global nuclear disarmament.

The purpose of this report is to inform the next administration's decision making on U.S. nuclear strategy, policy, posture, and related proliferation and arms control issues. The study seeks to "map" the decision space of key decisions and options, grouped by issue area; to facilitate strategic trades and linkages; and to identify the components of a possible package of nuclear initiatives that the next administration could use to build broad support for moving forward on a number of related nuclear issues. The authors recognize that there is a link to other national security issues facing the United States, such as ballistic missile defenses and military uses of space, but consider these subjects to be outside the scope of the study.

Study Approach

The American Physical Society (APS), the American Association for the Advancement of Science (AAAS) and the Center for Strategic and International Studies (CSIS) collaborated in this study in an effort to bring together the technical expertise of the scientific community and the policy expertise of the security studies community. This collaborative effort was organized around a series of workshops held in the first half of 2008 that brought together nuclear experts from the scientific, defense, and diplomatic policy communities. Military (April 10), technical (April 24), and international (May 2) issues were addressed at separate one-day workshops, which were followed by a fourth, integration, workshop (June 11) that built upon the results of the prior meetings. Two briefs or papers were commissioned for each of the military, technical and international workshops. For the integration workshop, a brief was prepared by the authors of this report that synthesized the results of the first three workshops and identified the urgent (both in significance and time-sensitivity) nuclear challenges facing the next administration and the choices to be made on U.S. nuclear policies and related nuclear nonproliferation and arms control issues. The reports from the three topical workshops, along with the commissioned papers and briefs, and the integration workshop briefing are available at http://cstsp.aaas.org/content.html?contentid=1792 and in a CD-ROM that accompanies the hard-copy version of this report. [See Appendix 1 for the list of workshop participants and see Appendix 2 for the titles of the supporting reports from the military, technical, international and integration working groups.] This methodology ensured cross-fertilization across disparate disciplines and perspectives without sacrificing issue-specific depth. Workshop participants also were chosen to represent a diversity of views across the political spectrum.

In its afternoon discussion, the integration workshop focused on identifying the possible components of an integrated package of nuclear initiatives behind which the next administration could build broad support. Despite diverse views about the role of U.S. nuclear weapons and their importance to U.S. security, integration workshop attendees found they held common, though not necessarily unanimous, views on many issues that were relevant to how the next administration could assemble a package of initiatives that, if taken together, could attract broad support. Throughout this report, these **commonly held views** will be expressed in **bold type.** This is not meant to suggest that such commonly held views were unanimously held by the attendees.

The project's core working group then used the results of the four workshops to develop an extended outline for the draft final report to vet internally with key stakeholders before circulating the draft final report among workshop chairs and some members, as well as a few prominent experts previously uninvolved in the study effort. Although APS, AAAS, and CSIS are very grateful for the time that workshop participants and external reviewers have given to this study effort, this report is an APS-AAAS-CSIS product and does not necessarily reflect the individual views of the workshop participants.

Nuclear Threats and Challenges in the Post-9/11 Era

THREATS TO THE UNITED STATES FROM NUCLEAR WEAPONS

During the Cold War, the United States used its nuclear arsenal to deter nuclear threats to the United States, primarily from the Soviet Union. Today, the most urgent threats to the United States from nuclear weapons are not from another major power's deliberate use of a nuclear weapon. In rough order of priority as reflected in workshop discussions, today's nuclear threats are:

- **Nuclear terrorism** – In an era of suicide bombers, non-state actors are, almost by definition, non-deterrable by the threat of nuclear retaliation. While the United States might be able to deter the states that may provide sanctuary, weapons, or financial support to would-be nuclear terrorists, direct U.S. efforts to cope with nuclear terrorism must focus on denial (e.g., securing "loose" weapons and materials to deny access), defenses (e.g., making it harder for terrorists attacks to succeed), and

prevention (e.g., disrupting terrorist groups or preempting attacks).

- **Nuclear proliferation** – Preventing the spread of nuclear weapons, particularly to states such as Iran that could lead to broad regional proliferation, may make it possible to maintain the taboo against nuclear use. As the number (and types) of nuclear powers increases, so does the potential for transfer to non-state actors as well as the danger of use in a regional crisis. The likely growth in the use of nuclear energy also carries the risk of proliferating fuel cycles and nuclear weapons programs.
- **Nuclear threats against regional allies and friends** – The credibility of U.S. security assurances, including nuclear assurances, is a key factor in the decisions that many nations make about their own nuclear futures. In addition to preventing proliferation, an effective U.S. extended nuclear deterrent may be essential in protecting critical U.S. regional interests.
- **Nuclear threats against the United States from regional nuclear-armed states** – Regional nuclear-armed adversaries, particularly those with revolutionary ideologies, may be significantly less deterrable than past adversaries. The challenge of securing critical U.S. regional interests, including the security of U.S. allies and friends, will be greatly complicated if regional adversaries acquire nuclear weapons, which are the ultimate asymmetric counter to vastly superior U.S. conventional capabilities.
- **Emergence of a Cold War-like threat from a nuclear-armed major power** – The apparent increase in Russia's reliance upon nuclear weapons in its security policy coupled with its ongoing nuclear modernization program is cause for caution. This is evident in recent nuclear threats against its neighbors for supporting U.S. ballistic missile defense deployments.[4] The increased salience of "tactical" nuclear weapons in Moscow might also make it harder to address the "loose nukes" threat from Russia's inventories of "tactical" nuclear weapons. China, as well, is in the process of modernizing and expanding its nuclear capabilities by adding submarine-launched missiles. While these changes might not significantly change U.S. deterrence calculations, a large-scale Chinese nuclear build-up would be cause for great concern in the U.S.-China relationship.

CHALLENGES TO UNITED STATES NUCLEAR CAPABILITIES

Although workshop participants disagreed on how salient U.S. nuclear weapons are to U.S. post-9/11 security, workshop participants generally, though not unanimously, held the following views:

- **As long as other nations have nuclear weapons, the United States must sustain a credible nuclear deterrent capable of:**
  - **Deterring state-based nuclear** (and possibly other weapons of mass destruction [WMD]) **attacks on the United States**
  - **Providing an extended nuclear deterrent as part of U.S. security assurances**
  - **Deterring global conventional war between the major powers**
  - **Contributing to U.S. status as a global superpower in a nuclear world**
- **Sustaining the human capital necessary to maintain the U.S. nuclear deterrent is an imperative near-term challenge:**
  - **As the work force ages, experience, expertise and competence is at risk of declining across the nuclear enterprise and, in the near term, it is critical to recruit, retain, and sustain highly skilled and motivated people across the DOD, DOE and the military services to execute the highly demanding nuclear mission**
- **A credible U.S. nuclear deterrent, in turn, requires a safe, secure, and reliable stockpile of nuclear weapons:**
  - **The standards of what constitutes reliability[5] must be debated in the military and technical communities**

While the nuclear community itself is divided on how important U.S. nuclear weapons are to U.S. security in the 21st century, President-elect Obama has stated that the United States must retain a credible nuclear deterrent as long as nuclear weapons exist even as the United States continues to decrease the size of its nuclear arsenal. Converting that intent into policies and implementing actions, however, depends on how President Obama chooses to have his administration address the nuclear threats facing the United States.

BALANCING NUCLEAR THREATS AND NUCLEAR CHALLENGES

There is a tendency in the nuclear weapons policy and technical communities to be "nuclear centric" in thinking and to focus on the challenge of sustaining the "legacy" stockpile of Cold War-era weapons, without thinking more deeply about the role of those weapons in the broader set of American national security priorities. The next president, however, will have to consider the broad set of external threats to U.S. security and will focus on the internal chal-

lenges facing U.S. nuclear capabilities only to the extent that those capabilities will contribute meaningfully to addressing the external nuclear threats. The truly pressing nuclear issues that will demand presidential attention are few in number:

- **Preventing the spread of nuclear weapons to more countries, including dealing with North Korea and Iran**
- **Securing and reducing global inventories of nuclear weapons and materials to prevent them from falling into the hands of terrorists**
- **Reversing Russia's apparent increasing reliance on nuclear weapons in its security policy by engaging in a new strategic dialogue that attempts to both prevent the emergence of a new 21st century nuclear threat and to gain Russian agreement to significantly lower U.S.-Russian stockpiles**

Common ground – between the internal challenge of continuing to refurbish and update the U.S. stockpile as necessary without creating new nuclear weapon capabilities, and addressing the external nuclear threats to the United States – may be found in how U.S. nuclear stockpile activities can enable the pursuit, particularly with Russia, of lower global inventories of nuclear weapons. The next president, for example, could be in a strong political position to negotiate deep reductions in U.S. and Russian inventories if he is assured of high confidence in a much smaller U.S. stockpile and that the U.S. nuclear infrastructure could respond quickly to circumstances that might require a greater than expected U.S. reliance on its nuclear weapon capabilities.

Policy and Political Context for Thinking about U.S. Nuclear Weapons

During the Cold War, nuclear competition was at the core of the conflict between the United States and the Soviet Union. The existence of vast nuclear arsenals on both sides reduced the risk-taking propensities of even the most ideological leaders and conventional war did not erupt between the two global superpowers.

The policy context today could not be more different. U.S. nuclear weapons are least relevant to the most likely nuclear threats to the United States and most relevant to the least likely. Of course, as the world's dominant conventional power, the United States would prefer a world free of nuclear weapons and, perhaps more importantly, free from the ability to produce them. However, few see feasible paths to such a world in the near term. Meanwhile, some potential adversaries – both those who have nuclear weapons and those who seek them – may view nuclear weapons as offsetting U.S. conventional superiority, much the same way as the United States and its European allies did against the Warsaw Pact during the Cold War. For these countries, nuclear weapons could be seen as a deterrent against U.S. intervention in regional conflicts. And in an era of suicide bombers and increasingly capable non-state actors, the specter of catastrophic nuclear terrorism has called into question the centrality of deterrence in thinking about nuclear weapons.

From a political perspective, U.S. nuclear policy and strategy post-Cold War and post-9/11 have not been well articulated and as a consequence are poorly understood both within and outside American borders. This situation has led to doubts and uncertainties about the roles and missions of nuclear weapons and their value against 21st century security threats, including allies' uncertainties about U.S. assurances as they relate to emerging nuclear-armed neighboring states. Ineffective or non-existent efforts to communicate U.S. strategy and policy statements in recent years have fueled these uncertainties.

Lacking a coherent and compelling rationale for U.S. nuclear strategy and policy, Congress has been unwilling to fund some Bush administration requests for new nuclear refurbishment efforts (both stockpile and infrastructure). Meanwhile, serious strains on the human, technical, and scientific infrastructure could undermine whatever strategy is ultimately selected.

On the fundamental issue of how important U.S. nuclear weapons are to U.S. security, there is no broad-based consensus. Instead, those within the policy community that closely follow these issues seem to fall into one of four "camps" on the salience of U.S. nuclear weapons, which tend to lead adherents in each camp to take differing positions on key nuclear issues.

- High Salience – Adherents of this camp believe that nuclear weapons retain a Cold War-like importance, and that deterrence functions much as it did during that era. To ensure a deterrent credible to 21st century adversaries, this camp's followers believe that the United States should develop new nuclear capabilities to hold at risk targets of value to these adversaries. While few advocate this view publicly, largely on grounds of political pragmatism, adherents to this policy stance could grow rapidly in the wake of a nuclear-use incident (e.g., by a rogue state against a U.S. ally) or a revived Cold War-like threat.

- Moderate Salience – Adherents to this camp believe that U.S. nuclear weapons still play a significant niche role and that an effective nuclear deterrent requires a safe, secure and reliable stockpile (but not new capabilities). This camp recognizes that U.S. nuclear modernization may affect U.S. standing in international forums, but are willing to pay that price if necessary for the requisite stockpile and infrastructure.

- Low Salience – This camp acknowledges that U.S. nuclear weapons make residual contributions to U.S. security (largely limited to deterring direct nuclear attacks against the United States and its allies) as long as there are other nuclear-armed states. They believe that this can be accomplished with a significantly smaller stockpile. Adherents of this camp would support limited nuclear refurbishment but not at the expense of reduced international and domestic support for policies intended to reduce the nuclear threat or prevent proliferation.

- Negative Salience—For this camp, the very existence of nuclear weapons constitutes a threat to humanity and the emphasis should be on the complete elimination of nuclear weapons. A subset of this group, "nuclear abolitionists," are willing to support deep unilateral reductions in the U.S. nuclear arsenal and oppose any nuclear modernization as wasteful and inappropriately legitimizing nuclear weapons. Others in this camp (e.g., the Quartet) have proposed initiatives that they view as necessary steps toward an eventual goal of elimination. This latter camp insists that all reductions be made in a bilateral, and where appropriate multilateral, fashion.

While the four-camp construct is useful for analyzing the nuclear debate and can provide insights as to why someone may advocate a particular position, its utility in constructing the potential components of an integrated package of nuclear initiatives is limited. In part, this reflects the fact that the salience of nuclear weapons is usually only one factor in reaching a policy position.

In addition, individual adherents to one camp may very well endorse recommendations associated with another camp. In fact, the effort made in this report to identify the components of a potential package of nuclear initiatives is premised on the assumption that sufficient numbers of people across the four-camp spectrum can agree on a new "centrist" way forward to end the post-Cold War drift on U.S. nuclear strategy, policy, and capabilities.

In facing the need to address the long-standing policy vacuum on nuclear issues in the United States, many recent studies have called for a clear, compelling presidential statement that provides a strategic rationale for U.S. nuclear weapons and how they serve U.S. security interests. Several efforts are currently underway, by both governmental and non-governmental organizations, to identify such a rationale. Regardless of the outcome of these efforts, the next president will need to accompany the rationale with action on several pressing nuclear issues. Our workshop discussions strongly indicate that the next administration can build broad support for a series of significant concrete actions among bipartisan groups, independent of those groups' respective visions on the role of nuclear weapons. Of course, a broad-based consensus behind a concise policy statement on the role of U.S. nuclear weapons is desirable, but considerable progress can be made on pressing nuclear issues while such a statement is being developed and debated.

"Mapping" the Nuclear Decision Space for the Next Administration

The next administration faces a situation somewhat analogous to that faced by NATO in the late 1970s when it adopted the "dual track" modernization and arms control approach for long-range theater nuclear forces. In the Cold War, when nuclear weapons were at the core of U.S. national security policy, both sides of this "track" worked symbiotically towards the common goal of strengthening the U.S. nuclear deterrent vis-à-vis its adversaries.

Today, this challenge is more complex. With no broad consensus on the mission and importance of the U.S. nuclear deterrent, internal and external policies may be motivated by different and sometimes incompatible objectives. In this context the political connections of the various protagonists may be more important than their respective strategic interests. Taking advantage of these political ties can be vital for generating support for centrist, proactive policies that, when taken together, can lead to a coherent vision for U.S. national security.

The commitment of President-elect Obama to a vision of a nuclear-free world and the continuing need to have a credible U.S. nuclear deterrent as long as nuclear weapons exist provide the basis for a 21st century version of a dual track nuclear arms control and refurbishment/updating policy:

- **The United States must re-establish its global leadership in nuclear nonproliferation, arms control and disarmament matters.**

AND IN PARALLEL

- **The United States must ensure a credible nuclear deterrent for as long as is needed through steps that include continuing to refurbish and update its nuclear stockpile and infrastructure as necessary without creating any new nuclear weapon capabilities.**

Nuclear Nonproliferation and Arms Control – Possible Initiatives

Given the intensity of the debate surrounding efforts to prevent, curb, or roll back the spread of nuclear weapons to new state and non-state actors, no comprehensive package of nuclear initiatives will be politically possible without elements designed to effectively counter existing and emerging threats.

The nuclear proliferation threats represented by North Korea and Iran will be immediate tests for the next administration, and will have to be addressed alongside efforts to combat the longer-term challenges represented by existing stockpiles of the nuclear weapon states, some of which are vulnerable to terrorist acquisition. The administration will also have to deal with the proliferation risks inherent in the recent surge of interest in ostensibly civilian, NPT-compliant nuclear capabilities. The reinvigoration of the American debate on disarmament and U.S. interest in reining in a resurgent Russia vis-à-vis arms control agreements make the composition of this package as complex as it is urgent. It will be critical for the United States to engage NATO allies prior to the 2010 NPT Review Conference so that their concerns can be folded into U.S. strategy.

Restoring the fractured international regimes that have weak enforcement mechanisms will require new nonproliferation and arms control measures for which the United States could take a leading role. Some possible initiatives for the next administration are discussed below.

ENGAGING RUSSIA IN A NEW DIALOGUE ON NUCLEAR ISSUES

The chilling in U.S.-Russian relations following Russia's August 2008 invasion of Georgia reinforces the imperative to re-engage Russia in a new strategic dialogue intended to avoid growing hostility between the two nuclear superpowers. **As part of a new strategic dialogue, the United States should reinvigorate nuclear arms negotiations with Russia both to address long-standing Russian desires for more comprehensive dialogue on nuclear issues and to reduce Russia's increasing reliance on nuclear weapons in its security policy.** Russia's ongoing nuclear modernization program and issuing of nuclear threats against its "near-abroad" neighbors (to deter them from either joining NATO or hosting U.S. missile defense systems) is of growing concern to the United States and its European allies. During the Cold War, U.S.-U.S.S.R. arms control talks contributed significantly to easing tension between the two superpowers. Today, U.S.-Russian nuclear arms control talks could play a key role in preventing the revival of such a hostile relationship.

Moreover, an essential component of the recommended 21st century dual track nuclear arms control and refurbishment/updating policy is further reductions in U.S. and Russian nuclear inventories. An important and urgent first step is an extension of START I, scheduled to lapse in December 2009, with its suite of protocols and verification measures. The next administration could also move beyond the 2002 Strategic Offensive Reduction Treaty (SORT or the Moscow Treaty) with its end state of 1,700-2,200 operationally deployed warheads, by negotiating deeper reductions in both deployed strategic nuclear forces and total nuclear inventories. This study did not attempt to define what the ultimate size of the U.S. stockpile should be because of its dependence on factors that are the purview of the President and the Congress. Although U.S.-Russian talks on their total nuclear stockpiles raise many complex political and technical issues (see next paragraph), they do address the widely held view in the international community that further U.S.-Russian nuclear reductions underscore the commitment of the nuclear superpowers to their NPT Article VI obligations.

For many in the broad nuclear community, continuing to refurbish and update the U.S. nuclear stockpile enables the United States to reduce to lower inventory levels because it increases confidence in the safety, security, and reliability of the remaining nuclear weapons and enables the United States to maintain a healthy infrastructure. Moving to significantly lower numbers of ***total*** **warheads, however, should be linked (through negotiations with verifiable limits) first to Russian reductions and then global reductions.** Although concern about the "loose nuke" threat of Russian "tactical" nuclear arms has eased considerably because of increased Russian weapons security (enabled by U.S. storage and transportation assistance), the large inventory of Russian tactical weapons is still of

great concern, particularly to the United States' European allies. Moving beyond a START I follow-on and a possible SORT II treaty (to limits lower than 1,700-2,200 operationally deployed warheads) to limits on total U.S.-Russian inventories must be preceded by extensive consultations between the United States and its European allies. The United States and Russia, however, could begin discussions on how they could "baseline" (and then verify) all nuclear weapons – including strategic and tactical, deployed, reserve, and decommissioned – in an effort to establish a systematic accounting system, first for the United States and Russia and then globally. This would both reassure the international community that the United States and Russia were fully accounting for their weapons and fissile material as they reduced their nuclear arsenals and, when extended to global nuclear limits, would reduce the risk that non-state actors could gain access to the means for catastrophic terrorism.

COMPREHENSIVE NUCLEAR TEST BAN TREATY

The United States has successfully maintained its nuclear stockpile without nuclear testing since 1992 using the science-based approach of the Stockpile Stewardship Program. While there are those who doubt that the CTBT is critical to progress on nonproliferation, **U.S. ratification of the CTBT would receive strong support from nearly all elements of the international community and, if coupled with related nuclear initiatives discussed below, significant support in Washington.** A key development in the almost ten years since the 1999 Senate rejection of CTBT ratification has been the global expansion of seismic and other sensors, including the International Monitoring System (IMS), whose sensitivity has been validated by the numerous natural events that are continuously recorded down to magnitudes lower than the design criteria of the IMS. Thus, CTBT cheating will be very difficult to hide and unlikely to result in nuclear weapon advances that would alter the strategic balance between the United States and major powers. It is in U.S. interests to freeze nuclear weapons technology and the CTBT would greatly hinder further nuclear weapon innovation.[6]

From a technical standpoint, the Stockpile Stewardship Program (SSP) should remain capable of resolving issues without nuclear testing, especially if some of the proposed approaches to maintaining the stockpile and the necessary nuclear expertise are implemented. The scientific advances in our understanding of how nuclear weapons work should enable high-confidence assessments of weapons safety, security, and reliability under a CTBT.

THE 2010 NPT REVIEW CONFERENCE (REVCON)

The 2010 NPT RevCon represents a major opportunity for the United States to re-establish global leadership in nuclear nonproliferation, arms control, and disarmament.

The next administration must develop its strategy for the 2010 NPT RevCon in its first months in office. At a minimum, the United States should be prepared to respond to the planned presentation of a Global Nuclear Disarmament Treaty drafted by extreme factions of the abolitionist movement. In addition, the next administration should seize the opportunity to establish U.S. leadership by presenting a bold set of proposals that includes a combination of the following:

- Utilization of any progress with Russia in agreeing to significantly smaller nuclear stockpiles coupled to better verification measures to propose negotiations among the P-5 states for even further reductions
- New measures to limit the ability of NPT member states to exploit the Article IV loophole.[7] These measures include an international fuel management system for assured nuclear fuel supply and waste processing for non-nuclear weapon states pursuing the use of nuclear power[8]
- The development of an international nuclear forensics data bank, including special nuclear material samples, which would strengthen the ability to attribute a nuclear explosion, and hence act as a proliferation barrier[9]
- The pursuit of a Fissile Material Cut-Off Treaty (FMCT) that could lead to significantly reduced stockpiles of fissile materials, although the next administration will need to address the absence of verification provisions in the draft treaty tabled by the current administration
- A major increase in scientific exchanges and cooperative programs to improve trust, confidence and transparency between the United States and other nations[10]

This list is not exhaustive but serves to demonstrate the opportunities for the United States to engage nations on a broad set of nuclear nonproliferation topics. While these initiatives by themselves will not eliminate nuclear weapons proliferation by states determined to achieve nuclear status, they will create a global environment for reducing the possibility that proliferation will escalate into a more dangerous and unstable situation.

NUCLEAR ENERGY AND NONPROLIFERATION

Given the likely expansion of the global use of nuclear energy, driven by mounting concern over global warming, the next administration should urgently address the challenge of how to increase global reliance on nuclear energy without increasing the risks of nuclear proliferation and without creating an unmanageable supply of nuclear waste that is a major concern for proliferation.

Some options[11] that could be pursued both at the NPT RevCon and in other forums include advanced technical safeguards for existing and future reactors, proliferation-resistant, next-generation reactor design and development, proliferation-resistant spent fuel storage and re-cycling, international fuel bank(s), and an international nuclear forensics data bank. The next administration could propose to strengthen scientific exchanges on these topics with a goal of developing global initiatives.

MUTUALLY BENEFICIAL PARTNERSHIPS

The United States has had successful bilateral partnerships such as Cooperative Threat Reduction (CTR) with Russia, aimed at controlling and protecting its nuclear weapons, weapons-usable materials, and delivery systems. CTR has been criticized for the lack of Russian investment in protecting its own assets. The next administration will have to address this rightful concern as it moves to new bilateral initiatives beyond CTR, especially on issues where it will be difficult to achieve global consensus.

The Global Initiative to Combat Nuclear Terrorism, initiated by U.S. President George W. Bush and Russian President Vladimir Putin in 2006, has engaged a significant number of partner nations in committing to a set of principles aimed at improving security measures that strengthen the barriers against terrorists obtaining nuclear materials.

Another successful framework has been the Proliferation Security Initiative, an informal, multilateral intelligence-sharing project incorporating cooperative actions and coordinated training exercises to improve the odds of interdicting weapons of mass destruction and WMD components and precursors in transit to and from states and non-state actors of proliferation concern. Similar partnerships could be considered to address difficult policy or operational questions involving a large number of nations without formal treaty agreements.

U.S. Nuclear Capabilities (Platforms, Weapons, and Infrastructure): Possible Initiatives

U.S. nuclear weapons are currently designed for and deployed on a triad of delivery systems (ICBMs, SLBMs, and air-delivered). If U.S. nuclear stockpiles are reduced beyond currently negotiated levels, the United States will need to address whether to maintain the existing triad or move to another configuration (e.g., a dyad) for both national security effectiveness and cost reasons. Workshop attendees were divided on this topic, but in any event, the next administration is likely to have to address it.

The need for a responsive (but smaller) U.S. nuclear infrastructure increases as stockpile levels go down because the hedge against weapon failure passes from stockpile to infrastructure. Further, at zero weapons, this infrastructure is a hedge against breakout by a hostile state acquiring nuclear weapons. The challenge of sustaining the national weapon labs and production complex with an appropriate level of competence will also increase as the stockpile shrinks.

There has been considerable reporting in the open literature that other nations, particularly Russia and China, are "modernizing" their nuclear weapons by developing new warheads and new delivery systems that provide new nuclear capabilities. Where "modernization" is used in this paper referring to the U.S. stockpile or infrastructure, it refers only to refurbishment or upgrading of the current weapons in the stockpile without addition of new nuclear capabilities. It is limited to those activities that would typically be done to any existing weapon system as it ages, e.g., replacement of worn, dysfunctional or no longer reliable components that use the same or newer materials or technologies. Such actions may make the weapon more reliable, safer or more secure, but do not provide any new military characteristics or capabilities.

The decision space for continuing to refurbish and update the U.S. stockpile is complicated and has clearly evolved over the past year. While the decision on how to sustain the nuclear deterrent was presented to Congress as an either/or choice between Life Extension Programs (LEP) and Reliable Replacement Warheads,[12] there is instead

> a spectrum of modernization options ranging between two extremes. At one extreme [is] the replication of weapons as they were introduced into the stockpile, using hazardous materials and outdated manufacturing processes, regardless of costs or modern assessments of the designs. At the other extreme [is] the replacement of aging weapons using new designs that have not been subjected to nuclear tests, trusting our ability to predict their performance.[13]

These options—each of which is designed to improve safety, security and reliability without providing new nuclear capabilities—include:

- *Incremental steps* taken to extend the life of a warhead (iLEP), which is expected to be functionally equivalent to the existing LEP process
- *Extensive reuse* of the components of legacy warheads to extend the lifetime of a particular warhead (erLEP)
- Development of replacement warheads with more robust margins but not new capabilities

It is important to note that

> the best option along the spectrum will depend on the issue being addressed and the requirements that are imposed. If [a] design [exists] in which there is high confidence, with a component that is not difficult to replicate almost identically, replication may be the optimal solution. If policy were to require that stockpile weapons contain certain advanced [safety or security] features, then new designs could be the most reasonable option. [Further,] LEPs have not stayed completely at the replication end of the spectrum. For example, the replacement W88 pit employed new personnel using new manufacturing processes and different facilities. [The certification of this pit implies] success in venturing, to some degree, away from identical replicates, even inside the [nuclear explosive package].[14]

In each of these cases, microsensors might be added that would allow better *in-situ* monitoring of the warhead. The ability to perform better monitoring becomes increasingly critical as the stockpile shrinks. Microsensors could alleviate some, but not all, of the need for regular disassembly of selected weapons and should allow reductions in the non-deployed reserve arsenal.

The U.S. should continue to refurbish and update its stockpile as necessary without creating new nuclear weapon capabilities through the "spectrum of options" approach, both to enable deeper reductions in the total inventory and to maintain a credible nuclear deterrent as long as it is needed. A solution along the spectrum of options would apply to each class of weapons in the stockpile, not to the entire stockpile as a whole. Different activities are likely to be appropriate for each system. In addition, as the stockpile shrinks, the Department of Defense will have to examine its current requirement for redundancy in each leg of the triad, as the degree of redundancy may have to be reduced.

The Stockpile Stewardship Program has been successful to date in maintaining the safety, security, and reliability of the U.S. nuclear stockpile without nuclear testing. There are, at present, no known technical reasons for a return to underground testing in the foreseeable future.[15] Applying the "spectrum of options" approach to stockpile refurbishment and updating could be a less expensive way to extend the lifetime of existing weapons and avoid an expensive and extensive rebuilding of the weapons production complex to a Cold War-like configuration. In addition, the spectrum may be broadened if it proves possible to reuse primaries or canned secondary assemblies. Finally, while the SSP has performed well to date, technical improvements, including new certification tools, will help achieve the long-term goal of sustained nuclear confidence with a reduced stockpile and without nuclear testing.

It is more important that the "spectrum of options" approach be considered carefully, on a system-by-system basis, to determine the proper course of action, than it is to commit to a particular program now. The success of the Stockpile Stewardship Program provides sufficient time to understand fully the future needs of the arsenal, given both better understanding of the potential failure modes of each system in the stockpile and proper guidance from policy makers regarding the arsenal's missions, composition, and size.

A full discussion of the issues facing the production and nuclear laboratory complex is beyond the scope of this report. However, several points emerged in the workshop discussions that suggest a critical need for the next administration to address the nuclear complex that would have to implement the program to refurbish/update the stockpile:

- The relationship between DOE/National Nuclear Security Administration (NNSA) and the nuclear weapons labs is contentious and must be improved. The relationship between DOE and DOD in nuclear matters must also be improved.
- DOE/NNSA must develop a transparent cost-benefit analysis for all options under consideration to help the administration and Congress decide on the most effective approach.
- While small fractions of the production complex are being closed or reconfigured, real cost savings will only be realized with significant downsizing of the entire nuclear complex. As noted above, the "spectrum of options" approach to refurbish and update the stockpile could avoid large investments in facilities, such as the modern pit facility. Without clearly identified and measurable cost savings, Congress is unlikely to provide funds for any new refurbishment or updating of the stockpile.
- Because of the critical nature of science and engineering in supporting the nuclear mission, the NNSA must pay

particular attention to Los Alamos, Lawrence Livermore, and Sandia National Laboratories to ensure that these facilities remain capable of performing world-class science. In particular, the role of the national nuclear labs in energy and non-nuclear weapons security – known as "work for others"—should be addressed as the non-nuclear national security links between the NNSA labs and other federal agencies are strengthened as a way to maintain critical skills and core competencies.

- Many important and expensive scientific tools such as the National Ignition Facility and the Dual-Axis Radiographic Hydrodynamic Test Facility are only just now coming on line. It would be a mistake to move funding from these facilities to expansive modernization of the nuclear complex given the likelihood of continuing downward budgetary pressures and the need to validate the simulations of nuclear weapons.
- The NNSA should focus on improving the process of discovering and fixing potential failure modes in the stockpile. The need for independent peer review—as noted in a variety of other reports, such as the JASON study titled "Reliable Replacement Warhead" (JSR-07-336E, September 7, 2007)—implies the ongoing need for two independent science labs and a better mechanism for peer review of the engineering lab and an independent evaluation of the entire review process.
- Congress must be more engaged in nuclear issues to better perform proper oversight of DOD, DOE/NNSA and the lab/production complex. Given the uncertainty in international nuclear affairs, Congress should review the desirability of allowing the laboratories to investigate novel nuclear concepts, not for our stockpile, but to avoid technological surprise to our nation.
- Some of the recent operational mishaps in the U.S. Air Force regarding nuclear weapons raised many issues regarding chain of command and mission support credibility. While discussed at the workshops, these were not pursued in more depth in this study because other studies were addressing these issues.[16]

Scientific Enterprise

Scientific and technical expertise is crucial to sustain the nuclear weapons mission. This can be enabled through a broad range of nuclear-related research and development activities.[17]

The ability of the U.S. to engage in a variety of both stockpile stewardship and nonproliferation activities rests, in a large part, on the experience of the current workforce at the national laboratories. Very few of the scientists and engineers having nuclear test experience remain at the laboratories and many of the most experienced weapons experts will retire in the next five to ten years. Recruiting the next generation workforce and passing on this experience to that new generation is critical to the continued success of the stockpile stewardship program.[18]

The monitoring of nuclear proliferation and foreign nuclear weapons–related activities is technically demanding. Currently, there is a broad array of sensors that can track the construction of new large facilities, the levels of activity at known facilities, and the deployment levels of strategic nuclear forces. There is also considerable technology available that can detect a nuclear test to a degree that would ensure that no country could alter the current strategic balance in any meaningful way. While there are technologies available to provide on-site surveillance in nuclear facilities and to detect theft or transport of nuclear material, these technologies can be significantly improved. Also, a critical research and development (R&D) challenge is the detection of relatively small nuclear production activities in countries that are potential proliferators. It is a considerable distance to go from indications that arouse suspicions to confirming that serious covert efforts toward a nuclear capability are being attempted. There are similar research and development challenges in the areas of warhead verification, nuclear materials inventory, nuclear forensics, and proliferation resistant reactors.[19] Also, despite significant technical achievements, there does not exist at this time the necessary technology to verify a regime for the elimination of nuclear weapons. Taken together, these challenges require a substantial R&D effort.

In addition to addressing crucial nuclear-related challenges, the U.S. scientific program can be a tool in the U.S. diplomatic arsenal and a basis for creating partnerships with countries. Even at the height of the Cold War, scientific exchange between the United States and Soviet Union served to keep the two nations informed of each other's technical capabilities. In the post-Cold War era, the U.S. scientific and engineering communities have facilitated progress in areas such as counter-proliferation, weapons reduction, environmental cleanup, nuclear safety, and counter-terrorism, while helping to divert foreign military manpower toward civilian goals. Several studies of the

National Academies have articulated the importance, for both United States and international security, of increasing scientific exchange as a mechanism for sustaining transparency in certain programs. Such openness has reinforced confidence and helped to promote the security systems that are necessary for controlling chemical, nuclear, and biological weapons.

The DOE should reinvigorate broad and interconnected non-nuclear and nuclear-related R&D programs for the weapons labs in a wide-ranging set of areas, including energy R&D. Such R&D activity will attract and engage scientists of appropriate expertise into the labs and directly complement the technical skills needed to sustain the nuclear arsenal. Such unclassified research also will allow the scientists to remain connected to the national and international scientific community, which should be a goal of the DOE/NNSA in developing its human capital. In addition, as mentioned previously, the United States can engage in scientific exchange programs with nuclear-capable countries, including Russia and China, in a broad range of nuclear R&D areas such as nuclear forensics and advanced technical safeguards. Military-to-military, academic, and industrial interactions between the U.S. and Russia have decayed to a large degree; these relationships should be reinvigorated and expanded to include other countries.

U.S. Nuclear Strategy and Policy

As it conducts its legislatively mandated Nuclear Posture Review (NPR), the next administration (unlike its predecessor) should conduct a U.S. government-wide review that includes Congress and should consult extensively with other P-5 states. The classified NPR should be accompanied by the release of an unclassified version of the report and an extensive outreach program to domestic and international audiences.

The components of the package described in this report could provide the basis for conducting the next administration's NPR. Before the next administration decides on the specific issues to be addressed in the 2009 NPR, it should first address, as discussed in this report, the broader issues involved in addressing both external nuclear threats and internal nuclear challenges.

Final Remarks

The nuclear challenges facing the next administration are substantively daunting and politically sensitive. It is our conviction that they cannot be addressed separately or sequentially. By adopting a comprehensive dual track nuclear arms control and refurbishment/updating policy, the next administration has an opportunity to forge a new "centrist" way forward to end the post-Cold War drift on U.S. nuclear strategy, policy, and capabilities. This report has attempted to support that effort by identifying the components of a possible package of nuclear initiatives that the next administration could use to build broad support for moving forward on a number of related nuclear issues.

Appendix 1: Workshop Participants

Military Track Workshop, April 10, 2008

CHAIR	
Mr. Franklin C. Miller	Independent Consultant
BRIEFERS	
Dr. James Miller	Center for a New American Security
Major General Thomas Neary	Science Applications International Corporation
PARTICIPANTS	
Mr. Paul Bernstein	Science Applications International Corporation
Ambassador Linton Brooks	Independent Contractor
Ms. Madelyn Creedon, observer	Senate Committee on Armed Services
Ambassador J.D. Crouch, II	National Institute of Public Policy
General Eugene Habiger	STRATCOM Advisory Group
Dr. John Harvey, observer	National Nuclear Security Administration
Ambassador Robert Joseph	National Institute of Public Policy
Dr. Arnold Kanter	The Scowcroft Group
Mr. Paul Lettow, observer	National Security Council
Admiral Richard Mies	Independent Contractor
Mr. Barry Pavel, observer	Office of the Secretary of Defense
Mr. John Reichert	National Defense University
Dr. Brad Roberts	Institute for Defense Analyses
Ms. Lynn Rusten, observer	Senate Committee on Armed Services
Mr. Robert Soofer, observer	Senate Committee on Armed Services
Dr. Robin Staffin, observer	Department of Energy
Ms. Amy Woolf, observer	Congressional Research Service

Technical Track Workshop, April 24, 2008

CHAIR	
Dr. J. Michael Cornwall	University of California, Los Angeles
BRIEFERS	
Dr. Marvin Adams	Texas A&M University
Dr. Sidney Drell	Stanford Linear Accelerator Center
Dr. Bruce Goodwin	Lawrence Livermore National Laboratory
Dr. Glenn Mara	Los Alamos National Laboratory
PARTICIPANTS	
Dr. Lars Bildsten	University of California, Santa Barbara
Dr. Kim Budil	Lawrence Livermore National Laboratory
Dr. Christopher Deeney, observer	National Nuclear Security Administration
Dr. Richard Garwin	IBM Thomas J. Watson Research Center
Dr. Joyce Ann Guzik	Los Alamos National Laboratory
Dr. Russell Hemley	Carnegie Institution for Science
Dr. Juliana Hsu	Lawrence Livermore National Laboratory
Dr. Raymond Jeanloz	University of California, Berkeley
Dr. Dimitri Kusnezov, observer	National Nuclear Security Administration
Dr. Charles Nakhleh	Sandia National Laboratory

Dr. Victor Reis, observer	Department of Energy
Dr. Robert Rosner	Argonne National Laboratory
Dr. Robert Selden	STRATCOM Advisory Group
Mr. Robert Smolen, observer	National Nuclear Security Administration

International Relations Workshop , May 2, 2008

CHAIR

Honorable James Leach	Harvard University

BRIEFERS

Dr. Raymond Jeanloz	University of California, Berkeley
Dr. John Steinbruner	University of Maryland

PARTICIPANTS

Mr. Spencer Boyer	Center for American Progress
Ambassador Linton Brooks	Independent Consultant
Dr. Chris Chyba	Princeton University
Dr. Ariel Cohen	Heritage Foundation
Dr. John Deutch	Massachusetts Institute of Technology
Dr. Steve Fetter	University of Maryland
Dr. Siegfried Hecker	Stanford University
Dr. Jeffrey Lewis	The New America Foundation
Mr. Bruce MacDonald	Provectus Technologies
Ms. Jenifer Mackby	Center for Strategic & International Studies
Ambassador Jack Matlock	Department of State (retired)
Dr. Brad Roberts	Institute for Defense Analyses
Dr. Peter Zimmerman	King's College London (retired)

Integration Workshop , May 11, 2008

CHAIR

Dr. John Hamre	Center for Strategic & International Studies

PARTICIPANTS

Admiral Henry G. Chiles, Jr.	Center for Strategic & International Studies
Dr. Christopher Chyba	Princeton University
Dr. J. Michael Cornwall	University of California, Los Angeles
Ambassador J.D. Crouch, III	National Institute of Public Policy
Dr. John Foster, Jr.	GKN Aerospace Transparency Systems
Mr. Steve Guidice	Department of Energy (retired)
Dr. Morton Halperin	Open Society Institute
Colonel Paul D. Hughes	Institute for Peace
Honorable James Leach	Harvard University
Mr. Frank Miller	Independent Consultant
Major General Thomas H. Neary	Science Applications International Corporation
Dr. Robert Selden	STRATCOM Advisory Group
Ms. Amy Woolf	Congressional Research Service

Appendix 2: Supporting Paper Authors and Titles

Military Workshop

James Miller. "U.S. Nuclear Weapons in the 21st Century: Aiming for the Midterm." April 2008.
Thomas Neary. "The Role of Nuclear Weapons in the 21st Century." April 2008.

Technical Workshop

Marvin Adams and Sidney Drell. "Technical Issues in Keeping the Nuclear Stockpile Safe, Secure, and Reliable." April 2008.
Bruce Goodwin and Glenn Mara. "Stewarding a Reduced Stockpile." LLNL-CONF-403041, April 2008.

International Workshop

Raymond Jeanloz. "Science-Based Arms Control." May 2008.
John Steinbruner. "Rebalancing American Security Policy." May 2008.

End Notes

[1] On military, technical, and international aspects, plus an overall integration workshop.

[2] The Treaty on the Nonproliferation of Nuclear Weapons (NPT) prohibits countries from seeking nuclear weapons but provides countries a specific right to seek nuclear technologies, including enrichment and reprocessing capabilities. This allows countries legally to construct, with international assistance, sophisticated nuclear enterprises, abrogate the treaty with no penalties, and be very close to having a nuclear weapons program.

[3] William Perry, George Shultz, Sam Nunn, Henry Kissinger, "A World Free of Nuclear Weapons," *Wall Street Journal*, January 4, 2007, and "Toward a Nuclear Free World," *Wall Street Journal*, January 15, 2008. See also Douglas Hurd, Malcolm Rifkind, David Owen, and George Robertson. "Start worrying and learn to ditch the bomb." *Times of London*, June 30, 2008 [Rifkind, Hurd, and Owen are former U.K. foreign secretaries; Robertson is a former NATO secretary-general] and U.K. Foreign Secretary Margaret Beckett's keynote address "A World Free of Nuclear Weapons" at the June, 2007 Carnegie International Nonproliferation Conference.

[4] See, e.g., Luke Harding, "Putin issues nuclear threat to Ukraine over plan to host U.S. shield," *The Guardian*, February 13, 2008, and Adrian Blomfield, "Vladimir Putin's nuclear threat to the West" *The Telegraph*, February 17, 2008.

[5] Reliability can be taken to mean any of several things, including the probability that a) the warhead will be delivered to within some range of the desired target, b) the warhead will detonate, or c) the warhead will detonate within some fraction of the design yield. These probabilities have different meanings when applied to single warheads versus classes of weapons.

[6] The APS statement on Nuclear Testing, April 4, 2003, (http://www.aps.org/policy/statements/03_2.cfm) notes that "that 'fully informed technical studies have concluded continued testing is not required to retain confidence in the safety and reliability of the remaining nuclear weapons in the United States' stockpile.' Resumption of nuclear testing may have serious negative international consequences, particularly on the nonproliferation regime. In addition, the Society strongly urges the Congress and the Administration to provide sufficient notification and justification for any proposed nuclear test to allow adequate time for informed and thorough analysis and public discussion."

[7] This "loophole" presently gives non-nuclear weapon state parties access to dual-use (for nuclear power and nuclear weapons) technologies and expertise, which can be used for nuclear weapons development without penalty if the signatory withdraws from the NPT.

[8] *Nuclear Power and Proliferation Resistance: Securing Benefits, Limiting Risks,* a report by the American Physical Society, Panel on Public Affairs, May 2005.

[9] *Nuclear Forensics: Role, State of the Art and Program Needs,* report by a Joint Working Group of the American Physical Society and the American Association for the Advancement of Science, February 2008.

[10] The APS statement on The International Nature of Physics and International Cooperation, November 12, 1989, (http://www.aps.org/policy/statements/89_2.cfm) states that "science can serve as a bridge for mutual understanding across political and ideological divisions and as a vehicle for the enhancement of peace."

[11] *Nuclear Power and Proliferation Resistance: Securing Benefits, Limiting Risks,* a report by the American Physical Society, Panel on Public Affairs, May 2005.

[12] *The United States Nuclear Weapons Program: The Role of the Reliable Replacement Warhead,* AAAS Nuclear Weapons Complex Assessment Committee, April 2007.

[13] "Technical Issues in Keeping the Nuclear Stockpile Safe, Secure, and Reliable", Marvin Adams and Sidney Drell, April 2008. These ideas are discussed in detail in both of the papers (Adams & Drell and Goodwin & Mara [LLNL-CONF-403041]) produced for the technical workshop; they are on the website associated with this document and are on the CD-ROM attached to the hard copy of this report.

[14] Ibid.

[15] A study from the JASON group indicates that the lifetime of pits should be at least 80-100 years: *Pit Lifetime,* JSR-06-335, January 2007.

[16] Links to these studies are available online at http://cstsp.aaas.org/content.html?contentid=1792.

[17] *Readiness of the U.S. Nuclear Workforce for 21st Century Challenges,* a report by the American Physical Society, Panel on Public Affairs, June 2008.

[18] See, for example, *Report of the Commission on Maintaining United States Nuclear Weapons Expertise,* H. Chiles, et al, March, 1999 and Report of the Defense Science Board Task Force on Nuclear Deterrence Skills, H. Chiles, Chair, September, 2008

[19] *Nuclear Power and Proliferation Resistance: Securing Benefits, Limiting Risks,* a report by the American Physical Society, Panel on Public Affairs, May 2005; Nuclear Forensics: Role, State of the Art and Program Needs, report by a Joint Working Group of the American Physical Society and the American Association for the Advancement of Science, February 2008.