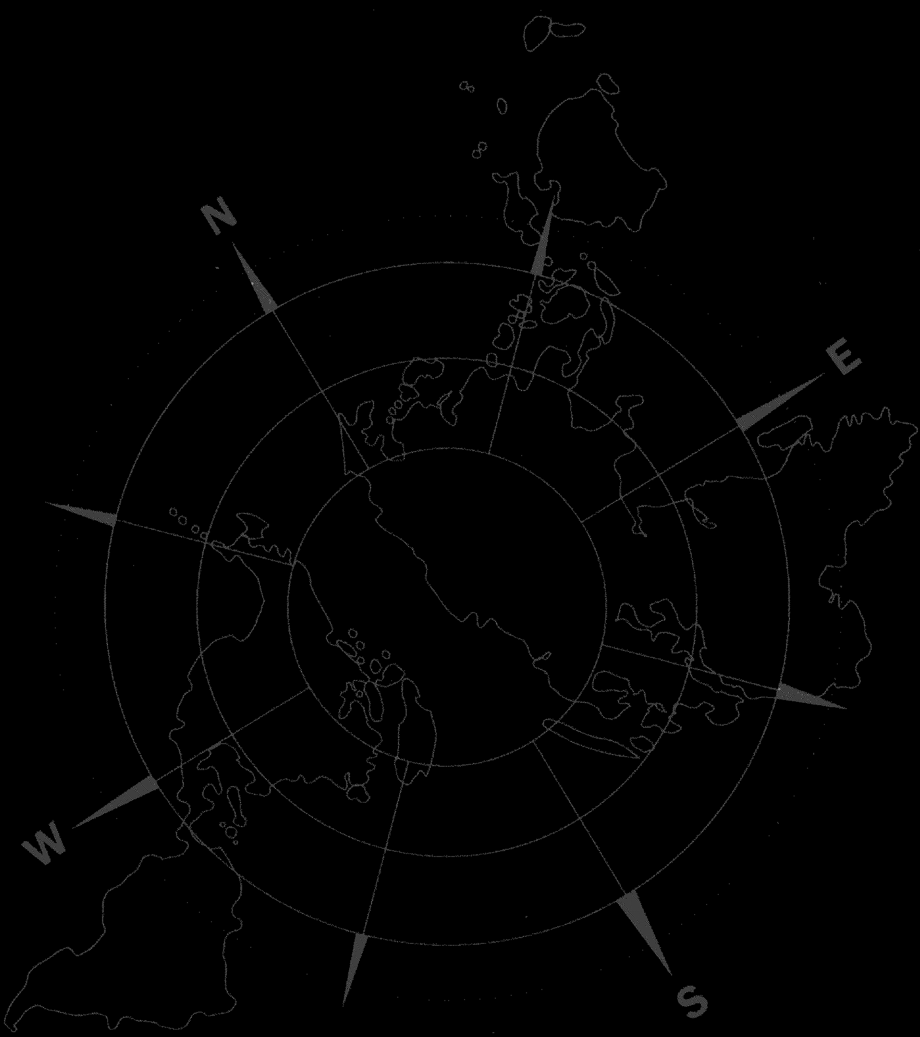
U.S. Nuclear Policy in the 21st Century

A Fresh Look at National Strategy and Requirements

Final Report



Center for Counterproliferation Research – National Defense University

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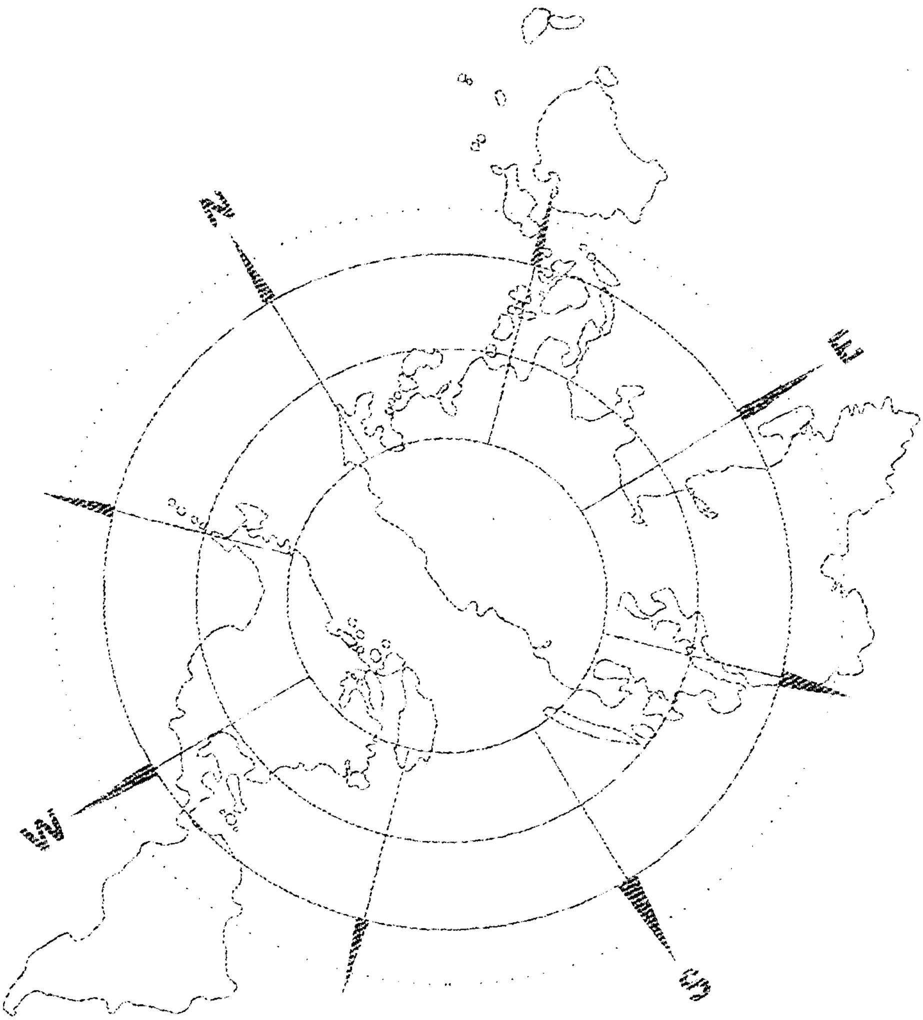

Center for Counterproliferation Research – National Defense University
Center for Global Security Research – Lawrence Livermore National Laboratory

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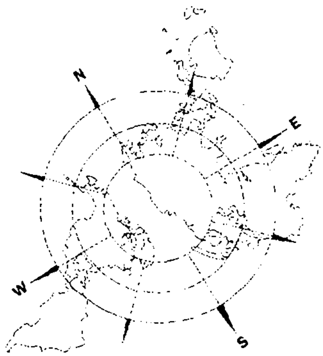
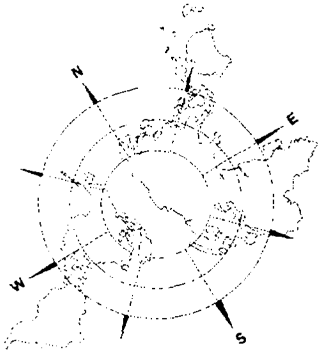


U.S. NUCLEAR POLICY IN THE 21st CENTURY



Preface

The security challenges facing the United States today are as complex as at any time in our nation's history. The confluence of revolutionary political, economic, and technological changes has made defense calculations less predictable and the maintenance of peace no less difficult than in the past. Recognizing the need for a fresh, long-term look at national strategy and requirements, and specifically at U.S. nuclear policy in the 21st Century, the Center for Counterproliferation Research at the National Defense University and the Center for Global Security Research at Lawrence Livermore National Laboratory brought together a group of experts with extensive experience in national security and military affairs. This Report is the product of their collective efforts, which were based on a shared perception of the need for a thorough review and greater understanding of the role of nuclear weapons in U.S. national deterrence policy.

The participants examined the broader trends in the international environment and considered how the United States could both shape and respond to them. A forward-looking paradigm for the nuclear dimension of U.S. security policy emerged that builds on the lessons of the past while addressing the opportunities and challenges of the future. The core of this paradigm is that nuclear weapons will continue indefinitely to play an indispensable role as a hedge against uncertainties, to deter potential aggressors who are both more diverse and less predictable than in the past, and to allow the United States to construct a more stable security environment. Thus, the United States needs a credible nuclear deterrent posture, broadly defined to include forces-in-being; capabilities for weapon system design and production; and the ability to assure the safety and reliable performance of the nuclear stockpile—a fundamental challenge in the absence of underground testing. Because this posture must be both adaptable and responsive to new threats, the national deterrent infrastructure must be treated as a strategic resource. The posture must also integrate the growing role of defenses in our deterrence calculations. All of this requires trained and motivated people, as well as new ways of thinking and considerable agility and foresightedness on the part of U.S. leaders.

The more than forty study participants and government observers included present and former policymakers, military officers, scientists, and academics. This Project Report reflects their research, analysis, and intensive discussions that took place during the winter and spring of 1998. The Report consists of an Executive Summary and four working group papers: Nuclear Strategy and Policy, Operations, DoD Infrastructure, and Stockpile. The Executive Summary contains the key judgements of the study, based on the findings and recommendations of the working groups Their four papers provide rich detail and insights in each of the critical areas. The views expressed are those of the participants. These views may not be shared by all members or observers, and do not necessarily represent official U.S. government policy.

While this Report was undergoing final editing, India and Pakistan each conducted a series of nuclear tests. The participants did not have the opportunity to consider the implications of these events. These events do, however, support our judgement that, whether we like it or not, nuclear weapons will be an integral feature of the world security environment for the indefinite future. These recent tests also reinforce the need for a broader national understanding of the role of nuclear weapons in U.S. deterrence policy. This Report is intended to contribute to that understanding.

Robert G. Joseph,
Project Director

Ronald F. Lehman II,
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The Project Directors extend their deep appreciation to all of the participants, and especially to the four working group chairmen, for their valuable contributions to the study, in the pursuit of sound national security policies and programs.

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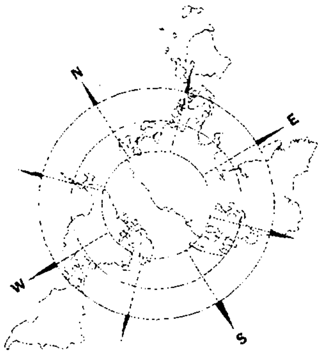
CHAPTER 1

EXECUTIVE SUMMARY



Introduction

Sweeping changes are occurring in the international system, presenting the United States with both opportunities and challenges. The East-West strategic rivalry that dominated the global security environment for over forty years has been fundamentally and, in a number of critical ways, irreversibly altered. Yet the world continues to be unpredictable and dangerous. Relations with Russia and China have improved dramatically in the last ten years but remain uncertain. Both states continue to emphasize and modernize their nuclear arsenals. In other regions of vital interest to the United States, potential adversaries increasingly have at their disposal advanced conventional and unconventional capabilities, as well as weapons of mass destruction and the means for their delivery. Together, these and other factors, such as the ongoing revolution in military technology, have engendered major adjustments in U.S. national security policy and in the strategy and forces that support U.S. security interests.

A series of U.S. government analyses, including the Nuclear Posture Review and the Quadrennial Defense Review, has guided the restructuring of U.S. conventional forces and provided the basis for the late 1997 Presidential Decision Directive on nuclear weapons policy. Further analyses and adjustments will certainly follow. As a contribution to this dynamic process, this Report assesses the rationale and requirements for U.S. nuclear weapons, and the infrastructure and people that are critical to their sustainment, in the current and future security environment. By so doing, the Report is intended to promote greater understanding of the issues and the measures that will be necessary to sustain deterrence in an uncertain future. The American public and its leadership in both the Executive and Legislative branches must remain informed, involved, and supportive. Absent concerted and continuing high-level attention to the policies and programs supporting its nuclear forces, the U.S. deterrent posture will erode, thereby undermining the ability of the United States to prevent war in the future. Nuclear deterrence is not self-sustaining.

In conducting this examination, the participants:

- Explored the past role of nuclear weapons in U.S. national security strategy and relevant "lessons learned" from that experience.

- Evaluated the changes in the international environment, including advances in technologies, and the implications of these changes for U.S. deterrence objectives, specifically for nuclear weapons policies, force structures and programs.

- Examined the nature of the contemporary and projected military threats, and the consequent rationale and requirements for deterrence into the future.

- Assessed the strengths and identified emerging gaps in the areas of nuclear operations, the supporting infrastructure, and the weapons stockpile that must be addressed to sustain deterrence as a key element of the overall U.S. security posture.

This Executive Summary presents the key judgements of the study based on the insights of the participants in the four working groups: Nuclear Strategy and Policy; Operations; DoD Infrastructure; and Stockpile. The papers of each of the working groups provide much greater detail and additional recommendations for action.

Nuclear Weapons and Deterrence in the 21st Century

Looking to the future global environment and to the ability of the United States to shape and respond to that environment, the project participants developed a paradigm suited to the new and uncertain security setting of the next century. Taking into account the understandings and experiences from the past, this paradigm envisages a dynamic, adaptable approach to the security challenges of the future. The paradigm recognizes the continuing need for deterrence in a complex world and for the retention of nuclear weapons as an essential component of the U.S. national security strategy. Yet, the role that these weapons will play in the early 21st Century, and the consequent requirements for the U.S. nuclear deterrent posture, will differ from the past. The paradigm is based on a number of elements:

- *Nuclear weapons will continue to play a unique and indispensable role in U.S. security policy.* The bilateral "nuclear balance" that occupied center stage in the past no longer dominates the strategic calculations of the United States or Russia. The number of nuclear weapons deployed by both sides has declined dramatically. Yet, U.S. nuclear weapons serve as a vital hedge against an uncertain future and contribute to deterrence of a wider and less predictable set of potential adversaries, including those armed with weapons of mass destruction. Nuclear weapons are also essential to ensure U.S. security guarantees to friends and allies, providing greater stability in the international environment and promoting U.S. non-proliferation goals.

- *Whether we like it or not, nuclear weapons will be part of the global security setting.* The knowledge to build them will continue to exist; they cannot be disinvented. Moreover, in some regions—notably South Asia and the Middle East—the value ascribed to demonstrated nuclear prowess has been increasing. The Indian nuclear tests in May 1998 and the rapid Pakistani response demonstrated the resolve of these governments, backed by domestic public opinion, to risk international censure for stated security reasons. The Indian and Pakistani tests may anticipate a long-term trend that could significantly increase the number of de facto nuclear weapons states. The emergence of more "declared" of "demonstrated" nuclear states may be inevitable. This trend points to a more, not less, nuclear world.

- *Even if the United States were to divest itself of its nuclear arsenal, other states would be unlikely to follow suit.* To the contrary, some would gain additional incentives to retain or acquire nuclear weapons against a conventionally superior but nuclear-free United States. Even if nuclear weapons were somehow eliminated, a serious deterioration of the international environment would engender strong incentives for nuclear rearmament. A rapid, competitive, multilateral race to rebuild nuclear arsenals could increase prospects for a devastating war. A century ago, no one foresaw the rise of Hitler, of Mussolini, or of Communism. The rise of similar leaders or ideologies in the future, coupled with a race to rearm with nuclear weapons, could be catastrophic.

- *In the changing security setting, the nuclear weapons infrastructure—broadly defined to include both the operational and the development/production capabilities that can maintain current capabilities and bring new forces into being needed—takes on a heightened strategic prominence.* This prominence will require a greater attention to adaptation and reconstitution. Greater flexibility in both planning and maintaining forces is also essential. Together, this requires "total posture planning," which recognizes that the credibility of deterrence, as well as the capabilities that form its basis, is the product of the totality of the U.S. nuclear posture—forces-in-being, research/development infrastructure and production potential, reserves, stocks of material, skilled manpower—and their integration with non-nuclear capabilities. Because changing the nuclear posture in response to a changing world will take time, total posture planning must look well into the future.

- *Increased and sustained engagement with other nuclear weapon states is required to foster non-adversarial relationships and to develop and strengthen the stability of nuclear postures.* With Russia, the United States must move beyond the corrosive Cold War posture of mutual vulnerability and build on cooperation to enhance mutual confidence, such as in the area of early warning. The United States will need to broaden today's discussion to encompass total nuclear capabilities (not just deployed strategic forces) and active defenses in order to enhance stability and permit the United States to meet its global security responsibilities and defend against the growing missile threat. The United States will also need to increase engagement with China, a state that presents even greater uncertainties than Russia. In a different context, it is necessary to sustain cooperative relationships with allies—nuclear and non-nuclear alike—to maintain the essential sense of security that flows from extended deterrence.

The paradigm recognizes that the fundamentals of deterrence have not changed: effective deterrence will continue to depend on both real capabilities and the perception of a national will to respond to aggression. Yet, there is an opportunity and need for a more balanced relationship among the three traditional elements of deterrence—retaliation, denial, and dissuasion. During the last half-century, each of these elements supported the overall U.S. security strategy. Although the relative importance of each changed over time in response to evolving political, military, and technological considerations, deterrence relied principally on a ready capability to retaliate with deployed nuclear forces. While robust and credible nuclear forces-in-being will remain essential, the United States can place greater emphasis on deterrence by denial through active defenses, and deterrence through dissuasion. Dissuasion is the term we use to characterize the impact of the total U.S. deterrent posture, including infrastructure, in shaping the security environment, and specifically in shaping the calculations of potential adversaries. A brief overview of how these elements operated in the past can help to anticipate how they may work in the future.

Retaliation: The central element of U.S. deterrence policy throughout the Cold War was the prospect of a prompt and unacceptable level of retaliation in response to nuclear or conventional aggression. The objective of U.S. nuclear forces was to prevent war by convincing the Soviet Union that it could not win any military conflict it initiated. The logic of deterrence required that the United States be able to destroy those targets that it believed the leadership of the Soviet Union most valued. These included conventional and nuclear forces, leadership, and industrial facilities that supported military strength and the power of the state. To be credible, particularly after the Soviet Union acquired nuclear weapons and the ability to strike the United States, the threat of retaliation had to be backed by responsive, effective, and survivable forces. After the early 1960s, the U.S. strategic force was embodied in the TRIAD—bombers, intercontinental ballistic missiles (ICBMs), and submarine-launched ballistic missiles (SLBMs)—which complicated Soviet planning and ensured that even if for technical or other reasons one leg became vulnerable, the vitality of the remaining legs would deny the Soviet Union any advantage from a first strike. Further flexibility was provided by theater nuclear weapons (also called "sub-strategic" or "non-strategic") integrated with combat forces to enhance deterrence against massive conventional attack. Because of the magnitude of Soviet conventional and nuclear forces, and the immediacy of the threat they posed, the United States could not rely solely on mobilization of resources after the onset of a crisis, as it already had done twice in the 20th Century.

Denial: Denying an adversary the ability to achieve his goals through military means, that is blunting or negating the effectiveness of his forces, was another means of strengthening deterrence during the Cold War. Before the advent of ICBMs, air defenses against Soviet bombers played a large role in the U.S. deterrent posture. Passive defense, in the form of civil defense measures, was also seen as enhancing deterrence. With the advent of large numbers of long-range ballistic missiles—and the adoption of the mutual assured destruction doctrine and its successors—defenses were given a much-reduced role. In the context of assuring the effectiveness of offensive retaliatory forces, the 1972 ABM Treaty codified strict limits on strategic defenses and thereby accepted the vulnerability of the U.S. population to Soviet nuclear attack. From the mid-1980s until the early 1990s, in an effort to move beyond this vulnerability, the United States greatly expanded research and development aimed at giving active missile defenses increased weight in the deterrent concept.

Dissuasion: During the Cold War, in addition to military forces-in-being, the United States possessed a range of other capabilities that, collectively, helped convince potential adversaries of the ultimate futility of large-scale military aggression. For example, in addition to U.S. economic strength and political leadership, the highly visible research and development, production, technology, and industrial base of the United States enabled it to deploy forces that would deter nuclear attack, and to portray a national commitment to counter any threat. This posture conveyed not only the existing capabilities of the United States, but its overall long-term potential, that is, what the United States could develop and deploy in the future. This helped shape Soviet views of their bleak longer-term options and prospects. Former Soviet officials have cited intermediate-range nuclear missile deployments, the Strategic Defense Initiative, the computer revolution coupled with export controls, and the expanding Western economy as factors

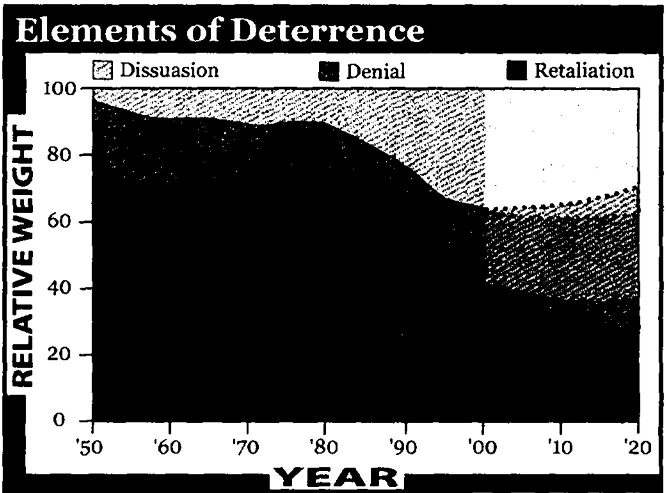


Figure 1. A notional representation of the changing contribution to deterrence of retaliation, denial, and dissuasion. The data are purely illustrative.

that helped convince the Soviet leadership that sustaining the strategic competition for an indefinite future would ultimately result in a situation they would find untenable. Recognizing the decay and near bankruptcy of their own industrial and societal base, these leaders understood the need to transform the Soviet system fundamentally, a process that, once begun, unleashed the forces that would bring down the Soviet state.

The relationship between and among retaliation, denial, and dissuasion in the security setting will continue to evolve. The United States will need to deter actors who may not respond to deterrence in the same way as the former Soviet Union. Effective retaliatory forces will always be a central requirement for and the ultimate foundation of deterrence—we place no credence in "virtual deterrence." Forces-in-being provide a critical hedge against other nuclear weapon states, and serve to deter major aggression more broadly, including the use of chemical and biological weapons (CBW). Yet, in this new security environment the United States must be prepared to adjust to the way it structures deterrence, relying less on the threat of retaliation and more on denial and dissuasion.

One challenge of the future will be to take advantage of denial capabilities. Technological advances and sound policy (such as a decision not to accept mutual vulnerability relationships with other states) will surely increase the perceived utility of active defenses. The emergence of regional adversaries armed with CBW and increasingly longer-range ballistic and cruise missiles has already created a new emphasis on denial in theater warfare, placing additional value on theater missile defense (TMD) and on other improved active and passive measures. Development of even longer-range capabilities by such states will increase the importance of national missile defense (NMD).

Another important challenge will be to articulate and enhance the role of dissuasion as a fundamental element of U.S. deterrence, to continue to develop effective tools of dissuasion, and to integrate them into deterrence policy. Some of the capabilities that bolster dissuasion and relate specifically to this study include the requirement to sustain a flexible nuclear posture, to embrace a visibly active planning process that encompasses the total posture, to broaden intelligence efforts that support deterrence, and to sustain an infrastructure capable of meeting any threat. The total posture must be planned so that it will be responsive both to new threats and to new opportunities to attenuate threats. The importance of sustaining a national deterrent infrastructure that provides the flexibility to respond in time to military threats against the United States and its allies will be fundamental.

Key Judgements

The United States faces two major foreign and security policy challenges as it moves into the next century: *first*, to create and use opportunities to achieve a more peaceful and prosperous world order and, *second*, to manage and discourage potential conflicts across a broad spectrum, many of which may engage the United States directly. Both of these challenges will require the United States to define the role that deterrence will play in national security policy. As in the past, deterrence will require a broad range of capabilities. In this context, a number of key judgements can be drawn.

Judgement:

Nuclear weapons will remain indispensable to U.S. security.

Nuclear weapons were first developed during a major conventional war that claimed the lives of tens of millions of combatants and civilians. The only employment of nuclear weapons to date was in that conflict, when this "absolute" weapon was used, not as a deterrent, but as a means to defeat Japan's will to fight, end World War II, and avoid the high human costs of an invasion of the Japanese mainland. Based on the number of casualties from Okinawa and the fire bombings of Tokyo and other cities, the decision to use nuclear weapons against

Hiroshima and Nagasaki is often credited with having saved many more lives, allied and Japanese,than it took.

Despite this legacy, nuclear weapons today are most commonly viewed as tools of deterrence—tools that were instrumental in maintaining a long-standing "balance of terror" shaped by the political, military, and technological dynamics of the Cold War when both the United States and Soviet Union managed an adversarial "coexistence" primarily through the prism of nuclear weapons. For the United States, these weapons were for decades seen as critical in deterring war, particularly a massive Soviet conventional attack in Central Europe that could include the use of nuclear and chemical weapons. No one doubted the terrible destructive power of these weapons or the incalculably horrific consequences of nuclear war. It was the very certainty of such knowledge upon which the policy of deterrence was based.

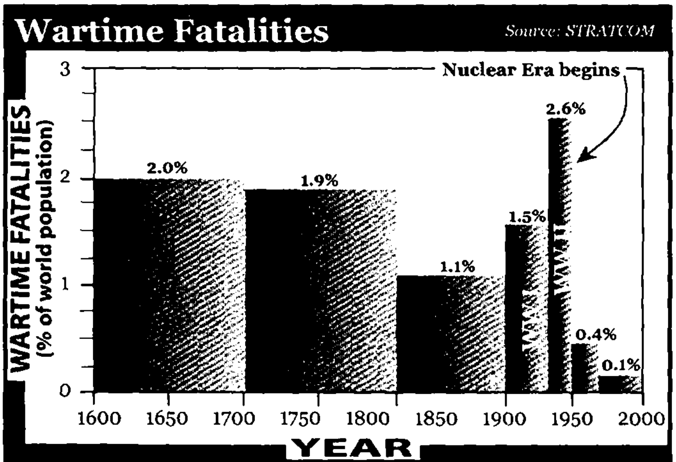


Figure 2. Wartime fatalities as a percentage of population have declined significantly in the 50 years since the nuclear era began.

The United States is no longer concerned with what was for many years a grave and urgent prospect of large-scale armed conflict in Europe. Today, the threat of war between the United States and Russia has been greatly diminished, as relations have improved politically, economically and militarily. The capabilities of this former opponent have changed fundamentally.

The positive changes in the relationship between the United States and Russia are apparent in the U.S. military posture. Conventional forces in

Promoting Strategic Cooperation With Russia

Since the end of the Cold War, the United States and Russia have made significant progress in addressing problems in critical areas of nuclear safety and security. Cooperatively, the two countries are working, with some success, to improve the overall security of former Soviet nuclear facilities, promote fissile material control and accountability, and support the dismantlement of some Russian nuclear forces.

There remain other areas of concern that could benefit from expanded cooperation. One candidate is the possible sharing of early warning data to enhance command and control and to increase stability in peacetime as well as during potential crises. The United States and Russia began preliminary high-level discussions on the possibility of cooperating on early warning in the summer of 1992, in the context of U.S. and Russian proposals for establishing global protection against ballistic missiles. At that time, it was becoming clear that Russia would experience a loss of radar coverage from sites that, following the break-up of the Soviet Union, would be located outside its territory. Consequently, among other things, the discussions explored ways that could fill gaps in the Russian early warning system. It was anticipated that such cooperation would be particularly useful on the southern periphery to provide better early warning against states that were acquiring weapons of mass destruction and ballistic missiles as a means of delivery. These promising discussions were discontinued.

The United States and Russia should resume high-level discussions on early warning. The prospects for mutual benefits from such cooperation remain valid today. A combination of several approaches could be pursued. One approach may be for the United States to provide Russia with selected technology that facilitates the indigenous rebuilding of its early warning systems. Another approach might be to share early warning data in a transparent framework. In addition to the obvious benefit for Russia, there is likely to be substantial value for the United States to have access to Russian information, because it might provide tracking or confirmation of launch locations from another azimuth, as well as useful data about missile launches from Asia. A third approach might be to establish a direct link between command centers to allow for resolution of ambiguous indications.

Europe have been reduced by two-thirds and restructured for regional conflicts. On the nuclear side, most U.S. theater nuclear roles—those that required atomic demolition munitions and artillery-fired atomic projectiles—that were relied on to offset Soviet conventional superiority, have been eliminated. In fact, U.S. theater nuclear forces have declined by over ninety percent. At the strategic level, through formal arms control agreements and mutual actions, the United States and Russia have each reduced from about 12,000 to 6,000 deployed strategic warheads accountable under START I. If START II is implemented, these levels will be reduced to about 3,000 to 3,500 on each side. The levels under discussion for START III would bring this down even further to about 2,000 to 2,500 accountable warheads. The corresponding reduction in U.S. megatonnage, a common measurement of destructive power, has exceeded the decline in the number of delivery vehicles, reaching over ninety percent.

Positive changes have occurred in the security setting. However, the world remains uncertain and dangerous. The United States should continue its efforts to prevent proliferation, but must recognize that other states will continue to retain nuclear weapons, and still others will try to acquire them. U.S. nuclear weapons serve to protect against an uncertain future with Russia and China, states that continue to value nuclear weapons for both political status and, in Russia's case, to overcome what it sees as a growing conventional inferiority. In fact, nuclear weapons appear to play a growing role in the security strategy of Russia, both in declaratory policy and defense planning. The retention of between 10,000 to 15,000 (and perhaps many more) theater nuclear weapons, the recent deployment of the new SS-27 ICBM, and a continuing investment in its overall nuclear infrastructure, especially hardened command and control facilities and the extensive nuclear weapons production complex, indicate how important these weapons are to Russian military and political leaders. The strategic uncertainties with China are perhaps even greater than those with Russia. As an emerging global power, China also highly values its own modest but capable nuclear forces, as demonstrated by its tests of a new generation of nuclear weapons before signing the Comprehensive Test Ban Treaty.

The United States also requires the means, both conventional and nuclear, to deter aggression and control escalation by regional and rogue states armed with nuclear weapons. States such as North Korea and Iran either have or are aggressively pursuing the acquisition of nuclear weapons. Evidence demonstrates that, despite the important contribution of international non-proliferation regimes and norms, a determined proliferator will likely succeed. Such states do not seek nuclear weapons because the United States has nuclear weapons. Rather, their motives for acquiring nuclear weapons are numerous and overlapping, ranging from status, to regime survival, to use as tools of aggression against neighbors. Key among these incentives is deterring the United States from intervening with conventional forces in regions in which these states seek to achieve their goals through the use of force. In this context, one principal lesson of the Gulf War was that such states currently cannot compete with the United States on the conventional battlefield and therefore must threaten to use asymmetric strategies to discourage U.S. intervention. U.S. nuclear weapons contribute to the prospect that any such attempts to deter us will not succeed.

As other weapons of mass destruction—chemical and biological—spread to potential adversaries in regions of vital interest to the United States, and as the likelihood of the use of these weapons increases, U.S. nuclear forces become an even more important factor in deterring attacks on U.S. forces and population, as well as on those of friends and allies. Because of their unique character, nuclear weapons have long served as an expression of the U.S. capability and determination to deter a broad range of threats to vital interests. These weapons may, in the future, provide the clearest and most visible statement of the national will to deter chemical and biological attacks. The new circumstances associated with the spread of CBW, as recognized in national guidance, have expanded the role of U.S. nuclear weapons as a deterrent against such use.

The real world example of Iraq's behavior in the Gulf War is instructive. While it is impossible to determine with absolute certainty why Iraq did not use its chemical or biological weapons against the U.S.-led coalition in 1991, Iraqi statements have emphasized that U.S. nuclear weapons played significantly in their calculations. Furthermore, U.S. policymakers sought to convince the Iraqis that they could not discount the possibility of a U.S. nuclear response to Iraqi use of chemical weapons. Some of these policymakers later stated that nuclear weapons would never have been employed. However, they make this statement not to deny the deterrent value of nuclear weapons, but to emphasize that there was no operational role for these weapons given the rapid victory of the coalition's conventional forces. Had Iraq used CBW, this judgement could have been quickly reevaluated.

U.S. nuclear weapons have also formed an indispensable basis for achieving stability through extended deterrence. U.S. nuclear weapons remain important to assure our friends and allies that their security is linked as fully as possible to that of the United States. The U.S. nuclear arsenal was designed and deployed in a way that provided credible security guarantees to allies. The United States extended deterrence by making it clear that it would, if necessary, use nuclear weapons in response to a Soviet nuclear or conventional attack on allies, especially in Europe and Japan. Although the United States, together with its NATO allies, sought to deploy a conventional force posture that could avoid an early resort to nuclear weapons to halt a potential Soviet advance, the Alliance did not forgo the option for "first use" of nuclear weapons, if needed, in a conflict in which the Soviet Union employed only conventional forces. Indeed, U.S. doctrine was "no first use of force," while reserving the right to respond to the use of force by others by drawing on the full range of available and appropriate capabilities. In this sense, U.S. strategy held nuclear weapons to be essential for deterring the use of conventional and chemical weapons, as well as nuclear use by the Soviet Union. The extended deterrence concept, which underscored the "coupling" between U.S. security and that of the allies, existed in a strategic setting in which the United States had an explicit security guarantee with allies, backed by vast nuclear and conventional military capabilities and the forward deployment of hundreds of thousands of U.S. troops and their families in Europe and Asia.

As with the United States, the overall threat to most allies has declined. Yet, from Japan and Korea in the Far East, to Germany and other NATO allies in Europe, U.S. nuclear weapons continue to reassure allies, provide stability, promote peace and, by reducing incentives or eliminating the need for others to acquire nuclear weapons, contribute to nonproliferation goals.

For political and strategic reasons, the United States, as a nation with vital interests around the globe, must maintain conventional and nuclear forces consistent with its security responsibilities, interests, and commitments. There is wide agreement that the global role played by the United States requires continued investment to maintain superiority in conventional capabilities. There is also consensus that the great superiority in conventional forces the United States currently possesses provides a key element of deterrence for a wide range of threats. However, while advanced conventional forces contribute to deterrence, they are not a substitute for nuclear weapons. The United States cannot be certain that all adversaries will be deterred by the U.S. edge in conventional capabilities, especially if these adversaries are tempted to acquire weapons of mass destruction, including nuclear weapons, precisely because of their perceived value in posing an asymmetric threat. Moreover, looking to the future, there is no guarantee that the United States will maintain its qualitative conventional edge in all key areas, either because of funding deficiencies caused by competing national priorities or because other states will supercede the U.S. in key technologies, or adopt effective asymmetrical strategies.

The United States has security interests and requirements different from all other states. The global role the United States plays today imposes unique risks and responsibilities. For these reasons, the United States should not tie its capabilities to those of any other single state, such as Russia, which for a variety of reasons may reduce its strategic nuclear systems to relatively low levels. Furthermore, the United States clearly could not meet its international security responsibilities if it reduced its nuclear weapons stockpile to a level comparable to that of a regional nuclear weapons state, such as China. Finally, the suggestion that the United States could accept very low numbers of nuclear weapons (e.g., on the order of the numbers estimated to be attainable by nations such as India and Israel) reflects more an aspiration for a nuclear-free world than the basis for a sound national security policy and capability. Such low numbers may even inspire other nations to seek parity with U.S. nuclear forces, with the perceived political status that equality would confer.

In addition to maintaining nuclear forces consistent with national security requirements, U.S. declaratory policy must be tailored to enhance credibility and reinforce deterrence. Proposals that the United States move toward a policy of "no-first use" of nuclear weapons, perhaps by expanding negative security assurances, have been consistently rejected for sound strategic reasons. These reasons remain valid today. To deter credibly, the United States must reserve the right to determine the time, place, and nature of its response to aggression. The United States must be very clear that it will respond decisively to aggression, leaving open the precise character of that response. To do otherwise risks allowing an aggressor to devise strategies that limit the ability of the United States to respond. The very uncertain nature of the potential U.S. response, coupled with an ability to respond overwhelmingly, complicates an aggressor's calculations, contributes to his uncertainty of success, and makes deterrence credible.

In conclusion, although nuclear weapons play a less visible role in U.S. national security calculus than in the past, they continue to make an indispensable contribution to the defense of the United States. Nuclear weapons remain the "ultimate deterrent"—instrumental in deterring the use of nuclear weapons against the United States, in deterring other weapons of mass destruction, and in deterring future large-scale conventional attack against the United States or friends and allies. Moreover, by enhancing stability and promoting nonproliferation objectives, U.S. nuclear weapons further contribute to U.S. and international security.

Judgement:

The U.S. nuclear deterrent force must be structured to counter existing and emerging threats.

The credibility of the U.S. nuclear deterrent must never be open to question. The U.S. nuclear posture today—both policies and forces—can be different from those of the past when the United States faced a much larger and more immediate threat. At the same time, based on the lessons of the past and an assessment of the future, it is clear that certain attributes of the nuclear deterrent must endure if the United Stated is to be perceived as having the capability and will to meet the security challenges it now faces.

To achieve a stable deterrent, experience has demonstrated that U.S. nuclear forces must possess certain fundamental characteristics:

- The nuclear deterrent forces must be *safe* and *secure*. There can be no relaxation of the extremely high standards of safety that have been achieved.

- The forces must be *responsive* to political control and *effective* against the entire range of potential targets contemplated in the strategy. Both U.S. leaders, and the leadership of the states to be

The Dangers of De-alerting

Stories about the possible erosion of Russian nuclear command and control capabilities, even if exaggerated, point to a legitimate concern. Precautions against accidental, mistaken or unauthorized use of nuclear weapons have always been of critical importance. Steps to strengthen precautions should include cooperation between the United States and Russia on enhanced early warning, the restructuring of nuclear forces as provided in START I and II, deployment of missile defenses and, over the longer term, continued support for political and economic reform in Russia.

The concept of de-alerting—that is, taking nuclear forces off alert status and rendering them incapable of timely response—has been offered by some as a means to assuage concerns over the deterioration of Russian warning and command capabilities. Numerous schemes have been proposed for de-alerting major portions of the U.S. deterrent forces or to have the United States rely solely on a single leg of the TRIAD. None of these proposals would contribute to U.S. security and most would be harmful. Some de-alerting has been done in the past as a symbolic political gesture to reinforce steps already planned and to encourage continued political movement. However, de-alerting measures that have been proposed in the name of safety and stability concerns would not solve any of the alleged problems for which they are advocated and, in fact, would make many of them far worse, including in the area of basic security of nuclear weapons.

Most fundamentally, the majority of recent de-alerting proposals are unverifiable and some would lead to crisis instability. De-alerting undermines a basic principle of deterrence; namely, the ability to retaliate promptly so as to prevent any aggressor from assuming it can achieve a "fait accompli." In this context, assertions that de-alerting of U.S. strategic forces would eliminate fear of surprise attack have not been demonstrated, and substantial evidence suggests de-alerting would make such an attack more attractive by making an effective first strike possible at very low attack levels. This possibility would only increase tensions on both sides and provide incentives to strike first. Any moves to place nuclear forces back on alert in a crisis (if needed for deterrence or survivability) would be seen as escalatory if taken, and would be destabilizing if not. Finally, de-alerting major portions of the U.S. deterrent force would undermine alliance security guarantees and further exacerbate the disparity in U.S. and Russian theater nuclear force levels.

For these reasons, the United States should not make significant changes to its current alert posture. De-alerting should not be allowed to become a back door to unilateral nuclear disarmament.

deterred, must have confidence in the ability of the United States to strike when and where it believes necessary.

- The overall forces must be *survivable* so that no adversary perceives vulnerabilities to exploit, thus undercutting stability.

The United States should retain the three legs of the TRIAD (ICBMs, SLBMs and bombers). Elimination of any one leg would weaken deterrence. The TRIAD remains valuable for the same reason it always has: the synergy of the three legs. That synergy provides flexibility to our leadership, enhances survivability, and complicates defenses, thus strengthening deterrence. Diverse basing and penetration modes also provide a hedge against both a technological breakthrough by an aggressor and discovery of significant material problems with any one system. Each component of the TRIAD has important qualities.

- *SLBMs.* Individual Trident submarines when in their patrol areas remain the most survivable forces in the TRIAD and thereby add significant stability. Yet, having too large a percentage of SLBM warheads in a small number of submarines would incur the risk of catastrophic failure in the deterrent in the event of a breakthrough in antisubmarine warfare capability, or undiscovered deficiencies in the Trident system. Further, strategic submarines are vulnerable in or near their two operating bases. Over time, limiting the U.S. deterrent to a small number of platforms could invite an adversary to invest in a capability for various forms of attack, including an attack for which it would be difficult to establish cause or blame. Because the losses would not be replaceable, overall U.S. capabilities could be significantly eroded.

- *ICBMs.* As Russian nuclear forces are reduced, the U.S. single-warhead, silo-based ICBMs are of increasing value in deterring large-scale attack. First, any attack on U.S. ICBMs would necessarily have to be large and unambiguous; any potential attacker would have to assume substantial retaliation. Second, to conduct a large-scale attack on the U.S. ICBM force with high confidence, an adversary would need to commit a large fraction of his forces, probably by using at least two warheads to attack each silo. Even if such an attack were successful, the result would be that the United States would retain (in the SLBM and bomber forces) a very large advantage in the number of remaining operational warheads, a position no adversary would likely find acceptable. In this way, the elimination of ICBMs with multiple warheads will change the perception of ICBMs from being considered de-stabilizing (because a small number of multiple warhead ICBMs can threaten a larger number of missiles in silos) to being considered stabilizing (because the attacker would need to expend far more warheads than would be destroyed and because the nature and source of an attack would be unambiguous). Further, if there were no U.S. ICBMs, an adversary might, during time of great crisis, be tempted to conduct a limited surprise attack (for example, from a single ship at sea) against the small number of U.S. bomber bases and submarine support facilities. Such an attack—which could be portrayed as the work of a rogue crew even if it were not—would have a devastating effect for an extended period on the U.S. ability to respond. The decision to retaliate might be difficult, given the ambiguity of the attack and the forces remaining to the adversary. The existence of significant numbers of single-warhead ICBMs greatly reduces the potential gain from such a small, ambiguous attack.

- *Bombers*. The United States will continue to require bombers for their conventional capabilities. The issue is whether these bombers should also be nuclear-capable. There are strong reasons to retain the bomber leg of the TRIAD. Given the continuing conventional contingency mission of the bomber force, the low incremental cost of maintaining its nuclear capability will remain a bargain. Further, bombers can be restored to full alert in a relatively brief period; and doing so could be a powerful signal of U.S. resolve, which does not in itself pose a first strike threat. Finally, without bombers, the United

States would be left with a single penetration mode (ballistic missiles), thus simplifying an adversary's problem of defending against a retaliatory strike and leaving the United States with no hedge against the emergence of effective ballistic missile defenses in China or Russia.

In addition to strategic forces, the United States requires theater nuclear forces that can couple U.S. capabilities closely and visibly to the security of friends and allies. The United States should retain the nuclear capability currently deployed in NATO Europe. In designing a posture to deter regional states that possess weapons of mass destruction, the United States should also maintain the capability to deploy nuclear forces with a range of capabilities swiftly into other regions. From an operator's perspective, strategic forces can strike targets anywhere on the globe, and strategic aircraft can be deployed outside the United States. However, there may be circumstances when the best deterrent will be a visible and more proximate deterrent force. The ability to bring theater nuclear forces into any region in a time of crisis and to use such forces, if necessary, could provide the most credible deterrent. There may also be circumstances where the deployment of nuclear forces to a region would send a powerful message of coalition political solidarity in a way that U.S.-based forces might not. This policy rationale supports the long-term retention of dual-capable tactical aircraft and nuclear-armed sea-launched cruise missiles. To retain this capability, the United States must maintain effective delivery means. This can be accomplished by ensuring that currently projected aircraft (such as the Joint Strike Fighter) are capable of performing both conventional and nuclear missions, and by assuring that the option to use a naval nuclear land-attack cruise missile is available.

Command and control of nuclear forces is critical for assuring deterrence. There must be no perception of vulnerability that could invite attack. There must be no doubt that U.S. forces can strike when and where directed by national authorities.

Strategic command and control—like all command and control—will continue to evolve. In the coming decades, the ongoing revolution in commercial capabilities, coupled with secure encryption techniques, will offer new possibilities. Hardened data rather than hardened systems is an important concept for future command and control systems. In the future, military communications will consist of military data flowing over many commercial networks, just as financial or any other data will. A related shift in focus will be in the transmission of data. Strategic command and control data will flow through two systems: a flexible day-to-day family of networks and a survivable, dedicated military element for absolute assurance of delivery of critical messages from the National Command Authorities.
There are some important caveats to these concepts. The United States must not further shrink its current nuclear command and control capabilities until commercial systems are proven to be as secure as the existing system. Encryption techniques that are designed to replace existing authentication procedures must be carefully assessed. Moreover, the issue of reliably communicating complex data relevant to flexible attack of targets anywhere in the world must be addressed. Further, commercial networks must be thoroughly tested to determine their vulnerabilities to disruption before they are used for communication of complex targeting information.

The various elements of nuclear planning must be integrated to ensure that plans are responsive to national policy guidance. There continues to be a shift in relative emphasis from large plans to limited, more flexible plans that apply to new threats. The future nuclear planning structure will need to combine effectively both pre-planning and ad hoc planning. The growth of knowledge-based systems will directly affect the planning process, making it possible to create options in near-real time. Flexibility and responsiveness incorporated into a well-trained and exercised force, will be essential for deterrence. The planning process itself is crucial because it trains each generation of planners, decisionmakers and operators.

The readiness of nuclear forces—the capability to plan and execute nuclear missions when required—is a crucial component of deterrence. Today, the tasks of operating, maintaining, securing and supporting nuclear forces in the field and at sea are being performed in a highly professional manner. Nevertheless, the continued declining focus on U.S. nuclear weapons is forecast to result in critical expertise shortfalls in the key areas of planning, weapons technical issues, command and control, arms control, and operational test and evaluation. In addition, the career military today generally view the various nuclear career fields as out of the mainstream and offering uncertain futures, which poses significant obstacles to the ability to recruit and retain the necessary nuclear expertise. While the Department of Defense and the Services are cognizant of these factors, it is imperative that senior-level attention be given to these issues today to avoid critical deficiencies in nuclear expertise in the near future.

Judgement:

A confluence of factors is leading toward a greater role for denial capabilities in the U.S. deterrent strategy.

Because of the increasing threat of missile delivery of nuclear, chemical, and biological weapons, combined with technological advances in missile defenses (against both cruise missiles and ballistic missiles), the United States should pursue active defenses as a major component of deterrence. The perpetuation of the Anti-Ballistic

> ***Moving Beyond Vulnerability***
>
> A policy that holds American society totally vulnerable to nuclear attack is not in the security interest of the United States or Russia. Emphasis on a policy of mutual vulnerability inhibits the long-term positive evolution in the relationship between these two states. Moreover, the United States should not allow a mutual vulnerability relationship to emerge with other states, either intentionally or otherwise. The ability of the United States to develop and deploy effective defenses against smaller-scale attacks will establish a firmer foundation for deterrence in the future and provide protection for forces and populations.

Missile Treaty constrains the ability to implement technological advances as they occur. Nevertheless, over the next ten to twenty years, advanced missile defenses are likely to play an increasing role in U.S. deterrence policy and strategy.

In addition to the current emphasis on developing and deploying theater missile defenses, the United States requires an effective missile defense against the emerging threat from rogue states armed with long-range missiles. States such as North Korea and Iran are acquiring these capabilities as a delivery means for weapons of mass destruction. To ensure the ability of the United States to resist blackmail threats, as well as the viability of U.S. alliances, the United States must have high confidence in its ability to defeat at least several dozen reentry vehicles aimed at its cities.

The specific attributes of deployed defensive systems will be strongly influenced by the political-military dynamics that unfold from technological advances. A number of factors apply:

- It will be feasible to field effective systems, though considerable testing remains to be conducted before any particular system can be designated as ready to make a meaningful contribution. Of course, improvements in offensive systems can make the defensive task harder, and point to the need for continuing improvements in missile defenses after they are deployed and as new technologies for defensive systems are developed.

- The ABM Treaty, while allowing limited strategic defenses, prohibits deployment of a nationwide ballistic missile defense and inhibits development of new technologies. The ABM Treaty was amended in 1974, but further changes to permit effective defenses, as proposed by the United States in 1992, were not accepted by Russia. Multilateralization of the Treaty, as proposed, would make such amendments even more difficult to achieve.

- Whatever happens to national missile defense in the near term, theater missile defenses will be developed at a deliberate pace with reasonably robust deployment of a land, and/or air, and/or sea-based system, which could build on the foundation that already exists.

- The deployment of a replacement for the Defense Support Program satellites (currently termed SBIRS-High) is essential. Although it is unclear whether SBIRS-Low (infrared detector in a low earth orbit) will be deployed, it is currently funded in the Air Force budget, and support in the Congress is strong. SBIRS-Low is needed for a truly effective theater defensive system.

- Networks capable of reliably transmitting data rapidly from space-based and other sensors to warfighters and TMD/NMD platforms—such as the Cooperative Engagement Capability architecture that includes SBIRS-Low—should provide the possibility of significantly increasing the area covered by any given defensive unit.

There is a clear need for U.S. missile defenses to have boost-phase intercept capabilities in order to defeat enemy offensive ballistic missiles that possess enhanced countermeasures. Therefore, development of boost-phase intercept systems that can respond to these threats should be undertaken. The Air Force is working now on an airborne laser. In the longer term, as technologies evolve, there will be a revolution in space-based architectures that will greatly enhance the prospects for effective defenses.

Judgement:

The U.S. nuclear deterrent infrastructure must be capable of maintaining current forces, as well as sufficiently adaptive to provide new capabilities when required.

The infrastructure needed to keep current forces operational and to meet future challenges encompasses the science and technology base; the industrial base; weapon systems; command, control, and communication systems; and the people who make it all work, including management structures that provide oversight and support in both the U.S. government's policy and acquisition organizations. The strength, flexibility, and responsiveness of the nuclear weapons infrastructure play an important role in deterrence. A healthy infrastructure is essential to making clear to any adversary that the United States could adjust and respond to any emerging threat, even with new forces or capabilities if necessary, more rapidly than the threat could be mounted. In this context, the infrastructure must be sufficiently flexible and robust to respond—in technology, numbers, and management perspective—to sharp departures from the expected security environment.

The Need for a Comprehensive Plan

The United States currently lacks a comprehensive roadmap to guide efforts to support the full range of capabilities needed to have confidence in the deterrent forces up to and beyond the lifetime of currently deployed systems. The existing approach is piecemeal. There is no overall plan or commitment to provide the funding necessary over the next decade. The Department of Defense should develop a companion plan to the Department of Energy's still evolving Stockpile Stewardship Program, the program that guides the entire DOE effort over the next decade to keep nuclear weapons safe and reliable. Such a plan would not only meet DoD's needs but also provide a requirement basis for DOE's efforts.

The absence of a Department of Defense (DoD) plan for the sustainment of nuclear deterrence draws attention to the lack of a management focus for nuclear weapon system matters. In the past, a near continuous involvement of senior civilian and military leadership in strategic force modernization plans, arms control activities, capability reviews, and exercises brought coherence to the activities associated with nuclear weapons policy and programs and thereby contributed to overall readiness. Because almost all U.S. nuclear force modernization programs have been canceled or curtailed with the end of the Cold War and the downsizing resulting from arms control agreements, nuclear force matters no longer demand the continuous involvement of senior leaders. In fact, the current reorganization schemes within the DoD leave it unclear which, if any, organization is the focal point for nuclear issues.

Within the acquisition structure there is no one with full time responsibility for the oversight of all nuclear weapon systems, the coordination of command and control systems procurement in support of nuclear weapon systems, or the coordination with the Department of Energy (DOE) for support for those systems. Serious consideration should be given to the creation of a position that would exercise oversight for all nuclear-related matters in the acquisition structure. This individual would work with other DoD components—including Policy, the Joint Staff, the Services and the military commanders responsible for nuclear forces—to create a DoD Nuclear Forces Program Plan. This individual would also support the Undersecretary of Defense for Acquisition and Technology in his capacity as chairman of the Nuclear Weapons Council to ensure the coordination of DoD and DOE nuclear weapon program planning.

The key initial challenge for the DoD nuclear weapons infrastructure is that it must be able to maintain the operational status of current forces through their currently expected lifetime. To be cost effective, this will require refurbishment, using as much technology from commercial applications and non-nuclear weapon systems as possible. However, technologies unique to nuclear weapon systems will have to be sustained as well. The character and disposition of today's U.S. nuclear forces are the result of the drawdown from the historic U.S.-Soviet competition. The United States is planning to maintain the current generation of missiles and aircraft and their associated warheads well into the next century. There are no replacement programs under way for any of today's nuclear forces. The U.S. nuclear deterrent posture will continue to be made up of the Minuteman III ICBMs, SLBMs deployed aboard TRIDENT submarines, an air-breathing force of B-52 and B-2 long-range bombers, dual-capable tactical aircraft, and air-launched and sea-launched cruise missiles.

Several programs are under way to sustain the effectiveness of current forces. Sustainment programs include replacing the propellant and guidance systems of Minuteman III missiles during the next decade and refurbishing of Minuteman III silos and launch control centers to keep the system operational through 2020. The B-52 strategic bomber will be operational through 2040 with planned modernization and sustaining engineering programs. The Navy has extended the lifetime of the TRIDENT ballistic missile submarines to 2030. TRIDENT II missiles will be retained for thirty years, with individual missiles reaching the end of their life beginning around 2015.

Keeping the current nuclear weapon systems operational over their predicted lifetime poses several challenges. Many subsystem components will exceed their service lifetimes before the systems themselves reach their end of life. These subsystems will have to be replaced. In most cases, especially where electronics are involved, the production lines that once produced the original components will no longer be available because of technological obsolescence. New subsystems, using state-of-the-art technology, will have to be designed, tested, and fabricated. To minimize the cost of refurbishment, it will be necessary to look for commonality with conventional weapon systems and make maximum use of commercial-off-the-shelf (COTS) technology. However, some components and some requirements are unique to nuclear weapon systems. Special efforts will be required to ensure that the industrial base is maintained so that the replacement components are available when necessary and nuclear stockpile safety, reliability, and performance can be maintained.

Greater attention needs to be paid to sustaining the nuclear capability of theater weapon systems—dual-capable aircraft and sea-launched cruise missiles—that can be forward deployed to regions of potential conflict. Theater systems are not receiving the same attention as the TRIAD. Specifically, the United States has no current plans to ensure dual capability in the next generation of tactical aircraft, and there is no planning for a next generation of a sea-based nuclear land-attack missile. A decision to preserve these important capabilities will be required in the near term if the United States is to maintain the requisite nuclear-specific infrastructure to field these delivery capabilities in the future.

The nuclear weapons infrastructure must be able to provide replacement delivery systems when the current ones are no longer able to perform their missions. In addition, the infrastructure must be prepared to respond sooner if political and technical changes occur that diminish the effectiveness of the U.S. nuclear deterrent. Prolonging the time before replacement systems will need to be designed, tested, produced, and fielded will raise serious questions about whether industrial competence and professional expertise will exist to perform modernization when it is required. Even before current nuclear weapon systems reach their end-of-life, the need could arise to replace one or more systems because their contribution to deterrence has become questionable. For example, the United States could lose confidence in the ability of aircraft or cruise missiles to penetrate to target because of more capable air-defenses. Changes in target hardness or concerns about collateral damage in some situations could lead to the need for capabilities such as new reentry vehicles. Some systems might fail to retain their current survivability.

The United States must ensure that, when new nuclear weapon systems are ultimately needed, the infrastructure will be in place for their design, development, testing, and production. In 2020, when the Minuteman III reaches the end of its life, it will have been more than forty years since the latest ICBM, the Peacekeeper, was designed. The replacement for the TRIDENT D5 missile will be needed twenty-five to thirty years after its predecessor was designed. When the TRIDENT submarine fleet reaches the end of its life, it will have been more than fifty years since designers took up the task of designing a ballistic missile launching submarine. Without specific and sustained attention, there is no assurance that the United States will possess the requisite technological and industrial infrastructure for the task of replacing these capabilities. On the other hand, while the air-breathing systems will also need replacement long after they were first deployed, the existence of an infrastructure for the production of commercial aircraft as well as tactical military aircraft should be able to provide the basis for successor nuclear weapon delivery systems. Nevertheless, even these systems have nuclear-mission unique requirements which must be met, such as the need to operate in nuclear environments and the need to incorporate command and control features that ensure that nuclear weapons can be used only when authorized.

Sustaining personnel competence in nuclear matters will be difficult without modernization programs and in an environment in which nuclear force matters have a much-diminished visibility and perceived importance. In selected areas there are concrete programs designed to keep parts of the nuclear forces infrastructure active. Two examples in this area, critically needed by both the Navy and the Air Force, are the Reentry Systems Application Program, designed to sustain unique reentry technologies for the Navy and Air Force, and the Guidance Applications Program, designed to sustain critical inertial guidance technologies. However, these and other activities are currently inadequately funded, despite their modest resource requirements.

In conclusion, when new systems are needed, whether because of aging or new security requirements, the entire infrastructure—industrial base and personnel, military and civilian—will be involved. The U.S. strategy for sustainment must be designed to fit within the likely budget constraints of the next decades. To do so will require effective approaches to sustaining critical expertise, including system and subsystem engineering and integration, and new strategies for reducing the dependence on "deterrence-unique" technologies and processes. For instance, there is a potential opportunity for increased commonality among SLBM, ICBM, and space-launch systems. In the past, the bulk of U.S. research and development (R&D) investment was aimed at achieving increased performance. In the future, priority must be given to reducing production costs, while balancing costs and performance and preserving safety and reliability. The general approach must include increased reliance on commercial and non-nuclear weapon system technologies. To achieve this objective, the DoD needs a comprehensive plan and dedicated, sustained management focus on nuclear infrastructure issues.

Judgement:

Retaining the safety, reliability, security, and performance of the nuclear weapons stockpile in the absence of underground nuclear testing is the highest-risk component of the U.S. strategy for sustaining deterrence.

In 1995, President Clinton stated "As part of our national security strategy the United States must and will retain strategic nuclear forces sufficient to deter any future hostile foreign leadership with access to strategic nuclear forces. In this regard, I consider maintenance of a safe and reliable nuclear stockpile to be a supreme national interest of the United States." The fundamental change in the international security environment resulting from the collapse of the Soviet Union, the impact of strategic arms control agreements, and the decision by the United States to sign and seek ratification of the Comprehensive Test Ban Treaty (CTBT) have significantly affected the ability of the United States to sustain its nuclear weapons stockpile.

U.S. nuclear weapons were not designed for indefinite stockpile life, and when the anticipated and unknown impacts of aging on the weapons in the stockpile will occur is uncertain. No program that could substitute for nuclear testing was validated before the 1992 testing moratorium. Building confidence in the emerging program will require time. There is no guarantee that some underground nuclear tests will not be vital in the future. The average age of the weapons in the stockpile is fourteen years; higher than it has ever been.

The environment within a nuclear weapon is unique and unlike any natural phenomena. The requirement for the indefinite retention of nuclear weapons may produce weapon-aging characteristics that are beyond the experience of the U.S. nuclear weapons R&D and manufacturing complex. The unknown effects of an intense radioactive environment on both nuclear and non-nuclear components and subsystems over an indefinite period of time pose the risk that an entire class of weapons will fail.

In the past, nuclear testing was an integral part of the assessment of the consequences of stockpile aging on safety, reliability, and performance. Nuclear testing is no longer permitted by policy and may be prohibited by treaty in the future. To mitigate this loss, the DOE science-based Stockpile Stewardship Program (SSP) has been proposed. Because the SSP will evolve and is unlikely to be completed before 2006, the ability to sustain confidence in the nuclear stockpile in the long-term is uncertain. In fact, this dimension of the U.S. nuclear deterrent posture is exposed to a higher risk than any other.

Additional critical factors affecting the safety, reliability, and performance of the nuclear weapons stockpile are diminished stockpile diversity; the medium and long-term issues related to retaining personnel with required expertise; and the ability to undertake new or modified nuclear weapon designs. U.S. efforts to sustain deterrence during the Cold War period led to a continuous process of nuclear weapon design, modernization, and replacement. Well over two dozen different weapon types were in the active nuclear weapons inventory in the 1980s. The reduction in the military missions for nuclear weapons and the implementation of strategic arms limitation accords have significantly reduced the number of weapon types. Current planning would retain only eight weapon types (plus one in reserve).

Decisions about safety, reliability, performance and refurbishment of stockpile weapons have depended on the judgements of a core staff of experienced nuclear weapon design and test personnel. Senior weapon designers with underground test experience are within a decade of retirement. The transfer of this expertise to the next generation of specialists responsible for the nuclear weapon stockpile is a difficult undertaking fraught with risk.

The requirement to sustain nuclear deterrence over an indefinite period makes it plausible that some modifications or design changes to the existing weapon inventory may be required. To retain the expertise needed to undertake such design changes or component refurbishment, there must be an enduring process for developing new or alternative designs and manufacturing techniques by the nuclear weapons establishment.

The Stockpile Stewardship Program is the minimum effort required to offset the risk of a loss of confidence in nuclear weapon stockpile safety, security, and reliability caused by the abandonment of underground nuclear testing. The SSP remains a high-risk endeavor because its conclusions cannot be validated by underground nuclear testing. The SSP has two major components. The first--surveillance, manufacturing, and operation—focuses on monitoring the condition of the existing stockpile, and providing the capability to refurbish, rebuild, or modify the warheads if necessary to sustain confidence in their safety, reliability, and performance. The second provides for the assessment and certification of the nuclear weapon stockpile. The SSP includes a number of analytical and experimental facilities to assess the impact of aging on the nuclear weapon stockpile. Separate diagnostic and experimental facilities and processes focus on various phases of the nuclear detonation cycle. The analytical and experimental facilities and processes are linked through the Advanced Strategic Computing Initiative. This initiative seeks to develop very high performance computational tools with validated critical elements of nuclear weapon code based on past nuclear test data, experimental data from SSP facilities, and first-principle calculations. SSP analytic and experimental facilities are highly diverse, and vary from table-top instruments to large and unique experimental facilities. Nevertheless, because the consequences of extreme aging on nuclear weapons is beyond U.S. experience, more advanced diagnostic, analytic, and experimental processes and facilities may have to be developed in the future to sustain the safety, reliability, and performance of the nuclear weapon stockpile.

The U.S. manufacturing complex is no longer able to support the serial production of nuclear weapons. As a result, there is no immediately available hedge against the failure of an individual weapon type. This risk can be mitigated to some degree by retaining weapon types withdrawn from the active stockpile as a form of reliability reserve, or "virtual manufacturing." The ability to serially produce nuclear weapons is an important hedge against the failure of a specific weapon type in the nuclear stockpile. As this capability has not been retained, other hedges that can provide time for the reconstitution of such a capability are desirable. The retention of some nuclear weapon types being withdrawn from the active inventory can diminish the risk without the cost of retaining a serial production capability.

Reconstitution of tritium production is necessary to sustain the nuclear weapons stockpile. The ability to recycle this material from the weapons being dismantled is limited, and the relatively short half-life of tritium makes it necessary that a production facility be put in place during the next decade. Tritium is a limited life material that must be replaced periodically to ensure that warheads will detonate reliably as specified. The United States is currently producing no tritium, and is dependent on recycling tritium from weapons being retired. If the United States waits longer than a decade to resume tritium production, it will lose the ability to maintain its inactive stockpile, which represents an important reconstitution capability. Thus, a decision to resume production should be made soon.

The risk inherent in the SSP can be mitigated by an increase in resources to accelerate the availability of the SSP elements. Further, increasing the scope of permitted experiments, and implementing a "virtual manufacturing" strategy could diminish some of the high-risk dimensions of the SSP. If the SSP fails, the United States must be able to resume testing. The SSP risk can be mitigated by increasing funding for SSP elements to ensure the early arrival of the complete SSP. By increasing the scope of permitted experiments, some of the confidence lost by the absence of underground nuclear testing could be regained, especially in the area of nuclear weapon safety and reliability. Finally, conducting weapon dismantlement in a way that retains key components can mitigate the effects of the decline in manufacturing capacity, and thereby provide a hedge against new weapon requirements in the future.

Judgement:

The nuclear arms control approach should be transformed. The United States and Russia should move from the long-standing focus on mechanically reducing deployed strategic weapons to an engagement encompassing the broad spectrum of total nuclear capabilities, taking into account the different security requirements of the United States and Russia.
U.S. interests and overall international security would best be served by a new, more comprehensive approach that would take into account total nuclear capabilities, including forces-in-being, infrastructure, and reconstitution capabilities. The analytical foundation and broad policy cohesion needed for this approach has not yet matured, but important considerations are becoming increasingly clear:

- The United States no longer views Russia as an enemy. U.S. and Russian nuclear roles, requirements, concerns, and priorities differ and are less linked to the forces of the other than in the past.

- At reduced levels of strategic forces greater attention must be given to theater nuclear weapons. As deployed strategic forces are reduced, the very much larger number of Russian theater nuclear forces—that have been excluded from arms control agreements—becomes increasingly stark and assumes substantial strategic importance.

- Russia and the United States share many objectives, such as reducing the cost of defense and insuring the safety, security, and control of their weapons, but they have different security concerns, requirements, capabilities, and vulnerabilities.

- Russia maintains a much larger nuclear weapons infrastructure and an active warhead production base to support its nuclear warhead requirements, whereas the United States relies primarily on backup warheads and stockpile stewardship. At reduced levels, asymmetries in infrastructure capabilities and non-deployed weapons become increasingly significant. Reconstitution capabilities can provide a desirable hedge. However, if not managed properly, such capabilities can also lead to undesirable competition and dangerous instabilities.

Over the long term, support for political reform in Russia and strengthened U.S.-Russian ties will be undermined by arms control arrangements that imply adversarial relationships, impose rigidity where flexibility is needed, or emphasize mutual vulnerability rather than cooperative approaches to defense. Immediate obstacles, such as limited resources and ratification difficulties, frustrate continued cooperation, but should not be allowed to deny both countries the benefits of agreements previously reached nor distract them from taking on difficult tasks together which might offer real improvements in security.

Russia and the United States may benefit from a new approach to nuclear arms control which would retain the stabilizing measures agreed to in START I and II, such as the elimination of MIRVed ICBMs and the retention of diverse forces, and might also provide:

- A ceiling on total deployed warheads, both strategic and theater, which might also provide a cap on deployed strategic warheads.

- An overall limit on total stockpile warheads, both strategic and theater, including deployed and non-deployed warheads.

- Controls on net production and total numbers, so that warhead dismantlement could actually reduce inventories rather than simply be symbolic.

The verification challenges for this approach will be enormously difficult. If these challenges are overcome, such an integrated approach to strategic and theater nuclear weapons would give Russia and the United States greater freedom to adjust their own forces to their own needs consistent with basic principles of stability, such as those included in the previous START Treaties. In addition, both states would have greater confidence in the other and in the arms reductions negotiated. Similarly, Russia has traditionally shown great interest in missile defenses, but today feels resource constrained and technologically disadvantaged. The security of both nations could be enhanced by reopening a dialogue with Russia in this area as well as cooperating on early warning.

This new approach will require careful explanation. To many in the public, the overall limit on total stockpiles of nuclear warheads will appear to allow for greater numbers of weapons than past agreements. In fact, because these agreements counted only deployed strategic warheads, the levels they established did not reflect the much larger number of weapons retained by both sides. The perceptual problem of a higher ceiling can be overcome with a well considered public education initiative.

Summary

In summary, nuclear weapons will remain indispensable to U.S. security for the foreseeable future. On this basis, this study sets forth several conclusions and priorities for action.

Despite calls from some quarters for radical reductions or elimination, the United States will need a nuclear deterrent well into the 21st Century. There will be opportunities to adjust the size and composition of the nuclear force. For deterrence, the United States should be able to rely less on retaliation and more on denial and dissuasion. However, given the complexity and diversity of the actors that need to be deterred, a credible U.S. nuclear posture must be based on a TRIAD of ICBMs, SLBMs, and bombers, as well as deployable theater nuclear forces. A significant portion of this force must be maintained in a ready status. A "virtual" or token nuclear deterrent has no credibility.

The United States can build on the positive trends with former adversaries. In its relationship with Russia, the United States should attempt to move away from the corrosive policy of mutual

The Changing Nuclear Environment

PAST	PRESENT/FUTURE
• Superpower confrontation	• Broader basis for engagement
• Nuclear weapons at center of relationship	• Nuclear weapons less central; major reductions
• Bipolar nuclear balance	• Proliferation of WMD and missiles
• Mutual vulnerability codified	• Vulnerability increasingly questioned
• Retaliation-based deterrence	• Defenses play greater role
• Net conventional parity	• U.S. conventional dominance
• Nuclear weapons were U.S. asymmetrical strategy	• WMD are adversaries' asymmetrical strategy
• Large, central employment plans	• AD hoc, adaptive planning
• Dedicated C^2 — expensive, reliable	• Increased reliance on commercial
• Large, dedicated infrastructure	• Flexible total posture planning
• Nuclear testing	• Science-based stewardship
• Hedge is having large forces-in-being	• Hedge is having reconstitution capabilities
• Arms control focus on deployed, strategic	• Arms control focus on total nuclear posture
• Senior-level advocacy	• Senior leaders less engaged
• Effective nuclear-specific organization	• Nuclear responsibilities diffused
• People matter	• People matter even more

Figure 3

vulnerability. The United States should seek to broaden its nuclear dialogue with Russia. Greater emphasis should be placed on cooperative attention to common concerns, such as reliable early warning of attack. The United States should engage China in a similar dialogue to the extent possible. In this process, symbolic measures that do not contribute to security—such as dealerting—must be avoided, for they are unlikely to solve the problems they seek to remedy, and may well exacerbate them.

The United States must be capable of accomplishing its deterrence mission in a reliable and affordable way. The United States needs to hedge against unexpected reversals in relations with other states that currently possess nuclear forces. Therefore, the maintenance of an adaptable nuclear infrastructure is critically important to ensure that the deployed force is modern, safe, and reliable, and to permit a timely response to new security challenges in an uncertain and dangerous world. This will require total posture planning, that is, integration of all the elements that contribute to the ability to design, manufacture, maintain, and operate nuclear forces. The United States must be in a position to respond to emerging threats more quickly than these threats can pose a clear and present danger to U.S. security. Although current nuclear programs meet these goals, the overall trends are disturbing. The most important immediate problem is the lack of sufficient high-level attention to nuclear matters in the Executive Branch and in the Congress, as well in the public as a whole.

Specific concerns highlighted in this report include an aging stockpile, diminished stockpile diversity, a shrinking nuclear weapons production complex, the prohibition on nuclear testing, and the gradual loss of skilled personnel trained in nuclear matters in the military Services, the National Laboratories, and the production facilities. In addition, there is no integrated long-term planning to sustain the nuclear infrastructure. Of critical importance will be the ability to maintain the nuclear deterrent in the absence of nuclear testing. Of all the challenges that the United States will face in maintaining the total nuclear posture, ensuring the safety and reliability of U.S. nuclear weapons without testing may be the most fundamental. The United States has never before carried out such a program and has no firm evidence it will be successful. With or without testing, the United States will need a long-term, ongoing program to ensure the safety and reliability of the nuclear weapons stockpile. In either case, substantial resources will be required. If nuclear tests are not permitted, even the best program will yield subjective, probabilistic judgements on the stockpile that are open to dispute.

Among the recommendations for ensuring a credible nuclear posture in the future, this report highlights the need for several major initiatives:

- The Department of Defense should prepare a long-term plan to develop specific needs for future U.S. nuclear weapons, delivery systems, and the supporting infrastructure. A senior official within the DoD Acquisition structure should be given overall responsibility for implementing such a plan, and for coordinating nuclear matters within DoD and with the Department of Energy and other appropriate agencies.

- Missile defenses will be of growing importance in the years ahead. The United States must be able to deploy effective defenses in regions with important interests and allies, as well as a national missile defense against the growing threat to the United States itself. It is unlikely that defenses will replace the need for a credible nuclear deterrent. Nevertheless, increasingly capable missile defenses can and should be deployed as an important component of deterrence. It is necessary to examine how a transition to greater emphasis on missile defense should take place and how the United States should prepare for it.

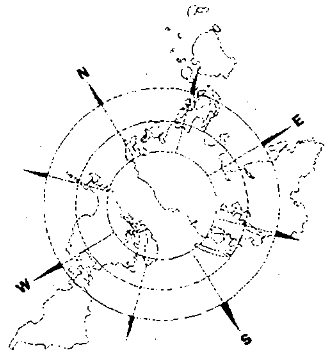
- The long-standing U.S.-Russian arms control approach—focused primarily on negotiating limits on the number of deployed strategic weapons—needs to be changed. This approach conceals important imbalances in total nuclear postures. It is necessary to move away from the presumption that the goal is "how much lower can we go?" A more sound approach is needed, one in keeping with the new security setting, which recognizes both the reality that different countries require different kinds of deterrent forces, and that theater nuclear weapons should be part of the nuclear dialogue.

- People are the *sine qua non* for the maintenance of a safe, secure, and effective deterrent force. If present trends continue, it will become increasingly difficult to attract and retain the people needed to build, operate, and maintain the nuclear deterrent forces in the future. Therefore, DoD and DOE—in cooperation with the National Laboratories, relevant industries, and universities—should develop a program to ensure that personnel with critical skills in nuclear weapons planning, operations, design, production, and maintenance are retained, and a suitable successor generation is developed before these key skills atrophy or otherwise pass from the scene.

In conclusion, nuclear weapons, although indispensable to deterrence, cannot in themselves ensure the credibility of deterrence. Credibility rests not only on forces-in-being and forces that could be reconstituted in timely fashion. It also encompasses longer-term policies and perceptions about the role of nuclear weapons within the overall context of national security capabilities and strategies. A nuclear force that is not backed by the perceived ability and willingness to maintain and, when necessary, reconstitute important elements will increasingly be seen as a hollow force. To prevent this outcome, the United States requires a new way of looking at the components of nuclear deterrence—from forces-in-being to system design, development, and stockpile maintenance—in an integrated fashion. To achieve such integration, a high level of strategic planning will be necessary within and among the elements of the national security policy and scientific-technological communities—both to have needed capabilities when required and to hedge against an uncertain future. The decisions and actions that the United States takes about the total force posture in the years ahead will shape decisively how both allies and adversaries perceive the credibility of the U.S. deterrent. In turn, this holds important implications for the overall capacity of the United States to shape the security setting at the outset of the new millennium and to provide for the nation's defense in a world of change and turbulence.

CHAPTER 2

NUCLEAR STRATEGY AND POLICY



Introduction

The United States faces two major security challenges as it moves into the next century: *first*, to maximize opportunities to achieve a more peaceful and prosperous world order and, *second*, to manage and, if necessary, prevail in conflicts across a broad spectrum where U.S. interests are affected. If the United States is to contribute constructively to the building of cooperative security arrangements in regions of importance—from the Pacific rim to Southwest Asia and the Euro-Atlantic area—it will need to employ both military power and diplomacy to reassure states that wish to cooperate, while at the same time preventing and countering the proliferation and use of military capabilities, including weapons of mass destruction (WMD), by states willing to utilize their military power for aggression or coercion.

These challenges make necessary a continuing role for deterrence, but that role has yet to be fully defined in a new context that is both more complex and less certain than that of the Cold War. This paper is the product of a working group[1] that met during the winter and spring of 1998 to discuss the role of deterrence in the 21st Century. The purpose of this report is to define that role, and particularly how nuclear weapons contribute to deterrence. *The main conclusion of the working group is that nuclear weapons will remain central in deterrence for*

1 The members of the Strategy and Policy working group were: Dr. Robert L. Pfaltzgraff, Jr., Chairman; Dr. Paul H. Carew; Amb S. Read Hanmer; Dr. Robert Joseph; Ms. Judyt Mandel; Dr. Keith B. Payne; Dr. John Reichart; Mr. Leon Sloss; and Dr. Richard Wagner. Government observers included Dr. Michael Altfeld; Mr. Mike Evenson; Dr. John Harvey; Dr. Maurice Katz; Col David Lopez, USAF; MGen Thomas Neary, USAF; LtCol David Nuckles, USAF; and Dr. Gary Stradling. The views expressed in this paper are not necessarily shared by all members of the group. Further, these views are not intended to be representative of members or organizations of the Department of Defense or the Department of Energy.

the foreseeable future. While their role will be less prominent than it was during the Cold War, nuclear weapons will continue to make a unique contribution to U.S. security. As the United States moves into the next century, nuclear weapons will provide an essential basis for deterring larger numbers and types of actors in possession of WMD, as well as massed conventional capabilities. With such considerations in mind, this report sets forth a deterrence paradigm to sustain the nuclear posture that the United States will require well into the 21st Century.

During the Cold War deterrence was closely identified with nuclear weapons. With the end of the Cold War a decade-long series of initiatives, many of them unilateral, have sharply reduced the size of U.S. nuclear forces, trimmed the budgets for nuclear weapons programs (both in the Department of Defense (DoD) and the Department of Energy (DOE)), shifted priorities within the nuclear laboratories, placed a moratorium on testing of nuclear weapons, promoted a "zero-yield" comprehensive test ban, and closed some production facilities. For the first time in a half century, there are no new U.S. nuclear weapon systems in development.

As the world approaches the new millennium, there are divergent views as to the future vision or paradigm for nuclear weapons. One paradigm centers on efforts to abolish these weapons. Further deep and rapid cuts in weapon stockpiles and readiness in the near term would be made as steps toward the eventual complete elimination of nuclear weapons—a goal which, in this view, is achievable.

In this report we articulate a different paradigm based on indefinite retention of nuclear weapons and nuclear weapon capabilities, complemented by further extension of a regime for continued dialog and engagement among nuclear weapon states (and others) by which stability of nuclear postures and relationships can be sustained and strengthened. Nuclear weapons cannot be disinvented. They will be a part of the international security landscape indefinitely. Even if the

United States were to divest itself of its nuclear arsenal, other states would be unlikely to follow suit. To the contrary, a conventionally superior but nuclear-free United States might provide other actors with an additional incentive to retain or acquire nuclear weapons in order to strengthen their overall capabilities. And even if all nuclear weapons were somehow eliminated, a serious deterioration of the international environment—which must be assumed possible, as the history of the 20th Century teaches—would engender strong incentives for states to rearm. A rapid, competitive, multilateral race to rebuild nuclear arsenals could increase the prospects for a devastating war.

In addition to an ongoing need for nuclear deterrence, our paradigm is based on two related premises: first, that the future is uncertain, and the circumstances around nuclear weapons will change. In a changing security environment, the relative emphases among the potentially diverse roles of nuclear weapons in U.S. and other nations' security postures are likely to change over time as well. Accordingly, the U.S. nuclear posture must be prepared to adapt. Our second premise follows: the U.S. ability to adapt can beneficially shape the security environment in several ways. One way is "dissuasion" of undesired developments on the part of potential adversaries. This is a central feature of our paradigm, discussed more fully below. Another aspect of dissuasion is reassurance of friends and allies. Dissuasion supports non-proliferation, among other objectives.

There is a profound difference between our paradigm and the abolition paradigm in regard to adaptation of nuclear weapon postures. The abolition paradigm envisages nuclear postures that, except for steady reduction in size of inventories and in readiness, are essentially qualitatively static. Our paradigm views adaptation of nuclear postures, responsibly managed, as contributing to stability and to avoiding potential dangers inherent in nuclear weapons. The philosophical differences between these points of view run deep. One basis for our belief in the essential need for adaptation is the experience of successfully maintaining the safety of the U.S. nuclear weapon stockpile by continually improving its safety features. We have learned that stasis breeds complacency, inattention, and danger.

Another aspect of our paradigm is change in the modalities of deterrence. During the Cold War, deterrence relied principally on a ready capability to retaliate with deployed forces. (Varying emphasis was also placed on passive and active defenses.) Deployed nuclear forces will be essential indefinitely; some threats are immediate, and we place no credence in "virtual deterrence." But in the proposed paradigm for the future, with its emphasis on adaptation and dissuasion, the nuclear weapons infrastructure—the operational infrastructure, and the development and production capabilities that can bring new or different forces into being when needed—take on a heightened strategic prominence. During the Cold War, requirements for the infrastructure derived almost entirely from requirements for near-term modernization of the deployed forces. In the paradigm set forth here, infrastructure requirements will be less directly connected to deployed forces and the characteristics of the infrastructure will contribute directly to deterrence, including its dissuasion component. Thus, a more explicit policy and strategy for managing the infrastructure will be required in the future.

In this paradigm, more emphasis is also placed on deterrence by denial through active defense. Active and passive defenses are almost certain to play a larger role in dealing with many aspects of WMD threats. It seems likely that they, together with the maturation and spread of space, information, and surveillance technologies, will continue to create a more prominent role for defenses in strategic relationships. The extent and pace at which defensive capabilities are deployed will be a matter for continued policy attention. A strategy for developing the infrastructures associated with defense capabilities will be important as well.

Our paradigm also calls for sustained engagement with other nuclear weapon states on overall nuclear postures, and sustained nonproliferation and counterproliferation efforts. History has thrust special responsibilities on the nuclear weapon states. They must ensure that their nuclear postures are not amenable to misuse—meant narrowly, as in relation to weapon safety and security, and also in broader and more political senses. Developing an understanding of how to ensure against misuse will require engagement among nuclear weapon states which steadily broadens in scope and participation. With Russia, continued engagement will build on what has been accomplished already in the post-Cold War political relationship. Increasing engagement with China is also called for. We believe that numerical reductions in deployed intercontinental forces will soon reach the point of diminishing returns, and that the next phase of negotiations (already partly presaged by some aspects of the Helsinki agenda for START III) will have to involve total nuclear forces, intercontinental and theater/tactical, along with measures to ensure stability of deterrence relationships between and among deployed nuclear forces. The next phase should also deal with reversibility—that is, balancing the benefits of reconstitution (as a needed hedge) against its risks, in case political relationships once again become tense. Managing infrastructure capabilities is integral to striking this balance.

Thus, because of its heightened emphasis on dissuasion, adaptation, reconstitution, defense, and total nuclear forces, integrating strategies for deployed forces and for the associated infrastructures is a central consideration in our paradigm. We have called this consideration "total posture planning."

The New Security Landscape

Several features of the security landscape we anticipate over the next decade (see the Annex of this paper for a fuller discussion) bear on our paradigm:

- While the immediate threat from Russia has declined markedly with the collapse of the Soviet Union, the proliferation of nuclear capabilities and other weapons of mass destruction has increased the variety of threats that might be used against the United States, its forces, and its friends.

- The end of the Cold War has increased possibilities, and enhanced the urgency, for cooperative threat reduction with the Russians. Progress has been made. However, Russian leaders now place greater reliance on nuclear weapons in their strategy. While they appear eager to reduce the financial burden of their nuclear forces, they also seem committed to modernizing and relying on them to compensate for greatly weakened conventional forces. At the same time, Russia is believed to retain formidable biological and chemical weapons capabilities.

- The United States, as the potential object of deterrence from a variety of quarters, has a strong interest in curbing the proliferation of weapons of mass destruction and deterring the use of such weapons. While there may be opportunities for reducing the salience of nuclear weapons in international relations, the current attitudes of nuclear states and near-nuclear states are not promising. None of the current nuclear-capable states (declared and undeclared) seems prepared to relinquish nuclear weapons or radically reduce current dependence on them.

- Meanwhile, several states with which the United States has major political differences are seeking to acquire nuclear weapons and other mass destruction weapons. In this situation, credible U.S. nuclear capabilities and defenses contribute to discouraging proliferation by making the costs to potential proliferators appear high and by reassuring non-nuclear states that they can receive the protection of extended deterrence without having to seek their own nuclear capabilities.

The Nature of Deterrence

The Department of Defense dictionary defines deterrence as "The prevention from action by fear of consequences. Deterrence is a state of mind brought about by the existence of a credible threat of unacceptable counteraction." It is useful to underscore that deterrence is a psychological condition—not the automatic result of any combination of forces and threats, no matter how fearsome they may seem. Deterrence arises from a conscious effort to influence an opponent's calculations of anticipated costs and gains in a manner that leads it away from unwanted decisions and actions.

Deterrence is not a policy, per se, but provides a means of achieving broader policy objectives. It is one component of the nation's strategy for protecting and advancing its security interests. A deterrent can be designed to prevent the outbreak of war or to curb the escalation of a conflict once it begins, particularly by discouraging the use of weapons of mass destruction. While attempts at deterrence will not always work, deterrence generally is preferable to the alternatives, e.g., to fighting a costly war or surrendering vital interests in order to avoid conflict. A powerful deterrent serves as a useful underpinning for negotiations in the pursuit of national objectives.

Deterrence is exercised by *threatened action or reaction,* and only in the most extreme circumstances by *use* of military power, for the aim of deterrence is to prevent war or the escalation of a war, not to defeat the enemy in battle. The threatened costs posed by a deterrent can be directed at an opponent's values (punitive) or at denying an opponent its goals (denial). The denial function can be achieved by maintaining the capability for offensive military action against enemy forces or by defenses that can intercept or disrupt an attack and thus reduce the enemy's confidence in the use of force, including WMD. The aim is to pose the prospect of failure to the attacker. The ultimate success of deterrence is determined by the opponent's calculations and decision-making. The opponent decides whether or not it is deterred. As has frequently been pointed out by commentators on nuclear strategy, deterrence is based on a combination of perceived capability and will. Both are important. *The credibility of deterrence is the product of cumulative actions taken by the deterring power over years and not just in the immediate crisis, and it is based on perceived attitudes toward the use of force, in general, not just nuclear force.*

A very important conclusion, drawn from historical studies, is that there is no single formula for deterrence. What is required to deter and how effective deterrence will be depends upon the party you are trying to deter and the context. Threats and actions that may seem to the United States as a credible deterrent may not deter others because their value system is different. Determining what others value and how to utilize that knowledge in deterrence is a major challenge for U.S. intelligence agencies, analysts, and planners. This challenge can only increase in importance as the number and types of actors to be deterred grow in the early decades of the 21st Century. Undoubtedly, there will be situations where the other party is so deeply committed to an action that deterrence may not work. There may be situations where a party can be deterred and where the United States thinks it knows how to do it, but cannot find effective ways of communicating with the other side in a crisis. Ideally, deterrence should result from a commitment to the defense of interests against hostile actions that is precisely stated and clearly communicated to the opponent. Deterrence should be based on a credible military capability to punish the enemy or deny its objectives. The party that seeks to deter should have demonstrated, by past actions, the will to use its deterrence capability. The opponent should be able to receive the signals communicated and rationally weigh the probabilities, costs, and benefits. The more flexible U.S. deterrent capabilities are, and the greater the number of options available to national planners, the higher is the likelihood that deterrence will succeed.

Deterrence and war fighting. The distinction between deterrence and war fighting has been the source of confusion and much debate over the years. The purpose of deterrence is to prevent war, not to fight it.

However, to deter war (and the use of WMD in war) a force must be backed by credible capabilities and planning. For deterrence to be effective, the aggressor must be convinced that the deterrent force can and will be used, and will be effective if used. Furthermore, the deterrer must have reasonable confidence that the force can be used without dire consequences to himself. A deterrent force must be survivable and pose a real military threat to assets that the deteree values. There must be forces and plans for those forces whose use is credible. The characteristics of the forces and the quality of the plans do makea difference. However, the criteria for assessing the effectiveness of deterrence differ from those applied to a war-fighting force. In designing a force to fight and win a war, there must be a high confidence of success. In designing a deterrent force, the adversary should be confronted with a high prospect of failure. The effectiveness of a deterrent is measured by how the state or leadership that one is seeking to deter perceives the capability and will of the deterring state. Admittedly, these are difficult parameters to measure, but they are what must be assessed in designing a deterrent posture.

An Evolving Paradigm

During the Cold War, the United States sought to deter major aggression—nuclear and conventional—and to shape the broader security environment by developing and maintaining the means for retaliation, denial, and dissuasion. Each of these elements supported the overall strategy, although the relative weight of each changed over time in response to evolving political, military, and technical considerations.

Retaliation. The central element of U.S. deterrence policy throughout the Cold War was the prospect of a prompt and unacceptable level of retaliation in response to nuclear or conventional aggression. The objective of U.S. nuclear forces was to prevent war by convincing the Soviet Union that it could not win any military conflict it initiated. The logic of deterrence required that the United States be able to destroy those targets that it believed the leadership of the Soviet Union most valued. These included conventional and nuclear forces, leadership, and industrial facilities that supported military strength and the power of the state. To be credible, particularly after the Soviet Union acquired nuclear weapons and the ability to strike the United States, the threat of retaliation had to be backed by responsive, effective, and survivable forces. After the early 1960s, the U.S. strategic force was embodied in the TRIAD—bombers, intercontinental ballistic missiles (ICBMs), and submarine-launched ballistic missiles (SLBMs)—which complicated Soviet planning and ensured that even if for technical or other reasons one leg became vulnerable, the vitality of the remaining legs would deny the Soviet Union any advantage from a first strike. Further flexibility was provided by theater nuclear weapons (also called "sub-strategic" or "non-strategic") integrated with combat forces to enhance deterrence against massive conventional attack. Because of the magnitude of Soviet conventional and nuclear forces, and the immediacy of the threat they posed, the United States could not rely solely on mobilization of resources after the onset of a crisis, as it already had done twice in the 20th Century

Denial. Denying an adversary the ability to achieve his goals through military means, that is blunting or negating the effectiveness of his forces, was another means of strengthening deterrence during the Cold War. Denial can include a range of active and passive defenses to protect forces as well as populations. Denial also encompasses capabilities that could be launched preemptively against an enemy's nuclear force, thus depriving an enemy of the ability to strike with such forces. Early in the Cold War, before the advent of ICBMs, air defenses against Soviet bombers played a large role in the U.S. deterrent posture. Passive defense, in the form of civil defense measures, was also seen as enhancing deterrence. With the advent of large numbers of long-range ballistic missiles—and the adoption the mutual assured destruction doctrine and its successors—defenses were given a much-reduced role. In the context of assuring the effectiveness of offensive retaliatory forces, the 1972 Anti-Ballistic Missile (ABM) Treaty codified strict limits on strategic defenses and thereby accepted the vulnerability of the U.S. population to Soviet nuclear attack. From the mid-1980s until the early 1990s, in a effort to move beyond this vulnerability, the United States greatly expanded research and development aimed at giving missile defenses increased weight in the deterrence concept.

Dissuasion. Beyond the role played by deployed nuclear forces in deterring an attack, the U.S. nuclear posture has helped to shape the broader security setting. In addition to offensive and defensive weapons systems, deployed and ready, the United States has possessed a range of related capabilities which, collectively, were designed to persuade potential adversaries of the ultimate futility of certain courses of action. For example, the entire research and development (R&D), production, technology, and industrial base enabled the United States not only to deploy forces that would deter nuclear attack, but signaled to any adversary an overall national commitment to counter any threat. This posture conveyed not only the existing capabilities of the United States, but also the overall long-term potential capability, that is, what the United States could deploy in the future if it chose to do so. This potential helped shape Soviet views of their longer-term options and prospects. The Strategic Defense Initiative, in addition to its fundamental call to alter the existing offense-defense relationship, also served an important dissuasion function by helping to convince Soviet leaders that sustaining the long-term strategic competition for an indefinite future would ultimately result in a situation they would find untenable. Recognizing the decay and near bankruptcy of their own industrial and societal base, these leaders understood the need to transform the Soviet system fundamentally, a process that ultimately unleashed those forces that would bring down the Soviet state.

The relative importance of the three elements of deterrence will continue to evolve. At the beginning of the Cold War and at its height, retaliation was the key element. Denial was important for a time (especially when defenses against bombers were thought to be possible), but diminished in importance for both political and technical reasons, only to reemerge as an important concept in the 1980s. During the Cold War, dissuasion helped change the way the Soviet leadership perceived the United States, profoundly altering the security relationship. The challenge of the future will be to recognize the continuing importance of dissuasion as a fundamental element of U.S. security policy to be integrated into deterrence policy in a way that enables each element to work in harmony to reinforce U.S. policy objectives.

It is unclear precisely how these three elements of deterrence—retaliation, denial, and dissuasion—will interact in the future. Clearly, the world continues to become more complex. The number of actors and the variety of threats the United States will want to deter have increased. As a result, the relationship between and among retaliation, denial, and dissuasion in the new environment will change. While the need for capable retaliatory forces will remain a central requirement for, and the ultimate foundation of deterrence, technical and other factors (for example, a policy decision not to accept mutual assured destruction relationships with additional states), discussed later in the report, will surely increase the perceived utility of denial strategies. The threat of regional adversaries possessing missiles armed with chemical weapons (CW) and biological weapons (BW) has already created a new emphasis on denial in theater warfare, placing additional value on theater missile defense (TMD) and on improved counterproliferation capabilities. The development of intercontinental capabilities by such states gives increasing importance to national missile defense (NMD). Dissuasion as a tool of deterrence also becomes more important as part of the underlying strength of the total nuclear posture to deter emerging threats.

Lessons From the Past

Although some suggest that conventional forces can replace nuclear weapons for deterrence purposes, there is no supporting evidence to that effect, and considerable evidence to the contrary. As we think about the future, it is appropriate to take stock of what is known about deterrence from the Cold War. One cannot state with absolute certainty that, in the absence of nuclear weapons, the Soviet Union and the West would have gone to war. Nevertheless, it is known that a large-scale armed conflict between two heavily nuclear-armed camps was avoided. More than two generations of political/military confrontation passed without actual resort to the use of military forces against each other. The Cold War spanned a period more than twice as long as the time between the two World Wars. However close the United States and the Soviet Union may have come to armed conflict in the various crises that they faced, the fact remains that there was what is now termed "the long peace." Recent research exploiting U.S. and Russian sources demonstrates convincingly that nuclear deterrence was a key to preventing some crises, such as the Cuban Missile Crisis, from escalating to war. The significance of nuclear deterrence also appears to have been demonstrated during the Gulf War; Iraq may have been deterred from CBW use by the fact that the United States (and perhaps Israel) possessed the ability to retaliate with nuclear weapons.

In Europe, where the United States and its NATO allies during the Cold War deployed the greatest array of nuclear *and* conventional arms ever assembled, there was no NATO-Warsaw Pact war. It remained for NATO to enter its first official military operation—Bosnia—after the end of the Cold War. Although numerous wars broke out, they were in regions beyond the extended security guarantees of the superpowers backed by their respective military capabilities, including nuclear weapons. Thus, the Cold War unfolded against the backdrop of nuclear weapons which, in retrospect, provided a powerful deterrent to the outbreak of armed superpower conflict. The United States broke the historic pattern of large-scale wars fought between major powers. The conventional warfare of World War I cost the world some 50 million lives. The conventional warfare of World War II resulted in the loss of some 80 million. The efficiency of U.S. conventional weapons has increased tremendously. While it is somewhat speculative to assign nuclear deterrence full credit for the prevention of total conventional war between the major powers since World War II, the magnitude of lives and property that would likely have been lost had the great powers followed the previous trend of periodic large-scale war would have been immense, probably measuring in many millions of lives and perhaps trillions of dollars of destruction. Although military spending during the Cold War was at a relatively high level, it was far less than what would have been required if deterrence had failed. Such wars would have had a compounding effect, depressing the world economy and leaving nations destitute, perhaps with their long-term economic recovery in doubt.

In sum, nuclear deterrence helped buy time in which democracy and market economies could demonstrate their superiority to communism. Communist systems were forced to confront the internal weaknesses that ultimately led to their collapse.

Deterrence Today: Responding to Continuing Security Challenges

Based on guidelines issued in November 1997, post-Cold War U.S. nuclear policy reaffirms that nuclear weapons, based on a TRIAD of nuclear forces consisting of ICBMs, SLBMs, and bombers, will remain a central although now less prominent element of national security for the indefinite future. The latest U.S. guidance takes greater account of the threats posed by chemical and biological weapons and the role of nuclear retaliatory forces in deterring the use of such weapons against the United States and its allies. Thus, contemporary deterrence includes several central roles for nuclear weapons:

- To deter nuclear threats against the United States itself,

- To deter other WMD use and, in some cases, deter large-scale conventional aggression and enable the United States to control escalation in conflicts in regions of importance, including the protection of U.S. military capabilities as well as the forces, territory, and civilian populations of allied/regional coalition partners, and

- To discourage the undesired proliferation of all WMD by giving reassurance to allies and other friendly states and by discouraging adversaries from acquiring such capabilities.

Russia

The threat from Russia has declined significantly since the end of the Cold War. The Russian army is greatly weakened, and U.S. and Russian forces no longer confront each other in Central Europe. There appear to be no issues at this time that could lead to war. However, Russia still poses major security problems, some immediate and others longer term.

At the present time the main threat from Russia stems from the fact that it still possesses thousands of nuclear weapons and may have less than complete control over the security of its nuclear infrastructure. With the radical decline in the size and effectiveness of the Russian armed forces, Russian leaders are looking to nuclear weapons to compensate for reduced conventional military strength. There is no question that Russian military and political leaders continue to see a major role for nuclear weapons and support the modernization of strategic forces.

Moreover, in the chaos of post-Cold War Russia the possibility that fissile material will become available to proliferants has grown dramatically. The United States also faces a potentially dangerous proliferation problem should unemployed or underpaid Russian scientists leak or sell their knowledge. Such events are, by their nature, difficult to deter. The International Science and Technology Center (ISTC) was established in Moscow in 1992 to help address this problem. Founded originally by the United States, the European Union (EU), Japan, Russia, and joined later by Norway, the ISTC provides weapons scientists and engineers from the Commonwealth of

Independent States (CIS) the opportunity to refocus their careers on nonmilitary research and development projects. To date, $165 million has been allocated (U.S.-$70 million from Nunn-Lugar funds; EU-$65 million; Japan-$26 million; Norway-$1 million; Other sources-$3 million) for 1,513 projects involving 17,000 weapons scientists and engineers from over 200 Institutes throughout the CIS. The recipients remain at their Institutes, are paid reasonably well, and contribute solutions to national and international science and technology problems.

Another potential threat from Russia is one, that could arise in the future. A new, nationalist Russian leadership could take power, perhaps establishing a regime that might seek to restore all or part of the Soviet empire, employing force if necessary. It would take Russia some time to rebuild its conventional military capabilities given the weakness of the Russian economy today. In such a situation, nuclear weapons could well become an instrument of coercion. As a hedge against a nationalist Russia that reverts to a hostile relationship (as discussed later), the United States needs to retain at least parity in nuclear forces-in-being, and an overall nuclear posture that permits reconstitution of nuclear forces at least as rapidly as Russia. In the years ahead measurements of relative capability will increasingly need to take into account overall capabilities, to include not only forces-in-being but the potential to create or reconstitute nuclear capabilities.

China

China has formidable military forces, but it is not well equipped for offensive action today. Its nuclear force is limited by comparison to that of the United States. The Chinese appear to view their modest nuclear capabilities both as a source of political influence and as a deterrent. China has the resources and the skills to expand its nuclear capability and to pose a much larger threat to the United States in the next century. To judge from its testing, development, and deployment program, China attaches great importance to nuclear forces. China is likely to seek a larger political role in Asia, commensurate with its growing economic power. The most probable focal point of potential military conflict between the United States and China is Taiwan. China and the United States also could find themselves on opposing sides if there were a new conflict on the Korean Peninsula. Although such conflicts may be averted through diplomacy, success in diplomacy can never be assured. Should China contemplate military action against a U.S. friend or ally, China will seek to deter U.S. intervention by whatever means it has. The United States will want to retain the capability to deter Chinese military action and particularly any Chinese use of weapons of mass destruction. For the foreseeable future U.S. nuclear weapons will have a role to play in deterrence of China in these unlikely, but not implausible, situations. For the longer term, the issue will be the extent to which China will develop a nuclear posture designed to rival that of the United States as a peer competitor. The United States should not accept nuclear parity with China or another emerging nuclear state.

Regional States

Emerging U.S. deterrence requirements place increasing emphasis on regional settings—Northeast Asia and Southwest Asia—where one or more states are likely to possess WMD capabilities. Such weapons could be employed against U.S. forces and/or bases abroad, U.S. allies, or targets in the United States with several possible objectives. Perhaps the most likely goal for use of WMD by such a state is to deter the United States (or other states) from intervention in a regional conflict. In this case the threat to employ WMD could be seen as effective as a deterrent, for the stakes involved for the deterrer (the regional state) are likely to be perceived to be higher than those for the deteree (the United States). WMD might also be employed in an effort to redress a regional imbalance of power, to force the United States to reconsider or alter its political and military involvement in a region (e.g., the Middle east), or to redress some real or perceived grievance against the United States.

The risk faced by a regional state seeking to employ WMD is that, should the United States retaliate, it is in a position to do far more damage than the regional state can do to the United States and its allies. Thus, the attacker may attempt to disguise the source of the attack, and may attempt to introduce weapons of mass destruction covertly. The attacker may use terrorist groups as a means of covert introduction in an attempt to dissociate itself from the attack. The attacker may also attempt to carry out its attack in a way that will temporarily paralyze a U.S. response by striking command and control and military logistics centers, or even civilian infrastructure, thereby diverting attention from a regional conflict and forcing the United States to channel resources to domestic recovery.

There is no single formula for deterrence of regional states. Each situation will be unique. Successful deterrence will depend on understanding the character and values of the adversary's leadership and society. In some cases, their value system will differ from that of the United States, but it may be penetrable with sufficient study. The success or failure of deterrence also will depend on how the aggressor perceives its own stakes and U.S. stakes in the particular situation. It will depend on whether the United States can communicate its objectives and intentions quite precisely to an adversary in a time of crisis and have a flexible range of tools to use in deterrence should they be required. The United States will need to make its willingness to use force, if necessary, manifest by actions that are taken in other prior crises and in day-to-day diplomacy. U.S. nuclear weapons may play an important role, particularly if weapons of mass destruction are possessed by the other side.

As in the case of China's nuclear weapons, the WMD capabilities of regional states will be designed to deter military intervention by the United States. Therefore, one major purpose of U.S. strategy must be to deter the deterrent of a regional state. For the United States, this will mean the need to have available a combination of retaliatory assets, including a flexible and proportional nuclear capability and means for denial, including missile defense systems.

Non-state Actors

Deterrence of non-state actors (e.g., terrorist groups) presents some unique problems that do not exist in deterring a state. Non-state actors may operate on their own and on a very small scale, or they may operate as agents of a state, in which case they could pose a larger and more sophisticated threat. That threat could include nuclear, chemical, and biological weapons. In many cases, non-state actors may operate within a value system that is indecipherable by the United States, which will make designing deterrent strategies especially difficult, if not impossible. Terrorists will attempt to conduct their actions covertly, for surprise is essential to their success, and they may or may not take credit for their actions. If there is a state behind a terrorist threat and if it can be identified, the threat of interdiction or of devastating retaliation may yet play a role in deterrence. In many cases, however, the United States may not know the source of a terrorist attack, and thus there may be no "home base" at which to direct retaliatory threats. To deter or defend against attacks by non-state actors, the United States must rely heavily on improved intelligence, surveillance, detection, and defenses, including effective consequence management.

Implementing the Evolving Paradigm

We believe that planning for the U.S. nuclear weapon posture should be based on six elements: nuclear forces-in-being; force diversity; flexibility; total posture planning (including the nuclear weapons infrastructure); stockpile stewardship; and a robust and sophisticated intelligence capability to maintain deterrence against an expanding range of actors.

Forces-in-Being

As a deterrent against WMD use or threat of use by the spectrum of post-Cold War actors, the United States will need to maintain nuclear forces that are ready, responsive, and effective. This means that the

United States must continue to have nuclear forces on alert as a basis for crisis stability and crisis management. Of course, the level and nature of alert depends on the circumstances. Compared to the Cold War levels, the United States has already taken off alert approximately one-third of its TRIAD. It has already removed all nuclear weapons from surface ships and non-strategic submarines and has de-alerted Minuteman II missiles. The United States has deactivated the entire Poseidon submarine force before its scheduled retirement and converted all B-1B bombers to a conventional role. It has removed all strategic bombers from strip alert. Further de-alerting of U.S. nuclear forces and, presumably, of Russian nuclear forces, has been proposed as a way to reduce perceived risks of unauthorized or mistaken launch of nuclear weapons. These risks are perceived to arise from the alleged unreliability of Russian nuclear command and control systems, as well as from alleged deficiencies in Russian attack warning systems which could increase incentives to attack preemptively or by miscalculation.

We do not minimize the risks of unauthorized or mistaken launch, but these risks need to be weighed against the very substantial liabilities of de-alerting—that is, taking nuclear forces off alert status and rendering them incapable of timely response. It is not clear that any practical scheme for de-alerting would contribute to reducing this risk. De-alerting could undermine a central element of deterrence: namely, the ability to retaliate promptly. A de-alerted nuclear force may make a first strike more attractive to an aggressor. An incentive to attack first would be heightened during a period of tension. At such a time an opponent might attack before U.S. forces could be re-alerted, or as U.S. forces were being placed back on alert. De-alerting could have adverse consequences for the safety and security of warheads and other nuclear weapons parts. How the removal of such nuclear components would affect the operation of the whole system would need to be considered. For example, storing de-alerted components at sites separate from the missiles could increase their vulnerability to sabotage or theft. In addition, reassembling such systems increases the possibility of malfunctions or accidents. Last but not least, de-alerting introduces formidable problems of intrusive verification. On-site inspections could be required to assure that de-alerted warheads were not re-mated with missiles. Other de-alerting measures, such as the removal of launch codes from submarines, are not verifiable. If such codes were removed, submarines would have to reveal themselves in order to receive launch codes, thus negating the purpose of having a deterrent that is survivable.

Given the large number of nuclear weapons already taken off alert, the questionable value of further de-alerting and the undesirable effects of de-alerting on force readiness, the measures already taken are, in our judgement, as far as the United States should go at present. From here on the risks exceed the very limited benefits, at least until the international situation changes markedly. Funding and support for de-alerted forces would suffer in the budgetary competition for scarce resources. As a result, when such forces were needed in crisis situations, they would probably not be available and they might not be reconstitutable in sufficient time. In short, while including a major reconstitution capability, the nuclear paradigm that we are proposing attaches fundamental importance to forces-in-being, given the range of threats for which nuclear weapons may be needed as deterrence and crisis management instruments in the early decades of the 21st Century.

From a safety, readiness, and command and control perspective, it is illuminating to examine what changed between the demise of the USSR and the Russia of today. Based on increased sharing of data, exchange visits, and observations by trained inspectors, far more is known about Russian procedures than in the Soviet era. From these sources it appears that the Russians have adequate procedures for handling and safeguarding nuclear weapons and that their personnel are well-trained. Fewer weapons, fewer locations/launch platforms, and less diversity in the background of personnel handling these weapons (since they have been removed from Belarus, Kazakhstan, Ukraine) in some respects make the task easier. The United States and Russia actively share ideas on weapons safeguards and continue officer exchanges.

From a launch control perspective, the Russian problem is also simplified with fewer units, a force that is much more "Russian," a strong senior cadre of knowledgeable personnel (where the United States uses first lieutenants, the Russians use lieutenant colonels or colonels), enhanced electronics for connectivity, and continued investment. Despite the understandable concerns expressed about the launch of the Norwegian weather rocket in January 1995, which was spotted by Russian early warning radars, the Russian command and control system functioned as expected, and personnel made correct decisions.

Since the collapse of the Soviet Union, however, early warning for Russian forces has substantially changed. In the Soviet era, there were diverse, sophisticated early warning facilities around the periphery of the Soviet Union that overlapped considerably. The Soviet Union maintained a robust, closely coupled network that made the Soviet leadership confident that it would receive sufficient warning of a ballistic missile or other attack. That situation has changed. With the demise of the Soviet Union, some of these early warning facilities are now outside Russia. Others are of dubious reliability, and funding for rebuilding the system has not been provided.

Hence, the risk of mistaken or unauthorized launch by the Russians appears to be a valid concern. Misunderstanding of early warning data could indeed lead to a mistake in understanding the threat situation to Russia and could potentially result in a deliberate counter launch. One solution might be to make technology available to Russia to help rebuild its early warning system. Another solution might be to share some or all early warning data (such as infra-red images) in a transparent framework between the two countries and/or share evaluation of the infra-red data. The United States could benefit from having access to the early warning data from Russian systems since these data might also provide tracking or confirmation of launch location from another azimuth or data about launches from Asia to parts of the world of interest to the United States. A disadvantage could be that such technology sharing could lead to the exploitation of any deficiencies found to exist in U.S. capabilities.

In sum, in our paradigm, nuclear weapon surety—safety and security, and assurance against accidental, unauthorized, mistaken, or inadvertent launch—is the object of continuing attention because there will be deployed nuclear weapons for the indefinite future. Most of this attention will be unilateral, each nation seeing to the soundness of its own nuclear posture, although limited sharing of safety technologies and lessons-learned has been of value, and should continue. But warning, alert, and command/control postures do interact; one nation's approach and doctrine necessarily takes others into account. For this reason, our paradigm states that guarding against risks in these areas should be one of the several topics for sustained engagement between Russia, the United States, and possibly other nuclear weapon states.

Diversity

The United States has long maintained diversity in its nuclear forces. The strategic forces have been and continue to be based on a TRIAD of strategic missiles and long-range bombers. In addition, theater-based forces have included land- and sea-based aircraft, cruise missiles, and shorter-range ballistic missiles. Each of these systems has made a unique contribution due to different characteristics, ranges, vulnerabilities, and basing modes. During the Cold War, an active pipeline of weapons under development and in production added prospective diversity to the overall posture. This diversity provided a range of capabilities in terms of survivability, confidence in penetrating defenses, responsiveness, positive control reliability, visibility of commitment to allies, forward deployability, and dependence on overseas basing.

As the size of the U.S. nuclear stockpile has declined and the number of weapons systems has shrunk, it will remain important to retain diversity in the future, particularly in light of the spectrum of potential threats described elsewhere in this paper. In a strategic sense, diversity has several advantages. First, should any one system experience technical or operational problems, there are alternatives available. Second, the several basing modes make it very difficult for an attacker successfully to launch a disarming attack, thereby investing the total posture with substantial stability in a crisis. Third, the diversity of systems provides the National Command Authorities with a number of options for tailoring deterrent threats to the specific situation and communicating resolve to a wider range of post-Cold War adversaries. Fourth, a diversified nuclear force furnishes important hedges against vulnerabilities resulting from technological breakthroughs, such as advances in anti-submarine warfare, that might render any one type of nuclear system obsolete. Specifically, this means that the United States will need to maintain a diversified nuclear force that includes aircraft that can be deployed as necessary in crisis situations, together with submarine-based capabilities and land-based missile systems. Combined, such capabilities reinforce each other by their diversity, flexibility, and survivability.

The argument for diversity (and flexibility, discussed below) extends to shorter-range nuclear forces. In designing its posture to deter regional states that possess WMD, the United States will need to retain a flexible capability for the timely deployment of nuclear forces into the region. While central strategic forces are capable of carrying out most, if not all, military missions that theater-based forces can perform, a successful crisis management strategy will require that the United States be able to bring shorter-range nuclear forces closer to, or actually into, the theater of conflict. Specifically, shorter-range nuclear forces, including air-delivered and sea-based systems, enable the crisis manager to signal intent and, if necessary, credibly to threaten a nuclear response in a regional conflict. Shorter-range nuclear systems can help shape the outcome of the crisis both by communicating resolve to adversaries and providing reassurance to regional allies and coalition partners. The precise numbers and types of shorter-range nuclear capabilities that will be needed will be determined, of course, by the nature of the crisis and the WMD capabilities possessed by the regional adversary, whose use the United States seeks to deter. Among their characteristics, shorter-range nuclear forces should have great accuracy, penetration capability, and discrimination to minimize collateral damage. The U.S. goal will be to deter the use of WMD against forward-deployed forces and the military capabilities and territory of U.S. regional allies and coalition partners. In situations in which the United States must deter a regional state's use of WMD, the U.S. crisis management strategy should include a flexible capability both to maintain in the region (e.g., NATO Europe) and to move into a crisis region an appropriate combination of retaliatory and denial assets (in the form of shorter-range nuclear systems and theater missile defense) to control the escalatory and de-escalatory phases, and thus assure for the United States and its allies/coalition partners a satisfactory outcome.

Flexibility

The overall U.S. defense posture will need to be designed so that it can be adjusted quickly to respond to changing threats in an uncertain and fluctuating global environment. If deployed forces are to be further reduced, the remaining balance of the posture will face increased demands to be prepared to respond if other states adjust their posture. The challenges that may require adjustment in the nuclear posture could come from several sources. For example, there could be changes in Russian nuclear policy and posture. The Chinese could decide rapidly to expand their nuclear forces. Additional proliferants with interests opposed to the United States could emerge. The U.S. posture must be capable of responding to such developments. This requires a hedging strategy that can discourage such changes and take account of them in a timely fashion (e.g., within the time lines of Russian or Chinese expansion). Future deterrence will clearly require effective nuclear forces-in-being, for contingencies involving WMD could arise quite rapidly. Deterrence of regional WMD use will probably require only a fraction of U.S. nuclear forces, but that fraction must be well suited to the special needs of WMD deterrence. Effective deterrence includes the ability to deploy nuclear forces within a region, which communicates resolve and intent to an adversary, as well as flexibility to respond to the types of targets appropriate for nuclear attack.

Total Posture Planning

Total posture[2] planning recognizes that credibility is the product of the totality of the nuclear posture. All elements of the nuclear posture must stand in relation to each other if they are to contribute to deterrence. Latent elements of nuclear potential (e.g., forces in reserve, development and production capabilities) become more important as forces-in-being are reduced. As active forces decline, the other elements of the total posture will become more important in sustaining deterrence. *The total posture must be planned so that it will be responsive both to new threats and to new opportunities to attenuate threats.* Total posture planning must take account of the latent, as well as the deployed, capabilities of others.

An important element of total posture planning is development of hedges against unexpected events. The posture must be flexible and adaptable so that capabilities can be adjusted in a timely fashion if new threats emerge. The nuclear infrastructure must be capable of creating new capabilities, if required, more rapidly than new threats arise. This capability to reconstitute should, in itself, contribute to deterrence. At the same time, planning must guard against over-hedging that might appear so provocative as to stimulate new threats. The total posture will need to be continuously evaluated to assure the proper balance between readiness and reconstitution capabilities.

Stockpile Stewardship

The new paradigm requires that the United States maintain a high level of confidence in the safety and reliability of the nuclear stockpile. Current national policy states that this confidence be accomplished without nuclear testing. Surveillance programs that ensure that the stockpile is safe and reliable continue to be necessary. These programs

2 Total posture includes forces, inventories (of weapons and material), operations, doctrine, development and production facilities, plans, skilled and expert personnel, and the policy, scientific, technological, and industrial infrastructure that supports them.

include techniques for certifying the reliability and safety of the current stockpile without testing as well as maintaining a standby capability to test. The lower the numbers and the fewer the types of nuclear weapons, the greater will be the need for stockpile surveillance and maintenance. A no-testing environment necessitates a robust stockpile program that provides confidence to the national leadership and respect from potential adversaries. Because the United States must maintain a nuclear posture for decades, at the very least, the capability must exist to redesign and remanufacture nuclear weapons systems at some time early in the next century. Furthermore, if the current Stockpile Stewardship Program (SSP) does not develop viable means for certifying current weapons in the stockpile and for evaluating possible new designs in the future, the United States must maintain the capability to restore underground tests in a timely fashion. Obviously, any decision to test nuclear weapons underground would be a momentous political decision, but the policies and programs of today must protect a capability to do so in the future. At the same time, we realize that there will be formidable competition for scarce resources. Policymakers may be tempted to reallocate funds from nuclear stockpile maintenance to support other security requirements. Funding of the nuclear deterrent forces, including stockpile stewardship and strategic delivery systems and modernization programs, which must be sustained over many decades, should be separate from and must not compete against near-term military funding imperatives.

Intelligence Requirements

Because of the multiplicity and diversity of actors to be deterred in the increasingly complex security setting of the early 21st Century, greater emphasis will have to be placed on accurate, precise, and up-to-date information about adversaries. During the Cold War the focus was on the Soviet Union. Today, priority emphasis must now be given to intelligence about larger numbers of actors. This emphasis includes an understanding of adversary WMD infrastructures and, in particular, the technology and production base, as well as weapons in stockpiles. The United States must acquire extensive information about scientific-technical skills possessed by adversaries. In other words, just as our paradigm for the United States is based on total force posture, the United States must gain knowledge of the total force postures of others—the forces-in-being of potential adversaries, as well as their ability to build nuclear and other WMD systems. Thus, the United States must know who it must deter, as well as understand the capabilities and motivations of potential aggressors. Effective deterrence also will require information about a particular opponent's cost-benefit calculations and military doctrines.

The need for this information will impose formidable requirements on the intelligence community. Based on such information, it will be necessary to establish a deterrence policy for each adversary. Such tailoring will be important to the reliability of deterrence because it is the unique opponent under specific circumstances that must be deterred. Deterrence based on a generically rational and sensible foe will not be adequate in the decades ahead. Differences in leaderships, decision-making processes, risk tolerances, threat perceptions, goals, values, and determination, and simply the potential for idiosyncratic behavior, limit the reliability of any general formula for deterrence. Detailed intelligence information about the particular opponent and context to guide U.S. actions will be essential to the effectiveness and reliability of deterrence policies. In the absence of such information, there can be little basis for confidence in making informed recommendations about how to deter any particular foe from a specific act.

These changing intelligence requirements create the need to develop the types of analytic skills required for timely, up-to-date, and accurate information. The United States will require a blend of scientific-technical expertise, a deep understanding of history and culture, and the ability to analyze military doctrines and force structures of potential deterees.

Nuclear Weapons and International Politics Under the New Paradigm

The new nuclear paradigm assumes a world in which circumstances and possible threats associated with them will be diverse, changing, and often unpredictable. U.S. planners must assume that there will be continuing fluctuations in political relationships and rapid changes in technology. While U.S. interests will sometimes benefit from rapid change, this will not always be the case. For example, the rapid spread of technology may create new opportunities, but it will also pose new challenges for U.S. strategy and nuclear weapons posture.

For the foreseeable future, the nuclear relationship with Russia, as already noted, will continue to present the single most formidable potential nuclear threat, and will demand the most attention. However, in planning its future nuclear posture the United States will increasingly have to take into account other potentially hostile nations with nuclear weapons and other weapons of mass destruction. U.S. diplomacy and defense planning should seek out and exploit opportunities that may emerge to develop more cooperative and less threatening nuclear postures. Nevertheless, the primary thrust of nuclear policy and planning must be to maintain and develop the continuing requirements of deterrence outlined above. Since the end of the Cold War and the collapse of the Soviet Union, much progress has been made, particularly outside the formal framework of arms control, for example in the Cooperative Threat Reduction (CTR) Program, in military-to-military and laboratory-to-laboratory discussions, and in non-official meetings. Improved East-West relations also have made it possible to make some progress on multilateral arms control. However, distinct limits to cooperation and openness remain. Many of the suspicions of the Cold War persist, and the future direction of Russia's foreign policy is not clear, even to Russian leaders. As a result, prospects for further cooperation and limitations on nuclear weapons are uncertain.

Future engagement with Russia (and for the most part with China) about nuclear weapons should be guided by the following principles:

- During the current period when a considerable dialogue is possible between Americans and Russians in a variety of settings, both countries should develop postures and understandings about postures that will be relatively robust should there be a period of heightened tensions in the future. Nevertheless, long-held suspicions will not recede readily and thus the relationship will continue to have adversarial elements. Both states will be tempted at times to seek advantage, even as they reach for improved stability and are driven by pressures to reduce the financial burden of a large nuclear force.

- An important objective of the dialogue should be to increase transparency and develop mutual understanding of doctrine and postures. Secrecy leads to suspicion and also increases the prospect of surprises that could be very destabilizing in a crisis. To a considerable extent, transparency in nuclear relationships will be a function of the underlying political relationship, but efforts to promote transparency also can help to improve political relations. A better mutual understanding of the benefits and risks of postures that are poised for reconstitution should be an important goal of the dialogue. A longer-term goal would be the establishment of ground rules that would help to make posture changes less threatening, particularly in a crisis.

- In this continuing engagement, striking the balance between the risks and the benefits of hedges and reconstitution, and dealing with the tension between, for example, security and transparency, and survivability and damage limitation, will require coming to a deeper common understanding—or at least a better understanding of each other's views—about the fundamentals of deterrence, stability, and the roles played by nuclear weapons and defenses in security relationships.

- The focus of efforts to control nuclear armaments needs to be adjusted. During the Cold War the nuclear relationship was dominated by a competitive search for advantage, and when advantage seemed impossible or too costly, crude efforts were made to define parity. These efforts were narrowly focused on deployed strategic forces, and the results of the Strategic Arms Limitation Treaty (SALT) and the Strategic Arms Reductions Treaty (START) process were to leave substantial asymmetries in nuclear elements that were not formally controlled; for example, theater nuclear forces, development and production infrastructures, and stockpiles of fissionable materials. In the future, efforts to arrive at agreed nuclear relationships should focus on the total nuclear posture, with the recognition that there will inevitably be asymmetries. The United States should focus its attention on those elements of the Russian posture of most concern, much as it has in the CTR Program. In particular, the United States should deal more comprehensively with ensuring the irreversibility of the recent trends toward lower and less threatening forces and developing means to address the existing imbalance in shorter-range nuclear forces. The United States should also seek measures that discourage or manage competitive reconstitution. A recognition that reconstitution can be a desirable hedge as well as a potential danger will lead to work towards postures that balance these considerations.

- Dealing with these subjects will require new modalities for conducting the nuclear dialogue. For example, the CTR program and existing military and civilian forums for dialogue might be broadened to include issues related to the total posture and to reconstitution.

Nuclear Arms Control After the Cold War

Unanimity on the interrelationship of deterrence, arms control, and non-proliferation never existed during the Cold War. Many have long debated the degree to which nuclear weapons were the problem or a symptom of the problem, a threat to the peace or a peacekeeper, an incentive for proliferation or the reason many nations did not proliferate. Consideration of ballistic missile defenses added another important dimension to that debate. Often the arms control debate was a surrogate for different views about deterrence, budget priorities, and relations with the Soviet Union.

A majority view, or at least a working plurality, nevertheless emerged around a step-by-step approach designed to address specific threats to the United States and its allies, enhance stability, provide more precise constraints with extensive verification, place greater emphasis on compliance enforcement, and shape political change in potential adversaries. The more clearly arms control measures supported the concrete national security objectives of the United States, the stronger the support within the Executive Branch, in Congress, and among the American people.

Numerous arms control treaties were concluded, such as the Anti-Ballistic Missile Treaty (ABM Treaty) and Protocol; SALT II, which limited deployed delivery systems by placing limits on ballistic missile warheads and air-launched cruise missiles; the Threshold Test Ban Treaty (TTBT), which limited underground tests to 150 kilotons, and a new verification protocol to that treaty; the Peaceful Nuclear Explosions Treaty (PNET); START I, which reduces accountable deployed strategic warheads; and the START II Treaty, which calls for elimination of multiple-warhead land-based missiles. Other agreements, less formal than treaties, include the Hotline Agreement, the Incidents at Sea Agreement (INCSEA), the SALT I Interim Agreement, Agreements on Accidents Measures, Ballistic Missile Launch Notifications, the Prevention of Dangerous Military Activities, a Bilateral Verification Experiment and Data Exchange Related to the Prohibition of Chemical Weapons, an Agreement on Destruction and Non-Production of Chemical Weapons, and an Implementing Trial Verification and Stability Measures of the Treaty on the Reduction and Limitation of Strategic Offensive Arms. Important multilateral treaties and agreements completed include the Limited Test Ban Treaty (LTBT), permitting only underground tests; the Nuclear

Non-Proliferation Treaty (NPT); the Biological Weapons Convention (BWC); the Treaty on Conventional Armed Forces in Europe (CFE); the Vienna Agreements on Confidence- and Security-Building Measures (CSBMs); the Open Skies Treaty; and Chemical Weapons Convention (CWC). Recently, a Comprehensive Test Ban Treaty was signed.

Although many of the same policy differences over goals, priorities, tempo, criteria, and standards in play during the Cold War remain today, changed circumstances, new interests, expanded complexity, and uncertainty about measures of merit have further fractured the policy community. The analytical foundation and broad policy cohesion needed for more effective arms control after the Cold War have not yet matured. Yet, important considerations for the future of nuclear reductions are becoming increasingly clear; namely:

- U.S. and Russian nuclear roles, requirements, concerns, and priorities differ and are less linked to the forces of the other than in the past;

- Russia and the United States no longer view each other as an enemy, and the likelihood of war between them is currently very low;

- Russia and the United States share many objectives, such as reducing the cost of defense and insuring the safety, security, and control of their weapons, but they do have some different security concerns, requirements, capabilities, and resources;

- Theater nuclear weapons play a more important role in Russian plans than in American plans; and,

- Russia maintains a larger nuclear weapons infrastructure and an active warhead production base to support its nuclear warhead requirements, whereas the United States relies primarily on backup warheads and stockpile stewardship.

Over the long run, support for political reform in Russia and strengthened U.S.-Russian ties will be undermined by arms control arrangements that may imply adversarial relationships, impose rigidity where flexibility is needed, or emphasize mutual vulnerability rather than cooperative approaches to defense.

Russia and the United States must overcome immediate obstacles, such as limited resources and ratification difficulties, so that both countries continue to benefit from agreements previously reached while together taking on difficult tasks that might offer real improvements in security. The enhanced strategic stability provided by START I and II provisions, such as the ban on ICBMs with multiple independently targetable re-entry vehicle (MIRV) capability, should be implemented. The United States should continue efforts to reduce the costs and burdens of verification, but not at a price of reduced confidence. Although unilateral defense decisions can shape mutual restraint and formal treaties are not always the appropriate tool to achieve national security objectives, a process of dialogue in depth, joint development of restraints, and close consultation with legislatures, including obtaining consent to treaty ratification when long-term commitment is needed, can be vital to the achievement of measures that actually enhance mutual security, build confidence in cooperation, and encourage the true openness and democratic practices that will be the foundation of closer bilateral relations. Strategic nuclear warheads have been reduced to levels at which other force elements need to be considered more closely. At reduced levels, greater attention must be given to theater and non-deployed weapons, and reversibility in general.

Theater nuclear weapons can be used in strategic roles and vice versa, especially in non-Strategic Integrated Operations Plan (SIOP) scenarios, which are the predominant scenarios with the end of the Cold War. At reduced levels, asymmetries in forces and infrastructure can be increasingly significant. At reduced levels, confidence in compliance must be greater.

Russia and the United States may benefit from a new approach to nuclear arms control. Building on the improved verification and stabilizing measures agreed to in START, a new approach might provide, for example, a ceiling on total deployed warheads, both strategic and theater. This ceiling, in turn, might also provide (1) a cap on deployed strategic warheads at START levels, within an overall limit on total stockpile warheads, both strategic and theater as well as deployed and non-deployed, and (2) verifiable controls on production and total numbers, so that warhead dismantlement could actually reduce inventories rather than be a symbolic measure. Such an integrated approach to intercontinental and other types of nuclear weapons would permit both Russia and the United States greater freedom to adjust their own forces to their own needs, build greater confidence in each other and in the arms reductions negotiated, and enhance cooperation on other objectives such as the fissile material cutoff. Significant nuclear arms control beyond START II will require major improvements in verification, but meeting the high verification standards necessary requires overcoming several problems which have become more vexing with the end of the Cold War.

Verification technologies and procedures have advanced significantly. However, arms control has moved into areas in which the verification challenges are increasing at the same time as tolerance of the costs of National Technical Means of Verification (NTM) and the burdens of on-site monitoring are declining.

Confidence in intrusive verification measures and in the revolutionary use of sanctions to enforce compliance, as in Iraq, has given way to fears that either or both may be insufficient and/or unsustainable. Expectations that technical verification advances and greater openness would be simply additive have proven unrealistic as transparency measures are increasingly advocated as substitutes rather than complements to verification. Increasingly, issues of compliance are difficult to press against nations with whom the United States seeks and is achieving broader diplomatic, economic, and cultural ties.

Oversight of negotiation and implementation of arms control has declined as the novelty of new treaties and agreements has worn off. International and domestic pressure for next steps may be greater than warranted by incomplete, inadequate, or delayed implementation of past measures or by achievement of conditions necessary to move forward. Traditionally, Russia has shown great interest in ballistic missile defenses but today feels resource-constrained and technologically disadvantaged. Reopening a dialogue with Russia on cooperation in this area could enhance the security of both nations. Frustration with the difficult and time-consuming efforts necessary to achieve meaningful arms reductions that meet high standards for stability and verifiability will increase pressure for informal or symbolic measures. Even if these measures should prove to be harmless in and of themselves, they can delay or preclude real improvements in international security and, therefore, should be resisted.

The Nuclear Relationship With Other Nations

During the Cold War the bipolar strategic relationship with the Soviet Union dominated U.S. nuclear planning. Largely as a result of efforts to cap the arms race, the United States fell into a relationship termed "parity" that was misleading. Because "parity" applied only to the relationship between the strategic forces of the two superpowers and was denominated in terms of deployed launchers, left out of the equation were theater nuclear forces, weapons that were not deployed on forces on line, and all of the infrastructure that backed up the nuclear force.

In designing and maintaining the U.S. total nuclear posture, planners must take into account important other nuclear and WMD states that were not as prominent in U.S. thinking during the Cold War. The U.S. posture must be sufficient to deter/dissuade China and rogue states even while it meets the above criteria *vis a vis* Russia. This will require the maintenance of clear superiority in total nuclear posture relative to any one or possible coalition of these states. The Cold War terms "parity" and "superiority" no longer capture this increasingly complex, multi-dimensional relationship. The U.S. nuclear posture must be capable of contributing to deterrence, including dissuasion, as defined in the new paradigm. At the same time the United States must take into account the fact that the old, more narrowly defined relationship that characterized the Cold War still retains some political significance. In other words, how the United States *appears*, relative to other states, in terms of visible measures, such as deployed warheads, does have significance politically. Nevertheless, the United States should strive, over time, to encourage broad international acceptance of a more sophisticated measure to evaluate strategic relationships among states.

Nuclear Relations With Allies

The U.S. nuclear relationship with allies and other friendly states is complex and multi-faceted, reflecting the variety of political relationships that the United States has with such nations around the world. However, it is possible to distinguish several categories of nuclear relationships. First, the relationship with its two traditional nuclear allies, the United Kingdom and France, differs from that with non-nuclear allies. Nuclear relationships also differ between states that have formal security ties to the United States (e.g., NATO states, Japan, Korea) and those that do not. Finally, among the large body of states with which the United States has no formal security alliance, nuclear relations range from very close, where states are seeking U.S. nuclear assurances, to quite contentious, with states that are driven primarily by the urge to eliminate nuclear weapons.

In many instances these nuclear relationships provide a deterrent to aggression, and thus have been, and remain, a source of stability in both Europe and Asia. The U.S. nuclear umbrella also is an important component of non-proliferation policy, for states that feel secure under the U.S. umbrella are less likely to seek independent nuclear capabilities. A major challenge for the United States in the post-Cold War era is to retain the credibility of U.S. security guarantees, including the nuclear component, even while the United States reduces overseas force deployments, as well as the emphasis on nuclear weapons in American strategy.

Nuclear Allies

For fifty years the United States and the United Kingdom have enjoyed a special nuclear relationship in the areas of nuclear policies and programs. The U.K. has drawn heavily on U.S. technology, production base, and test facilities in developing its own nuclear force. The U.S. and the U.K. have worked closely in developing NATO nuclear doctrine, and Britain, like the United States, commits nuclear forces to NATO defense. France has relentlessly pursued a more independent course, developing and testing its own weapons and delivery systems and remaining apart from NATO defense planning, particularly nuclear planning. However, the British and the French have much in common. Both have been cutting back their nuclear forces since the end of the Cold War, and will rely in the future on smaller, modern, sea-based deterrent forces. Both states are determined to maintain their nuclear deterrent indefinitely and have made plans to do so. Both want to keep out of strategic arms negotiations, at least until the United States and Russia reduce their forces to much lower levels. Finally, both nations acknowledge that despite their ambitions to retain an independent nuclear capability, the U.S. nuclear deterrent is important to their own security. Neither would feel comfortable if the United States were to eliminate or weaken seriously its deterrent.

Non-Nuclear Allies

Non-nuclear allies of the United States include the NATO countries, Japan, South Korea, and Australia. The United States has security treaties with all of these countries, and while nuclear weapons are not mentioned explicitly in any of these treaties, they encompass an important aspect of the guarantee to come to the defense of a threatened non-nuclear ally, employing all necessary means—including nuclear weapons. These nuclear assurances have provided and continue to provide a powerful deterrent to any form of aggression. They continue to be valued by U.S. allies, even though the threat of aggression has diminished. One indication of the importance that other states still attach to U.S. nuclear guarantees is the desire of many central European countries to join NATO. Of course, there are many motives behind the interest in joining NATO, but the security offered to NATO members by the link to U.S. nuclear forces is a potent driver.

U.S. nonproliferation objectives should also be a consideration in shaping the U.S. nuclear posture to provide assurance to non-nuclear allies in the future. Several of these allies have the capability to develop their own nuclear forces. Japan and Germany are the most prominent examples, but both South Korea and Taiwan have substantial industrial capabilities, and once started incipient nuclear programs. Even neutral Sweden and Switzerland once considered developing independent nuclear capabilities. In the past, these countries were deterred by the cost and by the political liabilities associated with an independent nuclear force. They also were encouraged to forego the costs by the knowledge that U.S. security guarantees (or in the case of the neutrals, the stability that resulted from guarantees to others) obviated the need for an independent deterrent. It is important that the United States conduct its overall security policy in such a way that none of these non-nuclear states feels it necessary to pursue independent nuclear programs. Of particular importance is the maintenance of a credible deterrent, and the continuation of a nuclear dialogue with key allies so that they can be assured that any U.S. decisions about nuclear forces take into account their views and concerns. Planners must make every effort to avoid surprises if changes in nuclear posture must be made. The main features of the new nuclear paradigm and its impact on extended deterrence need to be fully discussed with key allies.

Other States

The U.S. nuclear relationship with other non-nuclear states covers a broad spectrum ranging from close security ties with countries like Israel to a continuing contentious nuclear relationship with some of the "non-aligned" states. Most of these states have had less concern with nuclear threats than have the NATO allies and Japan. However, even states with no formal security relationship with the

United States benefit from so-called positive nuclear assurances. While the end of the Cold War has altered the urgency of these several nuclear guarantees, they remain important. Where a security threat exists, such guarantees can contribute to a sense of security that helps to discourage proliferation.

At the same time, some non-nuclear states center their nuclear policies on a strong desire to limit the importance of, and eventually to eliminate, nuclear weapons. These states have pressed the nuclear powers to adopt negative security assurances and commitments to further nuclear disarmament in return for their agreement to remain non-nuclear states. Many of these states seem to be driven to diminish the stigma of their non-nuclear status by pressing the nuclear states to reduce their inventories as rapidly as possible. The movement to curb nuclear weapons is particularly influential in large international bodies like the UN Disarmament Committee, the Geneva-based Committee on Disarmament, and the periodic NPT review conferences, where a few committed states can often influence the indifferent by appealing to the unity of the small powers or emphasizing the claimed inequity of the global nuclear regime. The United States and other nuclear-weapon states often find themselves in a minority in these bodies. As a result, most multilateral treaties dealing with nuclear weapons reflect a compromise between the desire of the nuclear-weapon states and their closest allies to retain a viable deterrent and the desire of many non-nuclear states to minimize the significance of nuclear weapons. If the United States is to retain a viable nuclear deterrent in the future, it will have to continue to defend, in international bodies, the importance of nuclear weapons to regional stability and non-proliferation.

The Role of Nuclear Weapons in Deterring CW and BW

The United States has consistently declined to adopt an unequivocal policy of "no first use" of nuclear weapons. Current U.S. policy is based on two, seemingly contradictory, propositions. On the one hand, the United States is pledged not to use nuclear weapons first unless (1) the state attacking the United States or its allies or its military forces is nuclear capable, (2) the state is not a party in good standing under the NPT, or (3) the state is engaged in a conflict where it is supported by a nuclear state. On the other hand, U.S. officials on several occasions have made it a point not to rule out the use of nuclear weapons in retaliation for use of chemical and biological weapons against the United States, its forces, or its allies. This does not mean that a nuclear response is necessarily the first line of defense against such an attack or that nuclear weapons would inevitably be used, even to attempt to destroy biological and chemical facilities and stocks. However, U.S. policy attempts to make clear that no state can plan on the use of chemical or biological weapons without having to take into account the possibility of a nuclear response by the United States. Not only does this help to deter use when a crisis looms, but such a stance also can play a role in dissuading states from acquisition of a new capability or expansion of an existing capability.

In some cases, it should be noted, ambiguity in declaratory policy may be perceived as an exploitable lack of commitment on the part of the United States. In such cases, where the challengers are cost- and risk- tolerant, deliberate U.S. ambiguity may need to be replaced by greater clarity regarding the U.S. deterrent threat. However, such clarifications can be made privately and specific to the situation without compromising a broader policy of calculated ambiguity and flexibility. The United States should be prepared to communicate, fully and effectively, to an enemy that it is in jeopardy with regard to potential U.S.-nuclear use if that actor resorts to biological or chemical weapons. At the same time, the overall posture of the United States needs to be able to support such a declaratory policy. One element of the posture is a defense that is capable of dealing with chemical and biological weapons. Another is the ability to retaliate in a credible and proportional way, if necessary, with nuclear weapons.

Nuclear Deterrence and Proportionality

Recent discussions of the deterrent role for nuclear weapons have focused on the relative lethality of conventional, chemical, biological, and nuclear weapons. Their relative lethality is important, it is said, because U.S. deterrence threats should be *proportional* to the threat they are intended to deter. It is argued that because nuclear weapons are more lethal than the others, they are "inappropriate" for the deterrence of any threats other than nuclear. From this perspective, nuclear deterrence would not be applicable to conventional or chemical threats. Such an interpretation of proportionality could also call into question the appropriateness of nuclear deterrence for biological weapon threats (although BW lethality may be considered comparable to nuclear). This argument fails both historical and practical tests.

First, the suggested requirement for "proportional threats" certainly is a misinterpretation of the Just War Doctrine wherein proportionality concerns the relationship between ends and means, not the relative lethality of the respective force postures. A requirement for symmetry between U.S. deterrent threats and the opponent's forces would be unprecedented and would pose a risk of undermining deterrence effectiveness. NATO's "Flexible Response" doctrine, for example, included the option for nuclear escalation by NATO, that is, "first use." The absence of symmetry in NATO's Flexible Response doctrine in this regard appears to have precluded neither the necessary political consensus for its decades-long acceptance nor its value as a deterrent.

In addition, effective deterrence threats against risk-prone and cost-tolerant opponents may have to be deliberately asymmetrical. There is evidence, for example, suggesting that implicit U.S. nuclear deterrent threats were effective in influencing Saddam Hussein during the Gulf War, where conventional threats were not. Implicit nuclear threats in this case were asymmetrical to the chemical threat faced by the coalition; they also were the key to the deterrence of Iraq's use of chemical weapons, according to senior Iraqi military and civilian officials.

In short, the United States should not restrict its application of nuclear deterrence to symmetrical threats in the future. Doing so would represent a gross distortion of the proportionality standard of the Just War Doctrine, and likely undermine the prospects for deterrence "working" in crises involving risk-prone and cost-tolerant opponents armed with CBW and/or enjoying local conventional force advantages. That said, this is not an argument for a *carte blanche* approach to using or threatening to use these weapons. They have been and remain weapons used to deter the most serious of threats.

The Future Role of Missile Defenses in Relation to Offensive Forces

It seems certain that active defenses will play a growing role in U.S. strategy and in the strategy of others in the early decades of the next century. Precisely how the role of defenses will evolve depends on developing technology as well as the political-military dynamics that unfold in the years leading to 2010 and into the subsequent period. Before 2010, there is likely to be a revolution in space system architectures, driven by rapidly improving commercially available technology. Space systems, built for civilian use, will have inherent military applications. By the same token, the U.S. military is likely to become increasingly dependent on space-based assets, including communications satellites that are built for, and used by, the commercial sector. Greater emphasis will need to be placed on the protection of space-based assets from such threats as electromagnetic pulse (EMP), for example, from one or more nuclear weapons detonated as part of an asymmetrical strategy against the United States and its allies and/or coalition partners. By 2010, deployed theater missile defenses, and possibly a national missile defense system, will be greatly enhanced by major technological advances in space systems. These advances will include remote sensing and communications data that will be available to both U.S. commercial and military users, and to U.S. allies and adversaries. Such technologies will provide the potential for global defenses, including the defense of the United States. Technologies will become increasingly widespread for boost-phase intercept at a time when the requirement for such defensive systems as part of the U.S. deterrence concept will grow.

As the technologies that support missile defense improve and proliferate, the United States will have to take more fully into account defenses in designing a future deterrence strategy. The denial component of the deterrence concept in the paradigm outlined earlier will grow. The increase in the number and types of actors capable of striking U.S. allies and coalition partners within regions of importance, from Northeast Asia to Southwest Asia and Europe, already underscores the need for robust theater missile defenses. Such defenses are required initially as an adjunct or supplement to offensive forces. The United States needs theater missile defenses because it cannot be sure that the threat of retaliation will always work against regional states which, in some circumstances, may not be deterred by the threat of retaliation. Once developed and deployed, defenses will also contribute to deterrence. These defenses must be sufficient to protect U.S. military forces deployed to such a region, while also protecting the population and the military assets of allies/coalition partners.

The growing range and accuracy of the ballistic missile threat, coupled with WMD proliferation, will enhance the need for effective defenses against WMD not only within the theater of operations, but also beyond the immediate region. As a result, the United States must be prepared to deter missile attacks against allies and coalition partners, as well as the United States itself, emanating from regions in which the United States has important interests.

For regional states seeking a decisive advantage, and as part of an asymmetrical strategy against the United States, their WMD-armed ballistic missiles could be seen as weapons of first resort. The U.S. concept of deterrence will need to take account of the need to deter such first use within and beyond the region of conflict. It will be necessary to provide missile defenses adequate both to deter attacks and to prevent blackmail threats to the United States. Specifically, this means an initial capability to defeat with high confidence several dozen RVs from regional states, targeted against the United States itself. It also means that the United States should not accept the establishment of a mutual assured destruction relationship with any future peer competitor or regional state. In other words, the United States should embrace a deterrence concept that incorporates defense sufficient to discourage or deny such a power the means to strike the United States or its allies and coalition partners.

While we do not project a defense-dominant world in which nuclear weapons would no longer be required as a basis for deterrence, defense will become a greater element in the deterrence equation as the United States moves into the early years of the next century. Although it is difficult, at this time, to project the extent and the pace of any such transition, the introduction of boost-phase, space-based intercept systems will have important implications for deterrence.

As the nation moves toward a deterrence concept that increasingly emphasizes a defensive component, planners will face important questions in any transition to robust defense. The key to managing an offense/defense transition will lie in evolutionary, rather than abrupt, change. Defensive systems, once deployed, will need to be upgraded on a continuing basis, in tandem with necessary strategic offensive modernization based on two essential considerations: (1) the need on the part of the United States to deploy missile defenses sufficient to prevent or, if necessary, counter the use of offensive systems, and (2) the ability to respond with devastating retaliatory strikes designed to destroy appropriate military targets if WMD are used against the United States or its allies or coalition partners. The specific defensive and offensive components of such a deterrence concept will be driven by political and military, as well as technological, factors that will become evident in the years ahead.

Sustaining Public Support

Unless the requirements for nuclear weapons and their unique contribution to U.S. national security strategy are broadly understood and accepted by the public, it will be impossible to secure the resources necessary to sustain them. Like the other elements of U.S. defense capabilities, nuclear weapons, including all of the elements of the total force posture set forth in our new paradigm, will compete for limited national resources. This, in turn, requires a systematic effort by U.S. policymakers and legislators to explain the underlying rationale and context for U.S. nuclear policies. Such an effort must include a renewed educational campaign aimed at the generation that is growing up outside the shadow of the Cold War. Otherwise, the essential role that nuclear deterrence has played in maintaining the peace for half a century, together with its role in the transformed global setting of the early 21st Century, is likely to be lost and the ability of the United States to shape the world of the future substantially reduced.

ANNEX

Implications of the New Nuclear Paradigm

The new deterrence paradigm suggested in this paper contains a continuing role for nuclear weapons for the foreseeable future. There are implications for all aspects of the nuclear posture. Policy, forces and operations, infrastructures, and the stockpile must be designed so that the United States can respond quickly and flexibly to changing circumstances—both threats and opportunities. Several implications will need to be addressed in more detailed fashion.

Policy Analysis

Policy guidance should be further developed in the following areas:

- Reversibility, reconstitution, and hedging. Dealing with the tension between maintaining hedges and limiting reversibility will require better understanding of the relationships among warning (intelligence and treaty monitoring) and response capabilities of forces and infrastructures.

- Infrastructure planning. During the Cold War, aggressive modernization determined DoD and DOE infrastructure requirements. A different planning basis is now needed—a strategy for the infrastructure—that takes dissuasion and response to changing circumstances into account.

- As technological capabilities mature and world circumstances change, the roles of active defense need to be better understood, and policy revised accordingly.

- Defense dominance and the transition to defense dominance.

- The requirements for deterrence of China.
- Nuclear weapons requirements in dealing with proliferation of WMD.

Nuclear Operations

Policy guidance should take into account the following:

- Deterrence is designed to influence the decisions of other states. For U.S. deterrence to be credible, force capabilities, deployments, and plans must convey the message that they can and will be employed. The United States cannot rely on token capabilities or phantom plans or threatened actions that would be self-deterring.

- The United States needs to plan on countering deterrence by states that will seek to offset U.S. conventional superiority by using WMD. Attempted covert attacks on the continental United States with WMD cannot be ruled out in the time period under consideration.

- The United States needs to maintain options for the measured and flexible employment of nuclear forces.

- The United States needs to maintain ready and rapidly deployable nuclear forces to deter/dissuade potential threats from rogue states.

- The United States needs to maintain a cadre of personnel highly trained in nuclear planning and operations.

- Nuclear weapons will continue to play an important role in deterring chemical and biological threats to the United States, to U.S. allies, and to U.S. forces overseas, although there are other means as well.

- The United States needs to improve intelligence on regional states and non-state actors, with a view to understanding what capabilities are needed to deter.

Nuclear Infrastructure

The following implications should be addressed in future policy:

- In the new paradigm, the maintenance of infrastructure should be seen as a vital part of force posture in light of its indispensable role in nuclear force reconstitution.

- The R&D and production base (and the skilled personnel supporting it) must be planned so that the United States can respond to new or changing threats in a timely fashion. Specifically, this means being able to restore production and deployments and develop new capabilities at least as rapidly as Russia or any other potential competitor.

- At the same time, the United States should be prepared to adjust capabilities to respond to genuine opportunities to reduce tension and confrontation. However, any such adjustments should maintain hedges should the political situation again change.

Nuclear Stockpile

Because stockpile expansion and modernization will no longer be the principal driver of planning:

- The capability to modernize and expand the stockpile in a timely fashion needs to be maintained, not just for years but for decades.

- Relevant agencies must retain and develop the capability to certify the safety and reliability of the stockpile without underground testing. At the same time, the ability to resume underground testing in a timely fashion must be maintained.

- Policies, procedures, and criteria need to be developed to assess if and when adequate confidence in the stockpile cannot be retained without testing, and these elements should be widely understood by the relevant agencies, Congress, the public, and the international community.

- The concept of a nuclear stockpile should incorporate nuclear materials as well as weapons.

- New mechanisms and procedures, involving both DoD and DOE, will be needed to plan and manage the total stockpile of weapons and material.

Finally, there must be detailed estimates of the costs associated with maintaining the total force posture required by the new paradigm set forth in this paper.

The Emerging Security Setting: Implications for Nuclear Weapons and Deterrence

Looking to the Future

There are some trends that can be anticipated with reasonable certainty for a longer period of time (e.g., demographic trends) and others that are hazardous to forecast beyond next week (e.g., will there be a new war in the Persian Gulf?). Here we identify some of the key variables that might change between the mid-term (1998-2010) and the longer term (2010 to 2025):

- Although the challenges that the United States is likely to confront in the coming decades are unlikely to be on the grand scale of the Cold War, their number and diversity still will place a substantial burden on U.S. ingenuity and resources. Although it is impossible to forecast just what those challenges may be, an underlying assumption of this report is that the United States will, of necessity, continue to play a leading role in shaping the international security environment.

- Although the United States will continue to be the predominant world power, it could be challenged by one or more peer competitors during the first quarter of the coming century.

- The United States will remain deeply engaged in the world—economically, culturally, politically, and militarily—for at least the next several decades. After that, the U.S. political and military role in the world will be less certain, if only because U.S. leadership, public attitudes, and overall capabilities relative to peer competitors at that time will probably change in an as yet unknown way.

- Just as U.S. security concerns demanded a high level of strategic engagement during the Cold War, U.S. economic, commercial, and political interests in the 21st Century will continue to require a substantial commitment of resources and energy to preserve the safety and well-being of the United States and the stability of the international community. In fact, U.S. leadership will be even more essential to deter would-be aggressors and to reassure allies in an age of uncertainty.

- Reasonably accurate forecasts about the technologies that will be critical to national security can be made for the next decade or so (e.g., information technologies) and even about their diffusion. After that, projections about what will be key technologies and how far and rapidly they will spread are far more uncertain. Increasingly, the U.S. defense technological and industrial base is part of the global economy, and therefore is a subset of a de facto global defense-industrial base in which future militarily applicable technologies may leave existing technologies far behind.

- In the next decade or so strategic defenses will be based on technologies that are familiar today. Theater defenses will grow in size and sophistication. Area defenses with substantial capabilities against small attacks will be feasible. However, defenses are unlikely to replace dominant offenses before 2010. In the period after 2010, the possibility of dominant defenses will exist, although whether they are deployed and how effective they will be depends on political decisions about both offenses and defenses that are yet to be made.

- In the next several years Europe will be moving slowly toward greater cohesion and the geographic expansion of the idea of "Europe." This trend could lead in the longer run, on the one hand, to a much more united Europe or, on the other, a recognition that unification has distinct limits.

- For at least the next decade Russia is likely to remain relatively weak economically, and this will affect Russia's military strength. After that, the possibility of a resurgent Russia is far more likely. Of course, politics in Russia could change at any time. Russia has rebounded from various setbacks in the past, as in the months following the invasion of the Soviet Union by Germany in 1941 and in the years after World War II, when the Soviet Union became a global superpower.

- China is likely to be an ever stronger and more influential regional power in the next decade. Beyond that, China will probably become a global power and peer competitor.

- Korea will remain divided for some uncertain period into the future, but at some point it is likely to be unified. The key question that cannot be predicted is when this unification will occur and whether by force or peacefully.

- Similarly, Taiwan may retain its present status, and China may eschew the use of force against Taiwan for some unknown period of time, perhaps a few years, perhaps many. In the longer run Taiwan may either assert independence more vigorously (and be so perceived in the world community) or China may move to unify Taiwan with China, quite possibly by force.

- The wealth gap between North and South will persist for some decades. However, this will begin to narrow unevenly (probably sooner in most of South America than in most of Africa). The consequences of this trend are uncertain but likely to be important.

- If South America (and Brazil and Argentina in particular) experiences major progress toward modernization in the early decades of the 21st Century, the basis for regional powers will have been strengthened with uncertain implications for major power relationships in South America.

- The Middle East will remain a source of friction for the indefinite future. A comprehensive Arab-Israeli settlement is not likely in the near term. Other tensions within the region will persist.

- Among the growing number of actors in the world of the early 21st Century will be fundamentalist and other groups inclined with varying levels of fanaticism. Some such entities will be states. Others are likely to include sub-state, non-state, and state-supported actors in possession of military capabilities based on a spectrum of technologies, including WMD.

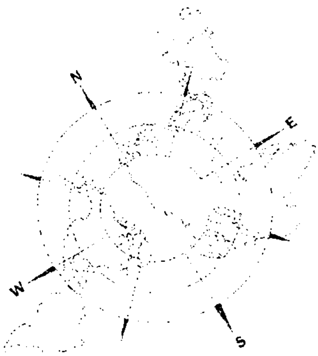
- The number of states and other actors capable of producing and deploying nuclear and other WMD capabilities will increase. There will also be latent proliferants—entities capable of moving quickly toward a nuclear status, should they choose to do so, including states hostile to the United States as well as states with which the United States shares common or parallel security interests.

- The significance of national boundaries will continue to diminish as a result of technologies that move information and financial resources instantaneously from one point to the another. Electronic technologies will further enhance the ability to communicate in the early years of the next century. These technologies will enhance the movement of ideas and people with scant regard for traditional frontiers.

Post-Cold War deterrence is made more complex because of the spectrum of actors *and* capabilities that the United States will need to deter. The types of actors encompass states, sub-state, and trans-state entities. State actors include peer competitors as well as smaller states that may possess WMD as part of an asymmetrical strategy. Sub-state actors include groups within states engaged in conflicts in which one or both protagonists may possess WMD. Trans-state actors may comprise terrorist organizations with WMD. As the United States moves into the early decades of the 21st Century, the number of actors having such capabilities can be expected to increase. Although not all such actors will pose threats to the United States and its allies/coalition partners, the likelihood of conflicts of interest requiring the United States to maintain the capability to deter and, if necessary, respond if WMD use takes place can be expected to increase.

CHAPTER 3

OPERATIONS



Introduction

This paper is the product of a working group[1] that met during the winter and spring of 1998 to discuss the diverse operational requirements for deterrence in the 21st Century. We have divided our discussion into five areas: plans, forces, command and control, defenses, and readiness. Plans and the planning process are the essential link between strategy and policy and the operating forces. The execution of the policy and strategy articulated in the Nuclear Strategy and Policy paper necessitates that the United States maintain credible, responsive nuclear forces that are perceived by potential adversaries as capable of causing devastating damage. U.S. nuclear weapons must be flexible enough for use in a variety of tasks and scenarios, and they must be able to avoid destruction or neutralization. Command and control must be robust and exercised sufficiently to ensure the personnel performing tasks are proficient and responsive to leadership. Defenses, in the coming decades, are likely to have a greater role in sustaining deterrence than during the Cold War. Above all, operations must stress safety and readiness of weapon systems. For continued effective safety and readiness, intelligent, well-trained people are key. Personnel are the real backbone of deterrence, as highlighted in both this and the Infrastructure paper.

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1 Members of the Operations working group were: ADM Henry Chiles, USN (Ret), Chairman; Amb Linton Brooks; Dr. Stephen Cochran; Amb Henry Cooper; Dr. William Dunlop; Amb S. Read Hanmer; Mr. Peter Huessy; Dr. John Reichart; GEN Larry Welch, USAF (Ret); and Mr. John Woodworth. Government observers included RADM Richard Buchanan, USN; Ms. Catherine Montie; MGen Thomas Neary, USAF; and Lt Col David Nuckles, USAF. The views expressed in this paper are not necessarily shared by all members of the group and are not intended to be representative of members or organizations of the Department of Defense or the Department of Energy.

Plans

Nuclear plans, and nuclear planning, are the essential link between policy and operations. As such, plans and planning tie together the various dimensions of the overall nuclear deterrence posture. At the same time, this posture is an integral part of overall defense planning that encompasses conventional forces and support systems. The spectrum of planning is wide, covering the objectives that are established by policy, the force structure that is needed to meet deterrence and defense goals, and the deployments and readiness posture that satisfy operational requirements. These various sub-elements—force plans, deployment plans, operations plans—need to be part of an integrated whole to assure that plans are responsive to national guidance.

Nuclear plans are also an integral part of the system for assuring the control of nuclear weapons at all levels by the National Command Authorities (NCA). Plans must communicate effectively to operators what the NCA wants to be able to achieve. Plans also largely define the nuclear employment options that are available to the National Command Authorities. In this sense, the planning process is a communications loop, with decision-making authority resting with the National Command Authorities. Plans are also central to the integration of U.S. allies into nuclear operations.

Nuclear plans are also part of the equation of nuclear deterrence that is communicated to potential adversaries. The knowledge that plans exist, combined with visible forces and declaratory policy, maximizes the deterrent effect of the nuclear defense posture. Should deterrence fail, restoring deterrence will depend on plans that provide for responses under a broad range of circumstances.

Challenges for Which Nuclear Plans Are Needed

Major threats, ranging from different categories of potential adversaries to different types of attack, include the following:

- Major nuclear powers are potential adversaries capable of putting the Continental United States (CONUS) and a broad range of other U.S. assets and interests at risk, effectively threatening U.S. national survival. Today, the residual nuclear forces available to Russia represent the only threat of this magnitude, even though this threat is substantially reduced from that posed by the Soviet Union. In the future, a resurgent and hostile Russia, or an expansionist China seeking to maximize military power, are the only potential adversaries on the horizon that could pose a threat of this magnitude.

- Regional nuclear powers would be capable of threatening U.S. theater and tactical assets, U.S. allies and partners, and possibly CONUS targets. An aggressive China seeking regional hegemony would pose a threat of this nature.

- Rogue states armed with a limited number of nuclear weapons and/or other weapons of mass destruction (WMD) could threaten targets in their region, and possibly could be capable of delivering weapons against targets in CONUS. The conduct of such states outside international norms makes their actions and the effectiveness of nuclear deterrence less predictable.

- Non-state actors, such as terrorists groups, that could be capable of using nuclear, chemical, biological (NBC) weapons in limited numbers but in widespread areas, pose special challenges for planning. Unless identified with state-sponsorship, nuclear deterrence of such actors is problematical and nuclear response would be inapplicable. Nuclear war plans, as such, cannot deal with these threats.

- Non-nuclear attacks by potential adversaries with decisive conventional force or with chemical or biological weapons may warrant or require a nuclear response. Nuclear plans for such contingencies and declaratory policies to accompany them extend nuclear deterrence to these threats.

Operational Objectives of Nuclear Plans

Effective planning must be guided by policy guidelines. The nuclear planning process can best serve the NCA when it is guided by clear and fully articulated policy that offers the rationale, purpose, objectives, and limits of the use of nuclear weapons. This will be particularly true for plans that support the possible use of nuclear weapons in response to the threat of, or the actual use of, NBC weapons in regional contingencies.

As a part of the overall nuclear defense posture, the core objective of nuclear plans is deterrence. Nuclear deterrence may operate at a variety of levels, including deterrence of aggression in general; deterrence of the vertical or horizontal expansion of conventional conflict; deterrence of the use of nuclear weapons; and deterrence of the use of chemical and biological weapons. The use of, and threatened use of, nuclear weapons against an aggressor could also have the effect, and possibly the purpose, of deterring other would-be users of NBC weapons. Once deployed, defenses will also play an essential part in sustaining deterrence. Moreover, effective deterrence will need to integrate offense and defense planning, which will require innovation as the United States adjusts to the new strategic environment and as defenses are deployed.

Beyond the overarching objective of deterrence, effective plans must have specific operational objectives that can be achieved through planned strikes against specific targets or target categories. These operational objectives must be responsive to NCA goals and define the spectrum of options that would be available to the NCA for decision. Broadly speaking, operational objectives could include limiting NBC damage on the territory or to the forces of the United States, its allies, or partners; preventing further use of NBC weapons by an adversary; reversing an adversary's conventional war fighting advantage; degrading infrastructure relevant to the adversary's military power; and disrupting leadership.

To accomplish these objectives, planners and political and military decision-makers need to take into account a variety of operational/ targeting considerations:

- Flexibility is an essential requirement. The circumstances under which nuclear weapons will have a role will depend heavily on the situation. NCA will want maximum latitude for real-time decision-making. The adaptability of plans will be critical, allowing nuclear deterrence and responses to be tailored to a broader spectrum of circumstances and countries than prevailed during the Cold War.

- Weighing conventional or nuclear responses will take on increasing significance. The advanced technologies of the future force will create a progressively wider spectrum of feasible response options. Differences in the deterrent effect of conventional or nuclear options could matter significantly in peacetime or crisis, especially in declaratory policy. Such differences may not be as significant in an actual conflict, where considerations of military effectiveness and escalation risks may dominate.

- The scale of nuclear use and the location of targets will be significant variables, with important differences in military and political effects. Plans in support of NCA decisions will need to incorporate explicit discussion of the consequences of using nuclear weapons.

- Collateral damage will be a major consideration. This will be true even at the higher end of the nuclear spectrum, but it will be especially relevant in limited-use scenarios. The objective of minimizing collateral damage will not only significantly influence the NCA's decisions on nuclear options, it will also heavily affect the choice between non-nuclear and nuclear responses. The credibility of the future nuclear defense posture will depend heavily on the possession of weapons with more discriminating effects.

- Recognizing the wide range of operational objectives and other considerations that will enter into decision-making, nuclear plans and planning ultimately come down to targets and targeting categories. The selection of targets by planners and decision-makers in peacetime or in time of crisis will have significantly differing implications. It is not the purpose here to examine those specific implications but rather to cite the types of targets that are likely to be relevant to future scenarios. These include: NBC capabilities, including delivery systems, main bases, handling facilities, storage sites, and weapons development infrastructure; maneuver units in cases where breakthroughs may be threatened; major rear area military bases, facilities, and assembly areas; logistics centers and nodes; communications networks; and political/military headquarters.

Within these targeting categories, several specific issues are prompted by the emerging strategic environment. First, in regional contingencies, mobile, or at least moveable targets will pose special challenges for tracking and delivery. Second, buried and hard targets may in some instances be effectively attacked only with nuclear weapons. Third, nuclear weapons may also in some circumstances afford the only reliable way to attack biological weapons sites with the relative confidence that toxic agents will be destroyed and not dispersed. These issues have implications for weapons planning as well as operational planning.

Nuclear Plans and Planning Structures

The United States has moved into a markedly different planning environment from the one that prevailed over the long decades of the Cold War. Instead of the singular focus on the Soviet threat, planners must now pay attention to a much wider spectrum of potential challenges. Instead of the emphasis of the past on the Single Integrated Operations Plan (SIOP), major nuclear responses, and the dangers of catastrophic escalation, the United States will be increasingly preoccupied with smaller but potentially less deterrable NBC-armed adversaries. This reality has produced a shift in relative emphasis from the large and centralized plans of the Cold War, to the limited, more decentralized and flexible plans applicable to these new threats.

The new challenges highlight the distinction between "plans" and "planning." Whereas in the past emphasis was on pre-planning of major as well as limited nuclear responses, increasingly planners will need enhanced capabilities for flexible ad hoc planning that can respond to emerging variable and unpredictable threats. The character of pre-planning should change to emphasize the procedures and technologies necessary for the rapid generation of response options for the NCA. Moreover, planners should develop and integrate skills in planning campaign and conflict termination strategies as opposed to simply nuclear response options.

As long as deterrence of a potential major nuclear competitor remains a strategic requirement, a central planning process must be maintained that can plan both major and limited pre-planned response options. However, the future nuclear planning structure will need to effectively combine pre-planning with the new emphasis on and improved features for ad hoc planning in support of the regional Commander-in-Chief (CINC). For example, with the assumption by U.S. Strategic Command (USSTRATCOM) of regional CINC nuclear planning functions, a new set of requirements for planning, connectivity, and exercises has emerged. In close coordination with the "supported" CINC, USSTRATCOM develops pre-planned, on-the-shelf options, and maintains the capability to perform ad hoc crisis planning should the need arise. These plans and procedures are subject to periodic exercises, during which skills and coordination are developed and sharpened. Both the planning and exercise processes indicate that connectivity between CINCs and USSTRATCOM needs to be improved. This includes the need for "real-time" discussion and interaction during crises and exercises (e.g., use of the Global Command and Control System at the Top Secret level). As capabilities and complexities increase, new competencies in contingency planning, near-real-time option generation capabilities including hardware and procedures, and close interface with the NCA chain of command and communications will be necessary. Flexibility and responsiveness will be the critical characteristics of planning.

In the decades ahead, U.S. nuclear forces will be smaller and less diverse. Planning will need to take into account solutions for meeting regional CINC nuclear support requirements, that is, through central systems or through the regional CINCs' dedicated non-strategic assets. New forms of integration of USSTRATCOM and regional CINC planning could be necessary for efficiency and responsiveness.

The relative de-emphasis of nuclear weapons that has accompanied the end of the Cold War and the draw-down of nuclear forces point toward the need for new endeavors to preserve the effectiveness of nuclear plans and planning. As indicated above, there is a need to establish and exercise effective channels of coordination among the relevant commands, and between the commands and the National Command Authorities. There is a special need to avoid the atrophying of planning expertise. Knowledgeable personnel must be developed systematically—people with relevant technical and operational knowledge as well as talent in strategy and planning. Participation in planning is an important element in developing these knowledgeable personnel. The field should be less compartmentalized than in the past in order to involve new talent and new skills for different and more complex planning requirements. Finally, there should be concentrated effort toward assuring the integration of advanced planning technologies, especially in support of the new emphasis on ad hoc, responsive planning.

Planning Linkages with Allies, Partners, and Others

The changing strategic environment has introduced new challenges to U.S. nuclear planning with other countries. These challenges arise at a number of different levels. At the core is the need for extended nuclear deterrence in a new and changing strategic environment.

NATO nuclear planning has an extensive history and has bequeathed a well-developed apparatus to the post-Cold War Alliance. However, the radical changes in the strategic situation in Europe have introduced major new assumptions. These assumptions are centered on the re-orientation of NATO to a non-directional strategy and toward out-of-area threats. The pre-planning of the past, which addressed nuclear confrontation with the Soviet Union, has been by-passed by political change and radically altered force structures. While there may continue to be room for some contingency planning linked to residual Russian nuclear forces capable of threatening NATO Europe, future preoccupations will center elsewhere—most importantly on the out-of-area contingencies that may be of concern to NATO members. Here, the threats are less clear, and NATO's response is less automatic. But, since the nuclear equation has not disappeared from such contingencies, the place of nuclear planning in sustaining NATO cohesion may have changed in degree but not in kind.

In these new circumstances, several issues bear on the effectiveness of planning. First, there is the question of both right-sizing and orienting NATO's nuclear planning activities in light of potential out-of-area NBC challenges. Second, the development of common policies for responding to such challenges could affect deterrence significantly and enhance the achievement of coherent action. Third, the operational coordination of delivery systems could require new approaches. Finally, there are implications for crisis consultations, including procedures, participation, and decision-making.

With other allies, such as Japan or South Korea, there will continue to be a need for careful political reassurance of commitment as well as confidence in responsible handling of challenges involving nuclear implications.

As for non-allied coalition partners, there are plausible scenarios where prior political consultation concerning nuclear weapons could become a factor in situations where NBC threats are involved. Should the use of nuclear weapons become possible, operational coordination could also become necessary. These are special circumstances, of which the United States has no precedence or experience. Planners will want to have thought through the implications.

Similarly, interactions with non-allied nuclear powers may assume significance in situations where nuclear weapons could be used in response to third-party NBC challenges. In addition to political considerations, for example, such linkages could be important in avoiding misunderstanding about the intent and location of a nuclear operation.

Conclusion

Nuclear plans and nuclear planning represent the essential link between policy and operations. Credible and effective nuclear plans are a critical ingredient of effective deterrence. The emerging strategic environment, with complex and changing challenges, necessitates heightened emphasis on flexible plans. The nuclear planning process must incorporate advanced technologies and well-exercised procedures to provide real-time situational awareness and near-real-time, ad hoc operational plans, augmenting pre-planned options for use of nuclear weapons. The consolidation of nuclear planning at USSTRATCOM combined with regular and systematic coordination and exercises with the regional CINCs affords new opportunities for more efficient and effective planning. Close and regularly exercised interface with the NCA chain-of-command and communications will be necessary. The planning process must also train and promote personnel to provide planners and decisionmakers who have the relevant technical and operational knowledge as well as talent in strategy and planning. The United States must devote attention to nuclear planning linkages with allies to take into account the changes in the post-Cold War strategic environment.

Nuclear Forces

Currently, the United States maintains a TRIAD of "strategic" forces (intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and bombers), as well as theater/tactical systems such as Dual-Capable Aircraft (DCA) and Nuclear Land-Attack Tomahawk (TLAM/N) (not currently deployed) for "non-strategic" use. In the post-Cold War world, the lines between strategic and theater/tactical nuclear forces are becoming blurred. The terms "strategic" and "non-strategic" derive from arms control, not operations; arms control has primarily addressed forces of intercontinental range (termed "strategic") that could directly threaten the Russian and American homeland. But so-called "non-strategic" nuclear warheads are, in many cases, indistinguishable from strategic warheads. Similarly, the distinction between non-strategic and strategic nuclear forces is less clear in future conflicts not involving Russia or China. Any regional power would undoubtedly consider any nuclear threat strategic. Finally, operational use of theater/ tactical nuclear forces requires planning similar to that required for strategic forces.

For all these reasons, an important conclusion of this study is that, from an operational perspective, categorizing nuclear weapons as either "strategic" or "non-strategic" has lost whatever utility it once had. In general, these terms will not be used in this section. Instead, the discussion will refer to (1) weapons and plans for maintaining deterrence through holding at risk relatively large target sets on the territory of nuclear-armed adversaries (e.g., Russia and China) and (2) weapons and plans for all other purposes.

Weapons and Forces for Large, Pre-planned Attack

Forces for large, pre-planned attack constitute the U.S. strategic TRIAD, which includes most deployed U.S. weapons. In March 1997, at Helsinki, the United States and Russia agreed to negotiate a Strategic Arms Reductions Talks (START) III Treaty, limiting each side to 2,000 to 2,500 accountable warheads.[2] Until Russian nuclear forces are drastically reduced or until the relations between the United States and the Russian Federation are transformed[3] so that Russian nuclear forces are no longer perceived as a threat, the United States will need the ability to deter aggression by holding at risk relatively large target sets in Russia. If the Chinese nuclear threat continues to grow, as some (though not all) analysts expect, it may become necessary to maintain pre-planned options for China as well. Maintaining options for a pre-planned, relatively large attack against both countries simultaneously could be difficult if future arms control agreements reduce forces significantly below the levels now planned; the requirement to maintain such attack options places a lower bound on the degree to which nuclear forces should be reduced.

Two major, interrelated issues face the United States with regard to U.S. forces for deterrence through the threat of large-scale retaliatory attack:

- Should the United States continue to maintain a TRIAD of ICBMs, SLBMs, and long-range bombers?

- How far can the United States safely reduce its forces for large-scale attack?

The TRIAD

The advantages of the TRIAD are well known: diverse basing modes to complicate a first strike, diverse penetration modes to complicate defenses, and diverse technology to hedge against a failure of one or more components. The need to guard against having a single failure invalidate U.S. nuclear forces also implies that no component of the TRIAD should depend on a single warhead design. A recurring issue is whether the TRIAD should be maintained. We believe that it should, even at lower levels of nuclear forces. Consider the following strengths and weaknesses of each leg:

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2 "Accountable warheads" is an arms control term that approximates deployed capability. START III may also limit other nuclear warheads (including non-deployed); it is not yet clear what those limits will be.

3 There is no current evidence that such a transformation is likely in the next two decades. If such a transformation occurs, the conclusions in this paper would need to be re-evaluated.

SLBMs. Trident submarines on patrol remain the most survivable leg of the TRIAD and thus add significant stability. As numbers shrink, however, the entire U.S. warhead allocation could be carried in only a few ships. Having such a large relative percentage of the warheads in a small number of submarines incurs the risk of catastrophic failure in the event of an anti-submarine warfare (ASW) breakthrough or a deficiency in the Trident system. Further, SSBNs are vulnerable in or near their ports. Over time, limiting the U.S. deterrent to a small number of platforms could invite an adversary to invest in a capability for various forms of attack, including a covert attack for which it would be difficult to establish cause or blame. Because it would take an exceptionally long time to replace losses, U.S. capabilities could be significantly eroded. The existence of the other two legs of the TRIAD makes mounting such a covert attack campaign both less credible and less consequential.

ICBMs. As Russian nuclear forces are reduced, single-warhead, silo-based ICBMs are of increasing value in deterring large-scale attack and may be the most stabilizing element in deterring smaller attacks. To conduct a large-scale attack on the ICBM force, an adversary would need to commit a large fraction of his forces, probably by using two warheads to attack each silo. Even if such an attack were successful, the result would be that the United States would retain (in the SLBM and bomber forces) a very large advantage in the number of remaining operational warheads, a position no adversary would likely find acceptable.[4] Further, because of sovereign basing, an attack on ICBMs would necessarily be a relatively large and unambiguous attack on the United States; any attacker would have to assume substantial retaliation. Thus, the continuing drawdown in forces coupled with the elimination of ICBMs with multiple independently targeted re-entry vehicles (i.e., MIRVed ICBMs) will change the equation, moving ICBMs from being thought of as destabilizing (due to vulnerability) to being considered stabilizing (due to the unfavorable exchange ratio for the attacker). Additionally, it is important to note that as nuclear weapons numbers decline, the alert status of the remaining forces is a

4 An attack solely against U.S. silo-based ICBMs would cause immense devastation in the surrounding area, but would not cause major damage to national leadership, war-supporting industry, or population centers.

key stability factor. With Russia likely to maintain a significant ICBM force capable of rapid assumption of alert status, the United States should avoid force structures that create an imbalance and destabilizing advantage for preemptive attack.

Further, if there were no U.S. ICBMs, an adversary could, during time of great crisis, be tempted to conduct a small surprise attack (e.g., from a single submarine at sea) against the small handful of U.S. bomber bases and submarine support facilities. Such an attack—which could be portrayed as the work of a rogue crew—would have a devastating effect for an extended period on the ability of the United States to generate forces. It could be difficult to make the decision to retaliate, given the ambiguity of the attack and the forces remaining to the adversary. The existence of significant numbers of single-warhead, silo-based ICBMs greatly reduces the potential gain from such a small, ambiguous attack.

Bombers. The United States will continue to require bombers for their conventional capabilities. Thus, the issue is whether these bombers should also be nuclear-capable. In the interest of cost reduction and efficiency, the nuclear bomber leg is now concentrated on only three bases, making it vulnerable to a limited surprise attack. Further, after years of a zero-alert rate for bombers, it has become increasingly difficult to return to an alert force (although Global Guardian exercises conducted during the past three years have reduced the operational difficulties). Thus, as now configured, the bomber force is not particularly stabilizing; without the existence of the ICBM leg this vulnerability might even invite a surprise attack, although planning such an attack would be difficult. In theory, the United States could quickly return the bomber force to full alert during a crisis; in reality, the President might be reluctant to heighten tensions by taking such a step.

Despite this, there are strong reasons to retain a bomber leg. Given the continuing conventional contingency mission of the bomber force, the low incremental cost of maintaining its nuclear capability is a continuing bargain. Further, bombers can be restored to full alert in a relatively brief period; doing so could be a powerful signal of U.S. resolve. As discussed below, bombers have an important nuclear deterrent role in smaller-scale responses. Finally, without bombers, the United States would be left with a single penetration mode (ballistic missiles), thus simplifying an adversary's problem of defending against a retaliatory strike and leaving the United States with no hedge against the emergence of extensive ballistic missile defenses in China or Russia.

Synergy and the TRIAD. As this brief discussion indicates, elimination of any TRIAD leg would weaken deterrence. The TRIAD remains valuable for the same reason it always has—the synergy of the three legs. That synergy in U.S. offensive forces provides flexibility to U.S. leadership and complicates defenses, thus enhancing deterrence. Diverse basing and penetration modes provide a hedge both against a technological breakthrough and against discovery of significant material problems within an individual system. This conclusion remains valid today and will remain valid at the lower force levels envisioned over the next 15 years.

Implications of Low Levels of Nuclear Forces

The second major question facing the United States is how low it can reduce its forces for large-scale attack. Although the United States, like other nuclear-weapon states, is formally committed to nuclear abolition under Article VI of the Non-Proliferation Treaty,[5] for the indefinite future such abolition is infeasible on verification grounds and unwise on strategic grounds (compare the number of deaths in European wars in the 50 years before and after the invention of nuclear weapons). Abolition or near-abolition of nuclear weapons would require a fundamental transformation in the way states behave. International antagonism and tension would have to be reduced to far lower levels than can be projected today. A worldwide system of dispute resolution, with extensive enforcement powers, would have to be devised and its viability and effectiveness proven. Other weapons of mass destruction

5 Article VI reads: "Each of the parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control."

(chemical and biological weapons) would have to have been eliminated with such stringent verification that undetected cheating was not feasible. There also would have to be a corresponding reduction in conventional forces, once again accompanied by adequate verification. The conditions allowing nuclear abolition are unlikely to be attained for decades, if ever. Thus, the practical question is whether the United States can or should reduce to "hundreds" of nuclear weapons any time in the next two to three decades. (This discussion assumes that all categories of nuclear weapons would be reduced as part of a negotiated regime. Such a regime might allow a few hundred "strategic" weapons, a few hundred "non-strategic" weapons, and a reserve also measured in hundreds. Reductions to low levels without including so-called non-strategic forces are dangerous and should be avoided, especially given the current significant imbalance between the United States and Russia in the numbers of these weapons.)

There are three fundamental issues associated with having low numbers of nuclear weapons. First, the lower investment necessary to match the capability of the two major nuclear powers could make building nuclear arsenals an attractive alternative for states that can only dream of such a possibility today. It is not in the U.S. interest to end its current position of prominence.

Second, low numbers could promote proliferation by allies. Germany, Japan, South Korea, Italy, and others have forsworn nuclear weapons in expectation of an enduring U.S. nuclear umbrella. They could reconsider their decision if they saw such drastic reductions.

Third, nuclear weapons serve as a hedge against conventional inferiority. Today, with U.S. conventional capabilities unchallenged, this is only a theoretical concern. But it is not clear what level of defense spending the United States will be willing to embrace 20 years hence, when the country may need to spend massive amounts on social programs for an aging population. The current U.S. status as the world's sole military superpower rests on a combination of nuclear and conventional capabilities; if the conventional superiority erodes, it will be even more important to maintain nuclear superiority.

Reduction of nuclear weapons to very low numbers would change the considerations that military planners must address if the operational plans were to provide credible deterrence. Several factors would have to be considered:

- At low numbers, in times of protracted international tension, there might be great pressure for an adversary expeditiously to acquire additional nuclear weapons, negate the effectiveness of offensive weapons by dispersal or other means, or take unconventional action to disrupt the opposition's systems. Plans would need to take this into account.

- The requirements of deterrence are different for different opponents. This necessitates tailored war plans; it is not clear that low numbers would provide sufficient flexibility for effective coverage. Low levels imply a reduced variety of weapons and thus limit the choices available to Unified Commanders in constructing options.

- Provision would have to be made for unlikely alliances of nuclear weapon states, which could drastically change the balance of nuclear forces arrayed against the United States.

- Very low levels could dictate pure counter-city targeting, which is incompatible with sound military planning and with U.S. values.

A reduction in numbers of nuclear weapons implies reduced redundancy in warhead design. With a Comprehensive Test Ban Treaty (CTBT) or self-imposed testing restriction, there would be little margin for dealing with nuclear weapon material problems. If the stockpile consisted of only a few weapon types (warheads as well as delivery systems), a problem common to an entire weapon category could effectively eliminate a high percentage of the weapons from service.

This places a large premium on the science-based Stockpile Stewardship Program (SSP) to determine the inception of problems and design corrective measures to sustain reliable and safe active service weapons at the requisite level. Without aggressive measures to sustain weapons, the country's leadership and military planners could not be confident that a full capability would be available if needed. Lack of confidence in the weapons would ultimately erode deterrence. Hence, at low numbers, there would be considerable need for the Department of Defense (DoD) and the Department of Energy (DOE) to reexamine their quality assurance programs to ensure those programs are effective. Further, reducing numbers probably implies reducing the associated weapons infrastructure. Thus, even if problems were detected, U.S. abilities to replace weapons (or even to maintain them) could be inadequate.

Future Forces

Although nuclear forces consume a small fraction of the defense budget, continuing fiscal pressures on that budget make any wholesale replacement of nuclear forces unlikely for decades. Fortunately, such replacement is not likely to be required until well into the next century, although concept exploration should begin in the next few years. When replacement is required, it will be important to have considerable operator input into the design of the replacement systems. Assuming that force levels remain roughly at START III levels, and recognizing that ICBMs with multiple warheads are banned, the next generation of submarine-launched ballistic missiles should be MIRVed (although not necessarily as highly MIRVed as the current Trident I/II missiles). From the standpoint of flexibility, single warhead SLBMs would be attractive, but political, economic, and industrial considerations probably preclude acquiring such weapons in sufficient numbers to support large pre-planned strikes. (A handful of single-warhead SLBMs, may, however, prove valuable; this point is discussed below.)

Weapons and Forces for Smaller-Scale Options

The chief purpose of nuclear weapons is to deter adversaries capable of nuclear attacks on the territory of the United States from conducting such attacks or from attacking U.S. forces or U.S. allies. Nuclear weapons will, however, continue to have other functions. For example, nuclear weapons deployed abroad played an important role in extended deterrence during the Cold War, particularly within NATO. Such deployments can continue to have a more limited role in the future. In addition, nuclear weapons play an important role in deterring attacks on U.S. forces with chemical or biological weapons.

Currently, U.S. forces for smaller strikes are the legacy of unilateral declarations of Presidents Bush and Gorbachev in 1991. President Bush eliminated all ground-based, short-range nuclear weapons and withdrew all tactical nuclear weapons (including cruise missiles) from surface ships (including aircraft carriers) and attack submarines (the subsequent Nuclear Posture Review eliminated all nuclear capability on surface ships).[6] The United States reduced its stockpile of tactical bombs in Europe, but considerable uncertainty exists as to the number and status of Russian tactical nuclear weapons. The United States retains a few thousand "non-strategic" weapons, while the Russians may have at least 10,000 to 15,000. This asymmetry needs to be addressed in future agreements with the Russians.

One case in which specialized nuclear forces might be required is deterrence of a regional nuclear power. Deploying nuclear weapons closer to a regional adversary, and in ways different from those associated with large, pre-planned attacks, could allow the United States to strengthen deterrence by increasing both the capability and credibility of its potential response to aggression. Appropriate nuclear targets would include nuclear forces and facilities of the adversary. Although the current "threshold" states of Israel, India, and Pakistan are not hostile to the United States today, the future could include a hostile regional nuclear power.

Two major factors will shape future U.S. planning and use of weapons for smaller attacks. First, the political leadership can be expected to be very reluctant actually to use nuclear weapons if there are any other

6 In response, President Gorbachev pledged to dismantle all Soviet nuclear artillery shells, tactical missile warheads, and nuclear mines, and to remove all tactical nuclear weapons from surface ships and multipurpose submarines. These reciprocal commitments, however, were not honored.

options. Second, if such weapons are used, there will be detailed, real-time political control over target selection (the political control over the selection of Tomahawk cruise missile targets in small strikes will serve as a model, although political oversight of nuclear strikes will be far more stringent).

Additionally, there are at least two classes of targets for which non-nuclear alternatives may prove inadequate for some time. Both may require that new nuclear weapons be designed.[7] The first comprises underground facilities that are deeply buried or hardened beyond conventional strike capabilities. Future U.S. nuclear forces should provide a capability for attacking such targets, although collateral damage will be a serious issue in such attacks. The second set of targets for which only nuclear weapons may be adequate comprise facilities with large concentrations of biological agents. Many chemical and biological facilities and forces could be subject to effective conventional attack.[8] A nuclear fireball may, however, be the only way to destroy biological weapons facilities and the agents contained therein without causing widespread biological contamination due to the spread of lethal agent downwind. This implies the need for extremely accurate, relatively low yield, low-altitude-burst weapons designed to minimize collateral damage and the spread of contamination, either radioactive (from the ground burst) or biological.

Deeply buried targets and biological weapons facilities are not the only plausible targets for small-scale attacks. Although non-nuclear weapons may be able to inflict adequate damage on most other classes of targets, in any specific circumstance it may be militarily necessary (for example, because of defenses) or strategically desirable (to impose shock and awe) for the United States to employ nuclear weapons against other targets.

Because of the extreme (and justified) reluctance of the National Command Authorities to authorize nuclear weapons use, the lead time available for planning small strikes will probably be short (hours or

7 It is important to note that U.S. adherence to the Comprehensive Test Ban Treaty does *not* preclude the design of new weapons.

8 Of course, such facilities might also be hardened to the point that a nuclear attack would be required.

days, not weeks). Further, the political constraints placed on nuclear target selection will probably be impossible to predict. To allow for the possibility that attacks cannot be pre-planned in detail, future weapons for small-scale attack (1) must either be previously deployed or be capable of use from CONUS, and (2) must be capable of real-time targeting. Bombers equipped with cruise missiles offer one option; another might be to have a small number of single-warhead SLBMs (perhaps two per SSBN) equipped with earth-penetrating warheads. Since the political leadership will insist on virtual certainty of success, air-delivered weapons will need to be carried on systems with both a high probability of penetration and extreme accuracy, even in the face of robust defenses. This suggests the need for improved and stealthy air-launched cruise missiles.

Arms Reductions

Arms control agreements provide a major constraint on nuclear force levels. Thus, it is appropriate to consider what the United States should seek to obtain from arms control and when, if at all, the present arms reduction process should cease. It is well established that arms control is not an end in itself but a means to improve security. For reductions to be in the national interest, they should (1) have some affirmative benefit, and (2) not weaken deterrence.[9]

The United States is currently committed to negotiating a START III treaty with Russia. Although the two sides agreed on a limit of 2,000 to 2,500 accountable warheads during the 1997 Helsinki summit, Russia has consistently argued for levels below these values. In theory, START III levels could be reached by reducing the numbers of U.S. ballistic missile submarines. For at least several decades, however, it will be necessary to hold targets in China at risk as part of a robust pre-planned option. To avoid the risks of miscalculation, such an attack should not involve overflight of Russia. Thus, START III should allow the maintenance of SSBNs in both the Atlantic and Pacific oceans. One way to accomplish this within the lower levels of START III would be to provide simplified procedures for inactivating and

9 In practice, this second criterion has meant that the Joint Chiefs of Staff (JCS) must certify that the national guidance for the employment of nuclear weapons issued by the President can be met at the lower level.

removing from accountability several launchers on each SSBN. Negotiating such procedures should be a goal of the United States.[10]

As the discussion thus far has indicated, the distinction between strategic and non-strategic nuclear forces is less likely to be useful in the future. Thus, any future arms reduction agreements should cover all categories of nuclear warheads. Otherwise, the indistinguishability and potential convertibility of strategic and non-strategic warheads will affect the balance between the United States and other powers, especially Russia. Because the numbers of Russian non-strategic nuclear warheads are so large, they must be counted in some way as strategic levels fall below START II. Verification of limits on these forces almost certainly requires new approaches that limit the actual numbers of warheads, not just the means of their delivery. Such approaches will be difficult to negotiate and to implement. Any warhead verification regime will be fairly intrusive. Future operations must consider the impact of intrusive arms control measures.

A central negotiating goal of the United States in future arms control negotiations should be to preserve a force structure that can maintain deterrence. Although it is not the purpose of this study to define the exact number and shape of future U.S. nuclear forces, the following guidelines would be consistent with the analysis in this paper:

- Maintain a relatively large force of single-warhead ICBMs, sufficient to deny an adversary any hope of making a small, "cheap" attack on the United States.
- Retain sufficient B-52 and B-2 bombers to fulfill U.S. conventional requirements. All B-2 and B-52 bombers should continue to have a nuclear capability.[11]
- Retain sufficient SSBNs to maintain a two-ocean capability, if necessary by removing some launchers on each ship from accountability.

10 This is the only element of the analysis in this paper that depends on the details of START III.

11 B-1B bombers reoriented to conventional roles are excluded from the overall weapons totals prescribed by START II; presumably this exclusion will extend to START III as well.

From an operational perspective, the United States should not agree to reduce its strategic forces below the levels suggested by these guidelines.[12] Operationally, force structure, not warhead counts or target coverage, should determine U.S. negotiating goals.

Special Considerations

Defenses. The importance of early deployment of capable theater ballistic missile defenses is well known. Such defenses do not invalidate the need for the smaller-scale nuclear options described in this paper. Further, it is unlikely that robust national ballistic missile defenses will be deployed in the immediate future. A "thin" defensive system would not alter the nuclear balance between the United States and Russia in any fundamental way; nor would it alter the analysis presented earlier. A separate section of this paper will analyze the situation in which more robust national defenses are deployed.

Nuclear Tomahawk. The earlier discussion suggests that most existing U.S. capabilities will continue to be required for the indefinite future. From an operator's perspective, TLAM/N may no longer have an operational role to play in U.S. nuclear planning. Many of the reasons that TLAM/N was so important during the Cold War (dispersed nuclear forces, strategic reserve, deterrence of Soviet attacks at sea) are no longer as relevant. With a shrinking submarine force (which also has multiple other missions), TLAM/N would make only an incremental contribution to large, pre-planned attacks even if it were re-deployed. For smaller-scale attacks, the weapon appears to offer no characteristics that could not be provided by other systems. Further, the time required to deploy it in a crisis makes it unattractive for such attacks, since it is unlikely that political leaders will be willing to anticipate nuclear weapons use far enough in advance to make deployment feasible.[13]

12 This does not mean nuclear arms control must end with START III. Adequate constraints on so-called non-strategic weapons will almost certainly require further negotiations following START III.

13 Although it does not invalidate the analysis presented above, some believe that sea-launched cruise missiles could pose special dangers to the United States. Future regional nuclear powers might be able to use such weapons against the continental United States more easily than ICBMs and with more control than terrorist-style covert delivery. Although there is no evidence that any such powers are now developing nuclear sea-launched cruise missiles, the Intelligence Community should place a priority on indications and warning for the emergence of such a threat.

Dual-Capable Fighter Aircraft. During the Cold War, a significant component of the U.S. nuclear delivery capability in Europe resided in Dual-Capable Aircraft—that is, those capable of delivering both nuclear and non-nuclear munitions. Current plans for future tactical aircraft such as the F-22 and Joint Strike Fighter do not provide for dual-capability. Given the strike capability inherent in the U.S. bomber force, there appear to be no operational reasons to retain dual-capability. There may, however, be overriding policy reasons—such as maintaining NATO cohesion—that dictate long-term retention of dual-capability in tactical aircraft.[14]

Conventional Forces. The possession of overwhelming conventional forces has and can continue to deter potential conflicts by making the costs so high and chances of success so low that adversaries are unwilling to take the risks. Some have argued that advances in conventional warfare technology constitute such a revolution that a new strategy of "conventional strategic deterrence" can replace nuclear strategic deterrence, at least for regional conflict. Revolutionary technologies enabling such a shift include precision-guided munitions, stealth technology for missiles and aircraft, and vast improvements in command, control, communications, computers & intelligence (C4I) systems. Much like nuclear deterrence, the new strategy would employ long-range strategic air power to threaten an aggressor's entire military and industrial complex without the need for ground troops (and associated casualties). Advocates believe this alternate strategy would have more credibility and much less potential for collateral damage than continued reliance on nuclear deterrence.

Despite the popularity of this view, advanced conventional forces cannot stand alone as a deterrent. First, nuclear-armed adversaries already exist, and other opponents with weapons of mass destruction or weapons capable of threatening the United States proper are likely to evolve. Second, conventional weapons have some technical limitations. For instance, for standoff munitions, crucial targets can be made increasingly hard to conventional attack; some may even be essentially

14 See the Policy and Strategy paper of this report for a discussion of the policy rationale for retaining both TLAM/N and Dual-Capable Aircraft.

impervious. Hardening or even dispersal or movement of a target may be so cheap that any attempt to kill it with expensive weapons could well cost more than the target is worth. Third, historical experience suggests that conventional deterrence fails. Technology inevitably spreads so that it is eventually used in warfare by both sides (the only exception being nuclear technology, so far). Further, air power—with high-precision weapons that might be dubbed "video game warfare"—has never won a war by itself.

Conventional forces have an important role in deterrence when coupled with nuclear forces. There will always be situations where nuclear deterrence alone is not credible. There is, however, no prospect of conventional forces replacing nuclear deterrence. The combination of nuclear forces to deter and superior conventional forces provides the best hope of ensuring deterrence into the future.

Nuclear Command and Control

Today's nuclear command and control system has served the United States well, but the world has changed and so must nuclear command and control. Command and control is of critical importance in assuring deterrence because even the perception of vulnerability may invite an attack.[15] In the 2010 to 2015 time frame, nuclear command and control—and all of command and control—must evolve. The most fundamental shift will be in focus from systems to data. In the future the United States will use a data-centric system with worldwide coverage. Military communications will consist of military data flowing over many commercial networks, just as financial or any other data will. A related shift in focus will be how to pass data. Nuclear command and control data will flow through two systems: a slim hard-line survivable element and a flexible day-to-day family of networks. Communication systems will become families of multimedia networks; emergency action and positive control procedures will embrace the electronic age; and knowledge-based software on distributed computer networks will rapidly filter data, develop plans, and prepare retarget orders for U.S. forces.

15 Thomas P. Coakley, *Command and Control for War and Peace*, National Defense University Press, Washington DC, 1991, page 6.

This subsection sketches, in broad terms, a vision of how future nuclear command and control might look. It begins by explaining the current system to ensure a common point of reference. This will include a definition of what constitutes "command and control," a short background describing past nuclear policy evolution, and nuclear command and control imperatives. From this reference point, the subsection will briefly explore some of the future trends affecting nuclear command and control and, finally, will describe the concepts that are critical to the future of nuclear command and control.

We do not attempt to present technical solutions to future nuclear command and control requirements, but instead focus at the broad conceptual level. Additionally, the concepts put forth are intended for use in the 2010 to 2015 time frame.

Background

Yesterday's world consisted primarily of a single major threat to the United States—the Soviet Union. In this bi-polar world U.S. national policy focused on containing communism. Militarily, the United States maintained overwhelming force in the nuclear and conventional arenas. Nuclear weapons were seen as the ultimate weapon and the United States prepared to prevail in a nuclear exchange if deterrence failed. Planners developed a nuclear command and control system that was strictly driven from the top down. This system, developed and financed by the military, uses multiple single-use, low-data-rate paths to convey nuclear orders from decisionmakers to executing forces. Today, some of the paths of this system are hardened; that is, they are designed to withstand nuclear blast and electromagnetic effects to ensure forces can receive appropriate orders during all phases of conflict. The current system is manpower and paper intensive, relies on older, proven technologies, and is becoming increasingly difficult to maintain. Nuclear command and control was a specialized system, expensive to build, and costly to maintain. However, in the absence of alternatives, the United States must pay these costs.

The political climate of today's world is different. Today's national strategy seeks to enhance U.S. security, ensure a healthy economy, and promote democracy.[16] Militarily, the United States does this by shaping the world, responding to crises, and preparing for tomorrow.[17] Instead of the single looming threat of the Soviet Union, the United States must now consider threats such as information warfare and chemical or biological weapons in the hands of potential enemies. Today, nuclear weapons are weapons of last resort. Primarily considered strategic weapons, their use or employment is adapting to other levels as the distinction between the strategic, operational, and tactical levels of warfare blur. Today's nuclear command and control system is largely a collection of legacy systems from the Cold War. It has been trimmed down slightly and made more flexible, but is essentially unchanged. Expensive, survivable systems dominate the current command and control architecture and limit flexibility.

The future world will likely be a multipolar one in which transnational groups and multinational corporations may well compete with nation-states for power and resources. Global crime and terrorism will continue to threaten the United States within its own borders. Scarce resources, such as water or oil, and the disparity between haves and have-nots may instigate much of the world's instability. Military success will increasingly depend on sharing responsibility with friends and allies. WMD, including advanced chemical and biological weapons, will be in the hands of many actors throughout the world. As information becomes an increasingly important—if not the primary—source of power, information warfare could become the weapon of choice. Nuclear command and control in the future must adapt and become a part of the overall network-centric communication system where multiple nodes provide guaranteed connectivity to any appropriate weapon system, in almost any environment. It will no longer be a unique system, independent of other command and control requirements, but will instead become part of a larger command and control system with one unique exception. In addition to the common-use network system, nuclear command and control will

16 William J. Clinton, *A National Security Strategy of Engagement and Enlargement*, U.S. Government Printing Office, 1996, page i

17 John M. Shalikashvili, *National Military Strategy*, CJCS, 1997, Executive Summary

continue to use a survivable "slim hard-line" communication system (such as today's ELF, VLF, and MILSTAR) to ensure Emergency Action Message delivery during nuclear war.

This dual-track system, using automation and rule-based decision aids, will simplify nuclear command and control while making it far more responsive than it is today. The future nuclear command and control system can become the command and control system for whatever "ultimate weapon" comes into being in the next century, whether it be space-based lasers, information warfare, or some other weapon.

Imperatives for Nuclear Command and Control

Secure. First, a nuclear command and control system must provide continuous friendly access to reliable data while simultaneously denying enemy access. This requirement existed throughout the Cold War, is critical today, and will remain a premier requirement in the future. Today the United States meets this requirement through the use of secure systems; in the future the emphasis should be on secure data. Rather than being concerned with how the information arrived, the focus should be on the data itself—hardened data. Such a system must be invulnerable to information operations. As access to and control of information becomes an important method to wage war, security against information operations will replace physical security as the greatest challenge to the nuclear command and control system.

Survivable. A second requirement of nuclear command and control is survivability. Survivability requires uninterrupted access to uncorrupted data. In the past the threat to data was physical interruption, and survivability was achieved through robust, independent, overlapping, unique systems. In the future, survivability must address both physical and virtual (virus or hacker) destruction. The future key to survivability will be redundancy; uncorrupted data will exist in many locations, with multiple ways to access these data. In the event of physical or virus destruction of the network-centric system, a single slim hard line will provide physical, hardened survivability. This single chain is critical to nuclear command and control; without it, there would be no deterrent against a first-strike attempt. For deterrence to work, the United States must convince the enemy that it has the will and capability to respond decisively. This dual-track nuclear command and control will provide the needed capability.

Responsive and Timely. The U.S. nuclear command and control system must be responsive and timely. It must be able to react quickly to whatever situation develops while supporting offensive and defensive operations. During the Cold War the United States focused on a known set of targets that did not vary a great deal. Today it faces a different threat environment populated by an ever-growing number of actors and weapons, driving a need to retarget quickly. Tomorrow, the U.S. nuclear command and control system must be able to accommodate real-time situational awareness and near-real-time planning, followed by deliberate action.

Although deterrence remains the bedrock of U.S. nuclear policy, new Presidential guidance makes it clear that the nuclear command and control system must change. Fighting and winning as an objective is giving way to an emphasis on adaptability. The current nuclear command and control system, with extensive requirements for survivability and little ability to flex, is unable to meet this requirement.

Technology Trends Affecting Nuclear Command and Control

Technology is changing command and control at a tremendous rate. The National Security Agency (NSA) has examined this and determined that three important overarching mega-trends emerge: the dramatic expansion of network bandwidth, mobile access, and widespread encryption.

Continued growth in the computer industry will enable high-speed processing, storage, and handling of vast amounts of data.

Communication bandwidths will allow more and more data to be exchanged by multiple users. The convergence of computing power and telecommunications accompanied by the explosive growth in network traffic (as evidenced by sustained 30% annual growth in the Internet) will enable unprecedented access to data.

Mobile access to global networks complements fiber optic and microwave Internet connectivity by providing radio frequency (satellite telephones, wireless local networks, wireless modems) access to networks. This extends the access to the individual rather than to hubs of users, which enormously increases the number of possible paths connecting sites.

The first two mega-trends facilitate a profound increase in the amount of data that can (and will) flow on networks. Data will become increasingly cheap, and eventually the sheer volume of data will create problems. Identifying "good" data, filtering data, and protecting data will also increase in importance, potentially faster than the growth in data. This provides the impetus for the third trend, encryption. Historically the value of data was proportional to its scarcity, which was achieved by controlling access to the data. In a future environment of unrestricted access to vast amounts of data, quality will be the new reference for value judgements. Protecting data quality will become critically important, whether it be political, financial, or personal data.

For the future, the question is not "Will technology change how the United States accomplishes nuclear command and control?" The question is "Will the United States have the foresight and willingness to make necessary changes in order to ensure a creditable deterrent, foster arms control, and safely operate its nuclear weapons in a changing world environment?"

The Future—America's Insurance Policy and Nuclear Command and Control

Current writings describe the nuclear arsenal as an insurance policy, a concept that may be useful in considering future command and control. In the past, the United States built nuclear weapons and their command and control systems to address the full spectrum of conflict and responsiveness. Extending the insurance analogy, this could be considered a "whole life" approach: durable, broad coverage, but expensive. The nuclear command and control system of the future (as an integral part of nuclear deterrence) could also be thought of using a life insurance analogy—a whole life policy supplemented by flexible term insurance. The core of the system, the whole life portion, is a slim hard line, a small collection of hardened systems that link together to assure a secure, survivable path to selected forces under any wartime environment. This is the part of the system that can survive a massive nuclear attack and respond in kind. It is a simple system that uses a very short message to tell surviving forces (primarily alert and mod-alert SSBNs) to launch their missiles. Although relatively expensive, the slim hard line, like whole life insurance, provides security in the future, no matter what might happen. It is the stable foundation upon which present and future security is built.

Using this foundation, it may be possible develop a flexible and responsive system that uses existing channels of communication and functions in any environment short of massive nuclear war. This system, combining bandwidth, mobile access, and encryption, will be easy to use, easy to procure, and easy to interpret. It will use the Internet, satellites, commercial TV broadcast systems, and remaining military-unique systems to provide redundancy and reliability. Using it, military planners will be able rapidly to retarget and execute small- to large-scale nuclear operations using any present or future weapon system. The key to this system is its inherent flexibility. It is like term life insurance—flexible, cheap, and responsive.

By combining the stable foundation of the slim hard line and the flexibility of the common network-centric system, the United States will have a nuclear command and control system that meets its long-term security needs and is flexible enough to meet and adapt to tomorrow's changing world.

Hard Data, Not Hard Systems

The current nuclear command and control system relies heavily on hardened communications systems, codebooks, and a paper-based information pedigree. All of these factors contribute to the survivability of the nuclear command and control system, but may not be required under the new concept of nuclear command and control.

Currently, communications systems for nuclear command and control consist of multiply-redundant, single-use (military-only) systems that are hardened against the effects of nuclear blast. Redundancy and hardening are deemed necessary to ensure that reliable communications will exist during and after a nuclear attack. Unfortunately, layers of redundancy, military-only systems, and reliance on paper products all result in large expenditures of both money and manpower. Additionally, non-use of automated, electronic systems increases the complexity of emergency action procedures, limits the flexibility of the systems, and increases the likelihood of compromise or spoofing of critical nuclear command and control information.

Systems. The slim hard line would provide assured response to attacks that threaten the nation's survival by guaranteeing execution message delivery during any stressed communication condition. Composed primarily of current legacy systems, it will evolve to incorporate new technologies as they mature. The associated emergency action procedures would not need to encompass re-planning/ re-targeting/adaptive planning options. Those types of responses would be handled by the common network-centric portion of the system. Likewise, communications systems for the slim hard line would be limited in scope and capability. The slim hard line guarantees execution through physical hardening, but does not provide the flexibility likely to be required in the future.

"Hardening" for the communications systems would come from multiple paths, multiple nodes, and multiple means of transmission. The drive to go from military-unique to commercial systems will be fueled primarily by cost. Communications systems are very expensive to build and maintain. However, shared use of them, for example, via the Internet, is well within the reach of most people; it is inexpensive and convenient. Our predicted future envisions unprecedented numbers of communications systems, of every type, each carrying encrypted data from decisionmakers to executing forces. Therefore, in any situation short of a major nuclear war, any number of means to transmit data from the decision-making authorities to the executing forces exists. A partial list might include the Internet, commercial (whether landline, SATCOM, or cellular) telephone, and television in the form of a video-teleconference. Any or all of these systems provide multiple paths between the cognizant parties, and bandwidth could be leased for day-to-day connectivity/operations and/or secured in the event of a national emergency.

Data. This concept would engender a major shift for the nuclear command and control system toward increased or exclusive use of electronic encryption to not only encrypt the messages transmitted, but also to establish the "pedigree" or authenticity of the message. This concept is called "hardened data." While it is arguable that nuclear command and control is currently "hardened" by encoding and use of paper-based authentication, a shift to electronic "hardening" provides several new capabilities.

Effective encryption would likely involve use of a multiple key system such that the data arrive at the user end as "read-only" data. Only authorized senders, presumably limited to the National Command Authorities and/or the authorized originators, would hold the "send" key. These two facets would combine to eliminate the ability of a "rogue" user to spoof the system, a fear that has driven and continues to drive costly and/or complex changes to the current system. Additionally, effectively encrypting the data limits an adversary's access to nuclear command and control information. Intercepts would consist only of electronic noise. The character and composition of the message would not be exposed.

Such a system could also effectively establish the "pedigree" of a message, thus eliminating the requirement for off-line authentication. Simply put, there are only two end states for data received at the user end: clear text or electronic noise. The receipt and correct decryption of a message assures that it has been sent by the proper authority.

Effectively hardened data could also eliminate the need for cumbersome and costly codebook systems. Codebooks by their very nature pose a problem in the planning and execution of forces. As flexibility approaches infinity, the size of the codebook necessary to cover all those options also approaches infinity. As the usefulness of the codebook goes up, the ability to use it goes down. Consequently, current codebook systems are a series of compromises, trading flexibility for operability. Developing an infinitely flexible codebook, aside from being nearly impossible, creates more problems than it solves. The encode/decode process, development, production, and training associated with such a codebook would be costly, time-consuming, and likely to result in message errors. All of these problems are fixed by use of a "plain text" Emergency Action Message transmitted over an encrypted circuit.

Use of codebooks also constrains how the National Command Authorities can execute the force. Fixed formats constrain options and force pre-planning not only of the codebook, but of the executable missions to ensure that the maximum number of options are available in the minimum amount of time. In addition to consuming multiple man-hours, the existence of pre-planned options favors their choice, whether or not they represent the best response to a given situation, because of the difficulties and time delays associated with developing options from scratch. Encrypted plain-text messages free decisionmakers from the tyranny of fixed formats and allow any amount of data, from a simple execution/termination of a pre-planned option up to and including an entire new target package, to be sent in an Emergency Action Message.

An additional benefit—addressability—may also be realized by using an Internet-type distribution system for Emergency Action Messages. If Emergency Action Messages were individually addressed to the executing unit, and the unit reported back receipt and understanding of those Emergency Action Messages, the necessity to blindly re-transmit Emergency Action Messages to ensure receipt would be eliminated. A report-back system could function automatically, like an e-mail return receipt, or be designed to require end-user input. Addressed units not responding to tasking will receive either a retransmission that the system could provide automatically, or the mission will be re-assigned (again, automatically) to another unit.

Another aspect of hard data is the process of ensuring that viable, uncorrupted data exist somewhere in the network and are capable of being retrieved by the user, a concept of data stewardship. Data stewardship involves the full spectrum (cradle to grave) control over specific data; capturing data, ensuring accuracy and updates, providing ready storage, archiving superseded data, and destroying unneeded or corrupted data. A critical part of a data-centric world, data stewardship will ensure consistent access to viable data.

A system using "hardened data" provides many benefits: increased security; more efficient management of Emergency Action Message distribution; more effective, flexible emergency action procedures; and potential savings from elimination of multiple paper products (codebooks and authenticators). Through encryption, the military can leverage off the enormous investment in the world info-structure. For the small access charge to the networks, encrypted military data can flow in unprecedented volume and speed to anywhere on the planet.

A New Emergency Action Message

Today, the military uses Emergency Action Messages to convey instructions to nuclear forces. Emergency Action Messages contain two critical types of data: weapon details and pedigree information. Weapon details include the desired option, weapon system, and technical parameters about the intended targets. Pedigree information addresses the issues of data quality and properly authorized direction. Driven by the need to use special low-data-rate communications systems, today's Emergency Action Messages contain both types of data, carefully structured to ensure brevity and rapid understanding. As described earlier, the mandate for brevity requires significant pre-planning of nuclear attack options, which limits flexibility.

Future Emergency Action Messages will include the same information, but technological capabilities and a need for greater flexibility suggest the opportunity for a process change. The new process or group of processes would separate the weapons data from the pedigree data. The advent and growth in knowledge-based systems will directly affect the planning processes, making it viable for planners to develop near-real-time options. Using the inherent power of networks for data sharing, the weapons data could be sent to all applicable platforms immediately after an option is generated. The pedigree data would comprise the new Emergency Action Message and offer the decisionmaker much wider freedom to communicate the decision, purpose, and rationale vital to a tailored response. This new Emergency Action Message, also hardened via electronic encryption, will greatly simplify operational procedures and provide the National Command Authorities with a high degree of flexibility.

Conclusion

After years of Cold War inertia, nuclear command and control must adapt to new realities. The dual-track nuclear command and control system presented will provide the insurance the United States needs. Instead of standing alone as its predecessor did, it must align with the conventional command and control system. The system will be network-centric, with survivability provided by multiple data paths as well as an independent slim hard line. Hardened data will preclude the need for further hardened systems while maintaining iron-clad survivability. Increased bandwidths and computing power along with mobile access will provide the flexibility and assurance required for future deterrence.

Future Defense Contribution to Deterrence

Over the next 10 to 20 years, defensive systems are likely to have a greater role in sustaining deterrence than during the Cold War. The specific attributes of deployed systems will probably be strongly influenced by the political-military dynamics that unfold from technological advances. We believe that it will be feasible to field effective systems against today's offensive systems, although considerable testing remains to be conducted before any particular system can make a meaningful contribution to deterrence. Of course, improvements in offensive systems can make the defensive task harder. A number of factors apply:

- The Anti-Ballistic Missile (ABM) Treaty currently prohibits deployment of a truly effective national ballistic missile defense. With he end of the Soviet Union, the future for this treaty is murky. If Russia, Belarus, Kazakstan, and Ukraine become successor states, modifying the treaty may be more difficult than in the past.

- Whatever happens to National Missile Defense (NMD) in the near term, Theater Missile Defenses (TMD) will be developed at a deliberate pace with reasonably robust deployment of a land-, and/or air-, and/or sea-based system.

- The deployment of a replacement for Defense Support Program satellites, currently termed Space Based Infra-Red System (SBIRS)-High (a detector in a geo-synchronous orbit), is essential. Although deployment of SBIRS-Low (a detector in a low earth orbit) is not assured, it is currently in the Air Force Program Objective Memorandum (POM), and Congress is a strong supporter. SBIRS-Low is needed for a truly effective theater defensive system.

- A new generation of low earth orbit space systems (Teledysic, Iridium, etc.) will provide commercial access to remote sensing and/or communications data of a quality previously provided only by military/national space programs to U.S. users, primarily military. Commercial access will mean much of these data will be widely available to U.S. adversaries as well as friends. Furthermore, the technology and architectures adopted by these commercial systems will enable "space weapons" that can be employed for space control purposes, including missile defense applications.

- Networks of data rapidly available directly from space-based and other sensors to warfighters and TMD/NMD platforms—such as the Cooperative Engagement Capability architecture that includes SBIRS-Low—should provide the possibility of significantly increasing the area covered by any given defensive unit.

- The need for boost-phase intercept is currently recognized to counter offensive theater ballistic missile countermeasures, and responsive boost-phase intercept systems will probably be under serious development or, possibly, deployed. The Air Force is working now on the airborne laser.

The implication for the future is that there is considerable technical potential to provide robust missile defenses with theater defenses leading in time to phased deployment. It is also reasonable to assume that wide area theater defenses can be extended to provide some defense for the United States. U.S. homeland defensive capability is likely to be considerable by the end of this time frame; the pace of the evolving U.S. homeland defense available over the next 25 years appears to be set by funding and policy (particularly with respect to the ABM Treaty) rather than the availability of technology. The confirmation of an agreed threat could expedite the rate of deployment.

Contribution to Deterrence

It should be emphasized that missile defenses could enhance the survivability of otherwise vulnerable strategic forces and the command, control, communications, and intelligence systems (C3I), thereby enhancing the second-strike capability of limited offensive forces. Certainly, missile defenses could undertake a post-launch counterforce role to target any missiles, including mobile missiles, launched against the United States.

The size of the defensive system deployment must be considered. Initially, it should be large enough to deter rogue states from building or from using long-range missiles but small enough not to threaten Russia's assured destruction capability. But that does not need to be the case for the long run. With the march of technology, political will, and sufficient funding in the future, it may be feasible to field a system to handle large numbers of incoming missiles. Although such a defensive system would have to be mammoth to handle the number of missiles potentially arrayed against the United States by Russia, it does not seem to be impossible. Future reductions of Russian strategic delivery systems through the arms control process will make this task easier.

Initially, to assure the viability of U.S. alliances and the ability of the United States to resist blackmail threats, the United States needs very high confidence in a missile defense system that will defeat small numbers of re-entry vehicles from rogue states that could attack cities. At least some boost-phase intercept capability will be needed to defeat likely countermeasures. Such a population defense could also enhance the survivability of strategic forces as well as the C3I systems against a few re-entry vehicles.

At the START II level, 1992 analytical studies indicated the Global Protection Against Limited Strike (GPALS) architecture (900 ground-based interceptors at 5 to 6 sites and 1,000 space-based interceptors) would not undermine Russia's assured destruction capability. (This would also be the case at offensive levels somewhat lower than START II, but additional analysis is needed to determine how much lower. In 1969 when the Soviets were thought to have fewer than 1,700 re-entry vehicles, then Secretary of Defense Harold Brown wrote in Foreign Affairs that "several hundred" NMD interceptors could deal with third country threats without challenging the Soviet assured destruction capability.)

If undertaken cooperatively with Russia and others, a Global Protection System could serve as a significant deterrent to proliferation, a common threat. This cooperative approach would be much preferred to the confrontational model associated with the Mutual Assured Destruction (MAD) doctrine. Perhaps it will be possible by 2010.

Allies can participate in global defense in a number of ways. Radar can be deployed on allied territory and made a part of a global Cooperative Engagement Capability network, for example. And, of course, Theater High-Altitude Air Defense (THAAD) or other ground-based interceptors could be deployed on allied territory, and allies such as Japan and the United Kingdom could deploy their own sea-based defenses. Cooperative command and control arrangements would be in order; this concept received considerable study in the 1980s and early 1990s.

Obviously, these possibilities provide significant policy challenges that may be outside the boundaries currently being considered for START III and beyond the limits of current debate. But the imperatives of technology will force the United States to face these challenges.

Hence, defensive systems can contribute to deterrence, especially if offensive missiles are limited in number. Defenses should be tested and deployed in sufficient numbers to persuade potential adversaries that the U.S. defense is capable of defeating their offensive capability; doing so could conceivably leave the United States with an intact military force capable of taking effective retaliatory action. From the U.S. perspective, there are three cases that should be examined in assessing the contribution of missile defenses in deterrence. These are:

- Adversaries have missile defense; the United States does not.
- The United States has missile defense; adversaries do not.
- The United States has missile defense; adversaries do also.

Adversaries Have Missile Defense; the United States Does Not

The first case, in which U.S. adversaries have effective missile defenses and the United States does not, seems implausible at this point because of the extensive U.S. resources expended and planned for the development of effective defensive systems and sensors that far exceed any other country.

Some might believe that the condition of an effective ABM system in the hands of a potential adversary exists today to some extent in that the Russians have the Moscow ABM system and an extensive network of surface-to-air missiles (AS-10s and AS-12s). In contrast, the United States has chosen not to deploy any ABM system and has no serious homeland air defense system. In fact, Russian defense systems do not significantly enter the deterrence equation as perceived by the United States because the United States possesses sufficient survivable nuclear weapons to defeat it. For a defensive system to play a role in deterrence, the adversary must perceive that the defensive system cannot be ignored or overcome simply because it is numerically inferior to the offensive weapons capability, and the potential adversary must believe that the system is technically effective against potential offensive countermeasures.

The United States Has Missile Defenses; Adversaries Do Not

The second case, in which the United States has an effective missile defense system and potential adversaries do not, may occur during the time frame being examined. Such a system could build on ground-based or sea-based TMD systems, or a dedicated ground-based NMD system in the near term and even encompass space-based systems.

The value of the defensive system as a deterrent would have to be carefully assessed from the perspective of each potential adversary. Against a country with a handful of offensive systems, a defensive system would potentially have a strong deterrent role, even with only a few (20 to 40) defensive systems deployed if it were perceived by the adversary as being effective. One could use the deployment of the Patriot system in 1991 to Israel and Saudi Arabia, and a few years ago to South Korea, as examples of this situation (although the technical effectiveness of the Patriot system may be questioned). Against a Russian or Chinese offensive capability of hundreds or thousands of missiles, there would not be a "defense dominant" deterrent role for the defensive systems for the foreseeable future; that is, it would not be likely that feasible defenses could deny a devastating attack.

The impact on allies and their assessment of U.S. commitment to their defense would have to be considered in such an environment. If the allies believed that U. S. strategic nuclear assurances no longer applied, they may then decide to develop their own offensive nuclear capability. However, if the United States had an effective TMD or NMD capability that would be shared with the allies, this could be a stabilizing factor by contributing to allied deterrence as well.

The United States and Adversaries Both Have Missile Defenses

The third case, in which the United States possesses an effective ballistic missile defense and some potential adversaries (especially Russia) do as well, could occur through negotiated changes to the ABM Treaty after development and testing of theater and national systems. One way for this to happen would be for potential adversaries to develop their own technology. The possibility of a negotiated change in the ABM Treaty suggests another mechanism. Agreement on changes to the ABM Treaty would probably be accompanied by some sharing of technology with Russia in an attempt to cement a relationship of partnership implicit in Russian willingness to agree to treaty modifications. Almost certainly, any arrangement of sharing would include early warning as an integral aspect. The United States could elect either to share the operational benefits of the system, or to share the technology. If the United States elects to share only the operational benefits of the system, there may be a feeling that it is withholding key provisions or would withdraw support at times of crisis. If the United States elects to share technology, it runs into the question of where to draw the line in connectivity, encryption, and other sensitive technologies. The United States also would be likely to be sharing information on vulnerabilities of the system and should understand the potential impact of such sharing.

Discussions with Russia on sharing some ballistic missile defense technology have occurred on more than one occasion. If the United States were to share ballistic missile defense technology with Russia, it certainly would also share such technology with allies or provide defensive assurances to them, therefore preserving the commitment to their defense. It seems unlikely that sharing would occur with other countries perceived as rogue states.

Clearly, potential adversaries could develop ballistic missile defenses on their own, by inadvertent technology transfer or via security lapses. In each case, there would have to be careful study of what "parity" in offensive systems might mean when an effective defensive capability existed. Even if the United States transferred the technology to Russia, it could expect Russia to continue to build on the defensive technology. In such a case, offensive strategic systems would continue to be important. The United States could require increased research into ballistic missile penetration aids and possibly place more dependence on bombers and cruise missiles in the overall deterrence equation. With regard to rogue states outside the agreement, the U.S. offensive commitment to allies would remain important.

Conclusion

The addition of defensive systems to the deterrence equation is not farfetched and will very likely occur between now and 2015. There is no indication that U.S. development of missile defense will slow or that there are insurmountable technical obstacles to the development of effective defenses. In fact, the Unified Commanders' concern about force protection is likely to spur development and deployment. That being the case, questions of how much to invest in defenses for what purposes will continue. Undoubtedly, the United States will want a system effective enough to discourage rogue states from believing they can successfully achieve a devastating attack against the United States (and its allies) but small enough, initially, not to threaten Russia's offensive capability.

Readiness

Five readiness-related issues provide insight into the Department of Defense's ability to sustain the nuclear deterrent:

- National Nuclear Deterrence Policy Structure.
- DoD Structure to Maintain Nuclear Forces .
- DoD Field Structure for Nuclear Forces (Below DoD/Service Headquarters Level).
- Nuclear Expertise and People Issues.
- Standards, Training, Exercises, Inspections, and Reporting for Nuclear Forces.

National Nuclear Deterrence Policy Structure

The national nuclear deterrence policy structure provides policies and policy documents, from the relevant Presidential Decision Documents to the Joint Strategic Capabilities Plan. Due to the continued importance of nuclear deterrence in the U.S. overall national security strategy, the personal involvement of the President and his immediate policy staff, the Secretary of Defense and his policy staff, and the Chairman and the Joint Chiefs of Staff is required to produce national guidance that is relevant to the times and coherent with the broader set of national policies.

DoD Structure to Maintain Nuclear Forces

There is a need for a well-defined formal DoD structure that focuses on sustaining and planning for current and future strategic nuclear forces. At present, there are well-defined responsibilities for each element of the forces. These are spread over multiple staff offices in the Office of the Secretary of Defense (OSD), the Services, and numerous field organizations. The overarching focus required to bring coherence to the activities and programs of these numerous entities has, in the past, emanated from near continuous involvement of the senior DoD leadership—civilian and military—in strategic nuclear forces modernization program decisions, arms control activities, capability reviews, and exercises. With this senior leadership focus, there was a well-understood virtual roadmap for building and sustaining the current and future forces that provided the needed overarching focus. Virtually all the nuclear forces modernization programs were canceled or curtailed at the end of the Cold War. The remaining forces have been significantly downsized to comply with START I. DoD planning assumes further reductions once START II is ratified. At the same time, the arms control focus shifted from hard policy and technical issues requiring in-depth involvement of a range of senior DoD leaders to incremental reductions requiring episodic involvement of a limited number of senior leaders. Consequently, strategic nuclear force matters no longer demand that a wide range of senior DoD leaders be frequently immersed.

Absent senior-level involvement, there is no assurance of the well-understood roadmap that characterized half a century of DoD planning for nuclear forces. Organizations within the Defense Department with assigned nuclear responsibilities include: the Under Secretary of Defense for Policy, which oversees policy development for strategy, forces and operations; the Under Secretary of Defense for Acquisition & Technology (Strategic and Tactical Programs), which oversees delivery platform acquisition programs; the Assistant to the Secretary of Defense for Nuclear, Chemical, Biological Defense Programs, which oversees acquisition and has some policy responsibilities for atomic energy matters; and C3I, which has responsibility for nuclear command and control, and strategic intelligence functions.

We are concerned, however, that current reorganization plans will leave no focal point for technical nuclear weapons issues, and that nuclear policy issues may be perceived to have been downgraded with the abolition of the Assistant Secretary of Defense for International Security Policy. To the extent these represent a reduction in the visibility of nuclear matters, it is a worrisome trend.

Over the past decade, both the Air Force and Navy, as well as DoD, have seen a substantial change in overall focus away from nuclear issues. Until recently, neither the Air Force nor the Navy staff had a single office within its organizational structure with overall responsibility for Service nuclear forces and issues. In January 1997, the Air Force refocused its approach to its still-critical nuclear mission by establishing the Directorate of Nuclear & Counterproliferation reporting to the Deputy Chief of Staff, Air & Space Operations. Now, a two-star general officer is the single point of contact for nuclear matters, from policy to institutional support for the Air Force. Although the Navy Strategic Systems Program Office continues to provide strong leadership in programmatic and sustainment issues for the SSBN force, the Navy staff does not have a single flag-officer level office serving as the sole focal point for overall nuclear matters.

Meanwhile, the Air Force and the Navy have plans and programs to sustain the strategic nuclear systems within their responsibility. The Under Secretary of Defense for Policy has important defined policy responsibilities and the Nuclear Weapons Council provides a forum for some crosscutting areas to include interfacing with the Department of Energy. In recent years, the Defense Special Weapons Agency assumed the added responsibility to provide technical and staff support to OSD to assist in sustaining the nuclear deterrent. Still, it is difficult to find a satisfying overarching plan or roadmap, in any form, that ensures a coherent whole from these various components and that ensures timely planning for the future.

There is opportunity and risk in the formation of the new super-agency for threat reduction. The Defense Threat Reduction Agency could become an important center of expertise and focal point to assist DoD in coherent, broad, and detailed planning to maintain the current and future deterrent. However, the concurrent demise of the office of Assistant to the Secretary of Defense for Nuclear, Chemical, Biological Defense Programs could be seen as further de-emphasizing the attention required to sustain the nuclear deterrent. The charter for the new agency must be very specific about the responsibilities, authorities, and control of resources needed for this agency to provide support to maintain the nuclear deterrent. Even with a clear and concise Defense Threat Reduction Agency charter, there still is not a single focal point within OSD's organization for nuclear matters.

DoD Field Structure for Nuclear Forces (Below DoD/Service Headquarters Level)

Since 1992, U.S. Strategic Command (USSTRATCOM) has provided a successful unified command approach for planning and operating America's strategic nuclear forces. Featuring a four-star Navy or Air Force Commander-in-Chief, centralized war planning at Offutt AFB, and decentralized operational task forces, this approach has been responsive to national needs.

The Air Force and Navy act as force providers working through major commands, fleets, and dual-hatted task force commanders. Services provide forces, people, and support infrastructure to USSTRATCOM. Although shortfalls do occur, they are generally issues of Service funding priorities, not organizational structure.

The key question is: "Is this field structure appropriate for operating and sustaining safe, secure, and ready deterrent forces for the nation?" Over the past five-plus years, USSTRATCOM has successfully answered this question. Through close coordination with Service components, the command stays abreast of the operational readiness of its Service components through nuclear surety and operational readiness inspections. Also, via annual Global Guardian exercises, the Command does full-scale assessments of command readiness and integration with Service providers, other unified commands, and their war plans. USSTRATCOM's centralized nuclear planning capabilities are a one-of-a-kind national asset responsive to current national and regional CINC planning needs. USSTRATCOM and its Service supporting structure are sound architecturally and provide a firm operational and planning basis for sustaining the U.S. offensive nuclear deterrent into the future.

A qualifying note must be added to this field structure assessment regarding the potential for future deployment of national missile defenses. Before the deployment of a strategic defense system, the organizational structures for operations and planning must be evaluated to define how an offense/defense mix would be integrated at the unified command level.

Nuclear Expertise and People Issues

Today, nearly a decade after the end of the Cold War, the tasks of operating, maintaining, securing, and supporting nuclear forces in the field and at sea are being performed in a highly professional manner. The Services have quality people at the "deck plate" level—airmen, sailors, and marines who are well-trained and highly motivated. They continue to stand tall, as they did during the long Cold War, as the

backbone of the U.S. nuclear deterrent posture.
As we look ahead, however, all is not well in terms of the ability of the United States to continue to provide the right kinds of nuclear expertise to meet future staff and planning requirements. Continued downward trends in emphasis/focus on nuclear weapons are forecast to result in critical expertise shortfalls in the key areas of planning; weapons technical issues; command, control, communications, computers & intelligence (C4I); arms control; and operational test and evaluation (OT&E). In addition, military people today generally view the various nuclear career fields as being out of the mainstream and having uncertain futures. These issues stand as significant obstacles to the ability of the Services to "grow" and retain the necessary nuclear expertise. While the DoD and the Services are cognizant of these factors, it is imperative that senior-level attention be given to these issues today to avoid critical deficiencies in nuclear expertise in the near future.

Both the Air Force and Navy are cognizant of these potential nuclear expertise shortfalls. In the Air Force, for example, results of a formal review recently set in motion an initiative to address nuclear experience issues. This initiative will:

- Define nuclear experience across several key AF specialty codes (officer and enlisted).

- Identify a "pool" of nuclear experience across the spectrum of AF needs.

- Identify key leadership billets in the field and at intermediate headquarters.

- Develop a plan to ensure these billets are manned.

The Air Force is also developing a career path to "grow" officers with specific nuclear weapons-related expertise. Planners are working closely with architects of the new Defense Threat Reduction Agency to link Air Force plans with a companion plan for nuclear experience. The plan will have four facets:

- Operational field assignments in either nuclear logistics or operations.
- Advanced education in hard science/weapons related fields.
- Fellowships with nuclear laboratories.
- Specific staff assignments throughout a career, e.g., Air Staff, USSTRATCOM planning, Major Commands, Numbered Air Forces.

Similar plans will be developed for Department of Air Force civilians whose positions demand critical nuclear weapons skills, that is, those employed at HQ USAF, the Air Force Nuclear and Counterproliferation Agency at Kirtland AFB, USSTRATCOM and nuclear-tasked Major Command Headquarters.

U.S. nuclear forces also face key shortfalls in trained people in some operational areas. The utilization of National Guard & Reserve personnel in nuclear-related duties can offset these critical shortfalls. Prior to 1997, a key obstacle prevented use of National Guard and Reserve people in the nuclear mission—the strict requirements of the Personnel Reliability Program. Recently, however, DoD directives have been changed to allow full-time support Air Force Reserve Component personnel to participate in the Personnel Reliability Program and, therefore, nuclear missions. Further study is ongoing to determine other potential uses for both full-time and traditional (part-time) guardsmen and reservists in the nuclear mission area.

Outsourcing and privatization of active-duty positions to civilian corporations offers another means of addressing expertise and continuity-of-experience problems within the nuclear community.

Outsourcing has already occurred in many Navy and Air Force mission areas, particularly maintenance, logistics, and supply. The core nuclear operational mission has not been privatized and significant outsourcing is not anticipated. However, some outsourced positions could provide needed continuity and experience within some specific nuclear units. At a minimum, more study should be encouraged with a view toward finding innovative ways to provide critical nuclear experience without sacrificing traditional concerns for Personnel Reliability Program and availability during crises.

In the Navy, recruiting, personnel training, career planning, retention incentives, and command structure all come together to sustain a highly capable, nuclear submarine deterrent force. Enlisted personnel are recruited specifically for nuclear weapons work and remain in nuclear weapons fields for their entire Navy career. The first year of training is devoted to acquisition of nuclear weapons skills. Completion is tracked by Navy Enlisted Codes to ensure that only properly trained personnel are assigned to nuclear weapons duties. Career progression and experience are provided in nuclear weapons-related sea and shore assignments. Reenlistment bonuses are offered to encourage retention of these skilled, nuclear-trained enlisted personnel. Navy officers with nuclear weapons responsibilities receive formal training and certification that is tracked by assigned subspecialty codes. Nuclear weapons missions are assigned exclusively to the submarine force and with over half of the crews being nuclear mission capable, a robust base of experienced officers is maintained.

Program managers, such as Director, Strategic Systems Programs, are critical in determining manning, training, and career requirements. Strategic Systems Programs is responsible for SLBM systems from initial design through system retirement and has direct input into all facets of nuclear weapons personnel policy. Reduced nuclear force levels resulting from START I led to the consolidation of nuclear weapons support infrastructure under Strategic Systems Programs and the submarine force commanders. This concentration of Navy nuclear weapons expertise in robust nuclear organizations prevents the dilution that might otherwise have occurred. Additionally, an established and "tuned" balance between in-house (military) and contractor operations at Navy nuclear weapons industrial activities assures continued development of the critical skills neccssary for program oversight and management. Submarine force commanders have responsibility for strategic force operations and maintenance. They set standards for qualification, conduct mission certifications and operational safety inspections, and provide direct input into Navy personnel policy issues.

Finally, one additional area of concern is the decreasing number of senior officers (USAF Colonel/Navy Captain and above) with nuclear weapons experience, and the resulting lack of understanding by senior officers in general regarding the role of nuclear weapons in U.S. national security. In terms of professional military education, the Intermediate and Senior Service Schools allocate little or no curriculum time to deterrence theory and the role of nuclear weapons in national security strategy. This lack of exposure manifests itself as a critical gap in experience and policy/strategy understanding by senior officers at Major Command/Fleet, Service, and Joint headquarters.

Elements of Nuclear Force Readiness

Any readiness system to maintain a capable nuclear deterrent force posture must consist of five key elements:

- Well-defined standards.

- A training and exercise program that prepares individuals and units to meet the defined standards.

- An inspection and reporting system that measures status against the standards.

- A system of review at all the levels required to correct deficiencies or adjust the standards and measures if priorities change.

- A system that allocates resources against identified deficiencies.

In the past, the readiness system for strategic nuclear forces was clearly defined and rigorously executed. Standards for performance remain clearly defined in terms of weapons systems reliability and performance, response times, delivery accuracy, support requirements, and so forth. For the SLBM and ICBM forces, the training standards and programs, and inspection and reporting system have remained virtually unchanged. Nevertheless, the current readiness system continues to provide an effective operational force.

For the bomber forces, the training and exercise program went through a period of upheaval in command relationships and mission role shift with the end of the Cold War and the demise of the Soviet Union. In the early 1990s, there were no nuclear Operational Readiness Inspections (ORIs) for the bomber forces and few large-scale force generation exercises. With the stand-down of the Air Force's major air command, Strategic Air Command, and the conversion of the specified command to a unified command, U.S. Strategic Command, the bomber forces moved from a command primarily focused on strategic nuclear readiness to a command whose primary focus was conventional tactical forces readiness. Air Combat Command has long had responsibility for tactical nuclear forces, while strategic expertise was transferred from Strategic Air Command to Air Combat Command with the bomber mission. Although the bomber force is integral to the Command's overall mission, the bomber's nuclear mission and requirements have been reduced as bombers prepare for a wide range of new missions (e.g., theater air campaign). Consequently, it takes far more special attention at the Command headquarters to ensure the nuclear bomber mission receives the right emphasis. Once the deficiency in inspection and reporting was identified to the Command's senior leadership, immediate action was taken to restore full nuclear ORIs and attention to nuclear forces readiness. Further, USSTRATCOM is playing a larger role in ensuring attention to the readiness of these forces. For example, full Global Guardian exercises, involving leadership at virtually all levels, were restored in 1995 and are conducted each year to exercise the full regeneration capability of the forces.

Additionally, the nuclear tanker force moved from Strategic Air Command to Air Mobility Command. The bulk of the day-to-day and contingency operations of the tanker force had long been in support of tactical and strategic airlift forces. Still, with the tankers assigned to Strategic Air Command, the first priority readiness requirement for the tanker force was to support strategic nuclear bomber operations. There is no evidence that readiness for this mission has been compromised with the reassignment to Air Mobility Command. But again, it will take extraordinary care at the command headquarters to ensure that, in the press of the day-to-day mobility missions, the demands for readiness to support strategic bomber operations remain the first priority.

The readiness standards for non-strategic forces went through a period of almost continuous change from the end of the Cold War through the mid-1990s. Nuclear annexes disappeared from theater plans except for the European Theater. Tactical nuclear weapons were removed from all naval systems with regeneration required only for TLAM/N on attack submarines. There were no provisions for supporting land-based tactical nuclear weapons deployments except for the European Theater. Deployable units from the CONUS maintained only ready aircrews, aircraft, and weapons load crews. Additionally, there were no provisions for command and control of these forces outside the European Theater and deployable forces did not interface with the other support needed, such as transportation and security of weapons.

To correct the above deficiencies, the responsibilities of CONUS-based forces were clarified to include response times and deployable wing-level command and control. USTRATCOM assumed responsibility for command and control connectivity with the National Command Authorities and for coordinating other support requirements. The challenge, once again, is senior leadership involvement, given the continuing absence of forces in the theater or any specific contingency plans for their use.

Conclusion

Maintaining the readiness of U.S. nuclear forces will be crucial for the United States to meet the challenges of an uncertain future. Continued focus at all levels of leadership within the Executive Branch, and especially the Department of Defense, is essential to maintaining the high quality of standards, training, exercises, inspections and reporting, planning, and most important, the people needed to sustain a credible nuclear deterrent.

Overall Operations Summary

The analysis in this paper suggests the following conclusions with regard to future nuclear operations and forces:

- Thoughtful planning is necessary to link policy to operations. Today's environment necessitates real-time situational awareness and near-real-time, flexible planning.

- Consolidation of nuclear planning at USSTRATCOM for the regional Commanders-in-Chief is wise given the reduction in military personnel and the need for flexibility and responsiveness in pre-planned options and ad hoc planning.

- Not only are the plans important, but the planning process is crucial in that it trains each generation of planners and decisionmakers in the difficulties of crisis management and war fighting.

- The former distinction between strategic and non-strategic nuclear weapons should be eliminated. U.S. operational and arms control policy should encompass all nuclear weapons.

- Nuclear forces for large-scale attack should include both land and sea basing and both ballistic and air-breathing penetration modes. For the foreseeable future, the best way to accomplish this will be to maintain a TRIAD of ICBMs, SLBMs, and heavy bombers.

- In the present strategic environment, reductions in strategic forces significantly below those likely to result from START III are unwise.

- At the reduced levels of START III, failure of a single component could have severe consequences. This is especially true for warhead failure under conditions of a nuclear test ban. Therefore, the United States should maintain two different warhead designs in the active inventory for each major component or TRIAD leg.

- To allow holding China at risk using both ballistic missiles and air-breathing systems without overflight of Russia and to be able to effectively hold at risk installations in Russia, the U.S. ballistic missile submarine force should be maintained at high enough levels to allow operations in both the Atlantic and Pacific Oceans. Arms control treaties should facilitate maintaining this capability.

- Assuming force levels remain at START III levels until a new SLBM is required, the next generation of submarine-launched ballistic missiles should be MIRVed (although not necessarily as highly MIRVed as the current Trident I/II missiles).

- As a hedge against the re-emergence of a robust and sophisticated air defense system in Russia or the deployment of such a system in

China, the air-breathing component of the forces for large pre-planned attacks must continue to stress stealth as a means of penetration of air defenses. This probably means further investment in stealthy air-launched cruise missiles.

- Future arms control agreements must begin to address "total nuclear posture," including so-called non-strategic nuclear weapons and other infrastructure that affect the ability to reconstitute nuclear forces.

- The United States should develop a nuclear warhead capable of attacking deeply buried or hardened underground facilities as well as an extremely accurate, relatively low-yield, low-altitude burst weapon for use against biological weapons facilities.

- Neither TLAM/N nor DCA appear crucial on operational grounds, although there may be a policy rationale for retaining either or both capabilities.

- Although a robust conventional capability is important for many reasons, conventional forces should not be thought of as a substitute for nuclear weapons.

- The advent of and growth in knowledge-based systems will directly affect the planning process, making it possible to create options in near-real-time.

- Hardened data rather than hardened systems potentially will be the hallmark of strategic (as well as other classified military) command and control systems of the future. Future systems should also include a hardened, dedicated system (wartime secure and survivable) for absolute assurance of Emergency Action Message delivery.

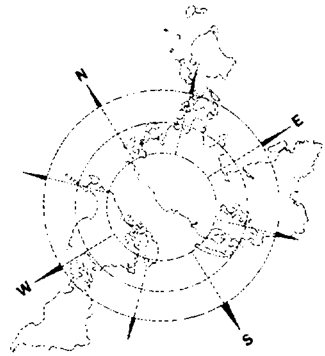
- In the future, technology development will allow defenses to make a significantly greater contribution to deterrence than in the past.

- Deterrence as a concept and contribution to national security depends on the attraction and retention of intelligent, well-trained, dedicated people at all levels.

- Senior-level attention to the safety and readiness of nuclear forces and their advocacy in the highest levels of government is imperative to the long-term viability of the nuclear deterrent.

CHAPTER 4

DEPARTMENT OF DEFENSE (DOD) NUCLEAR INFRASTRUCTURE



Introduction

Nuclear deterrence cannot be sustained without an infrastructure that can keep current systems operational and that is capable of providing evolutionary improvements and next-generation systems when they are required. This paper is the product of a group[1] that met in the winter and spring of 1998 to address a very basic question: Does the United States possess the necessary nuclear-related infrastructure to sustain deterrence?

The U.S. deterrent has been designed, developed, tested, produced, and maintained by a DoD infrastructure that encompasses the country's industrial base, the science and technology base, the personnel that make the system work, and the management structures that oversee and support both policy and acquisition organizations. A special element of the nuclear forces infrastructure is the Defense Programs activities of the Department of Energy, which is responsible for ensuring that the nuclear weapons carried by U.S. nuclear forces remain safe and reliable.[2] Today's forces are the result of the steady

1 The members of the Strategy and Policy working group were: Dr. Robert L. Pfaltzgraff, Jr., Chairman; Dr. Paul H. Carew; Amb S. Read Hanmer; Dr. Robert Joseph; Ms. Judyt Mandel; Dr. Keith B. Payne; Dr. John Reichart; Mr. Leon Sloss; and Dr. Richard Wagner. Government observers included Dr. Michael Altfeld; Mr. Mike Evenson; Dr. John Harvey; Dr. Maurice Katz; Col David Lopez, USAF; MGen Thomas Neary, USAF; LtCol David Nuckles, USAF; and Dr. Gary Stradling. The views expressed in this paper are not necessarily shared by all members of the group. Further, these views are not intended to be representative of members or organizations of the Department of Defense or the Department of Energy.

2 The Department of Energy's sustainment responsibilities are discussed in a separate paper on the nuclear weapons stockpile.

evolutionary improvements identified and implemented in interactions between the U.S. nuclear infrastructure and the operators of weapons systems and nuclear command, control, and communication systems.

For deterrence to remain effective, U.S. nuclear forces and infrastructure must continue to be able to respond to changes in the international environment. This requires that they remain strong and flexible. By making it clear to potential adversaries that U.S. forces and infrastructure can adjust and respond to any threat more rapidly than a threat can be mounted, deterrence is reinforced and aggression may be dissuaded.

The initial challenge for the nuclear forces infrastructure is to maintain the operational status of current forces through their currently expected operational lifetimes and perhaps to extend those lifetimes in some cases. As a result of the drawdown of U.S. nuclear forces, the character and disposition of today's arsenal has changed dramatically. The United States is planning to maintain the current generation of missiles and aircraft and their associated warheads well past the year 2010. There are no replacement programs under way for any of today's nuclear forces. The U.S. nuclear deterrent posture will continue to be made up of the Minuteman III intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs) deployed aboard TRIDENT submarines, an air-breathing force of B-52 and B-2 long-range bombers, dual-capable tactical aircraft, and air- and sea-launched cruise missiles.

Technological progress, coupled with political changes, inevitably will result in the levy of new requirements on the U.S. deterrent. The nuclear weapons infrastructure must be able to meet these new requirements by modifying or replacing systems when the current ones are no longer able to perform their missions. Absent appropriate adjustments, the day will arrive when today's nuclear forces will no longer be able to destroy next-generation targets or to confidently penetrate defenses of ever increasing sophistication. Nuclear forces may even become unacceptably vulnerable to threats. The requirements for the reliable, assured, and flexible command and control of nuclear forces will become more demanding, and may not be met by aging and inflexible systems left over from the Cold War era. The infrastructure must be able to respond to new and resurgent threats with quantity production if called upon to do so.[3]

Required changes in the nuclear posture may be very minor adjustments (such as a technical modification to an existing weapon or system), or may entail major posture changes (such as the deployment of a new nuclear-powered ballistic missile submarine (SSBN)). The DoD outlook today suggests that near-term adjustments will be minor, and major changes will only occur, if at all, in the long term (2020 or beyond). However, the infrastructure must be of such a character that it can respond in a timely fashion if the national leadership determines that significant posture changes are warranted sooner. For the U.S. nuclear deterrent to remain viable, potential adversaries must perceive that the U.S. nuclear infrastructure is responsive enough to make any required adjustments quickly and effectively.

The near-term prognosis for the DoD nuclear infrastructure is generally reassuring. Decades of investment and the current management plans of the U.S. Navy and Air Force, assuming adequate funding, will sustain planned strategic nuclear forces into the next century—at least until 2020—provided the United States can keep competent people interested and involved. Several initiatives are under way to improve the U.S. ability to sustain the deterrent. Some are programmatic. Service sustainment programs include refurbishing Minuteman III missiles, silos, and launch control centers, and sustainment of the B-52 strategic bomber through 2040. The Navy has several programs under way, including efforts to extend the life of SSBNs and associated measures to ensure availability of missiles. It

3 A number of issues related to these elements came up during discussion and were deemed important to examine, but were not treated because of time and resource limitations. Some of the more prominent issues include the vulnerability/survivability of the industrial base to information warfare, weapons of mass destruction (WMD), and terrorist attack; active and passive defense measures; the ability to assess promptly the results of an attack on U.S. assets at home or abroad; continuity of government issues following an attack; and civil defense and the management of the consequences flowing from a WMD attack.

will be important for the United States to ensure adequate funding for these efforts. The Air Force and Navy will benefit from the Re-entry Systems Application Program and the Guidance Applications Program—two programs designed specifically to sustain technologies especially important to deterrence—if full funding can be maintained. Still other areas, such as preserving the knowledge base in underwater launch, have yet to receive funding. Other efforts are managerial: within the military there has been an increasing centralization of the management of strategic nuclear forces. The Air Force has made several organizational changes to manage better its nuclear component.

Looking beyond current systems, the adequacy of the nuclear infrastructure is less reassuring. Some of the sources of concern stem from possible threats: the spread of hard, deeply buried targets that today's systems may not be able to defeat; the global diffusion of advanced air defenses threatening the ability of air-breathing systems to penetrate to their targets; and information warfare threats to nuclear command and control. Other sources of concern have more to do with the U.S. willingness to fund certain efforts at the required levels: maintaining necessary SSBN design competence; planning for an ICBM force beyond 2020; creating programs to evaluate new capabilities that take advantage of increased accuracy to minimize collateral damage; and establishing an ability for fully covert SSBN navigation.

Greater attention also needs to be paid to the infrastructure that once supported the "theater nuclear" (or "non-strategic") assets. Specifically, plans must be established to ensure dual capability in the next generation of tactical aircraft; and planning must begin for the next generation of Nuclear Land-Attack Tomahawk (TLAM/N) in order to maintain its effectiveness against plausible target sets. The strategy and policy paper of this study makes clear that air-delivered and sea-based nuclear weapon systems capable of forward deployment to regions of potential conflict make a unique contribution to deterrence. A decision to preserve these important capabilities will be required in the near term if the United States is to maintain the requisite infrastructure to field these capabilities in the future. The strategy for sustaining the U.S. deterrent must be designed to fit within the likely budget constraints of coming decades. Planners must create extremely effective approaches to sustaining critical expertise, including system and subsystem engineering and integration, and new strategies for reducing the dependence on "nuclear-unique" technologies and processes. The general approach will have to include increased reliance on commercial and tactical system technologies and increased examination of commonalities among SLBM, ICBM, and space launch systems. In the past, the bulk of R&D investment was aimed at achieving increased performance. In the future, DoD must work to reduce production and operational costs. At the same time, DoD must balance costs and performance and preserve safety and reliability. DoD must fully engage its industrial partners in shifting the emphasis.

Expectations about what can be drawn from the commercial sector must be tempered. Much discussion today focuses on the subject of increased reliance on commercial software in nuclear systems. Using commercial software is certainly feasible and efficiency is worthwhile, but nuclear safety cannot be compromised. Success in applying commercial software to nuclear systems will require software developers with a shared sense of the importance of the nuclear mission.

A less obvious concern than force structure, but extremely important, is keeping people with the right skills and experience interested in nuclear infrastructure and weapons matters. Personnel competence in the military and civilian infrastructure is critical to the sustainment of deterrence. This competence arguably has eroded in some areas and is now on the mend, but will require attention to ensure there are no reversals. Other areas are fragile and require corrective actions to prevent erosion. The overall tendency to place people who lack the needed experience and skills in positions previously held by those who had the required competence, and the sharp drop in nuclear interest and education on nuclear matters in the military are pervasive symptoms of this fragility. The investment required to stop erosion is comparatively modest, but must be continuing if the United States is to maintain the basic knowledge base. Management attention is key to success.

There also is dwindling experience in the Executive and Legislative branches regarding deterrence and matters related to nuclear weapons. In another decade or less there will be few at either staff or senior levels who have nuclear expertise, crisis experience, or academic instruction involving nuclear weapons.

There is no long-term DoD roadmap that addresses the entirety of capabilities that must be supported for the United States to have confidence in the deterrent up to and beyond the lifetime of currently deployed systems. Today's approach is piecemeal. A DoD Nuclear Forces Program Plan is needed that addresses all nuclear forces evolution from refurbishment of current systems to the deployment of the next generation systems; this plan should specifically address the industrial base and science and technology base commitments needed to achieve it. The same should be done for the nuclear command and control system. And, measures should be identified that will be used to recruit and retain nuclear-competent military and civilian personnel for every position in DoD where such competence is necessary. This DoD Nuclear Forces Program Plan would be a companion plan to the Department of Energy's still-evolving Stockpile Stewardship Program , which describes the entirety of DOE's efforts over the next decade, and their funding implications, to keep nuclear weapons safe and reliable. Such a DoD plan would not only meet DoD's needs but also provide a requirement basis for DOE's planning. A DoD plan also would help focus discussion within DoD on the merits and drawbacks of integrating DOE's defense activities into DoD, should that issue be re-visited. Given associated lead times, preparations and funding must begin now to guard against possible long-term adverse developments.

An important organizational change that should be undertaken promptly is the creation of a high level nuclear advocate, with adequate staff, within the Office of the Secretary of Defense. Within the Office of the Secretary of Defense there is no one below the Deputy Secretary of Defense who is formally responsible for: the oversight of all nuclear weapon systems; the coordination of command, control, communications and intelligence procurement in support of nuclear weapons systems; or the coordination of DOE nuclear weapon support for those systems. Within DoD, several individuals with oversight responsibilities for nuclear forces and infrastructure have competing, and often higher priority responsibilities within the DoD acquisition structure.

Nuclear deterrence is sufficiently important that it deserves a full-time, high-level advocate responsible for coordinating the oversight of all nuclear-related matters—the weapons, the delivery systems and support equipment, and nuclear command and control. This advocate should report directly to the Under Secretary of Defense, Acquisition & Technology (USD (A&T)) and should lead the creation of the DoD Nuclear Forces Program Plan, working with the Office of the Under Secretary of Defense (Policy), the Assistant Secretary of Defense for Command, Control, Communications and Intelligence, the Joint Staff, the Commander in Chief, U.S. Strategic Command, and the Service elements responsible for nuclear forces. This individual would also support the USD(A&T) in the capacity of Chairman of the Nuclear Weapons Council to ensure the correlation of DoD and DOE nuclear weapon sustainment planning. The high-level advocate would fulfill oversight responsibilities for the Secretary of Defense pertaining to the Services' nuclear safety and security responsibilities, as well as be the proponent for nuclear matters at appropriate decision-making points.

Particulars aside, the broad outlines of what must be done are clear. A smaller, more cost-effective infrastructure is required, but one responsive to future changes. To be flexible and affordable, the future infrastructure for nuclear forces will need to leverage both commercial and general-purpose force infrastructures. Responsiveness will need to be measured in terms of technological sophistication, production numbers, and management. There also will need to be a national commitment to sustaining the most critical element of this infrastructure—skilled people. Strong, knowledgeable, sustained management attention to the personnel issue is essential. Nothing less will be adequate in a world of scarce resources and sizable risk.

The main body of this paper sets forth in greater detail our observations on the adequacy of the nuclear-related deterrent infrastructure. The first section focuses on the nuclear forces, treating, in turn, SLBM, ICBM, and nuclear bomber and cruise missile infrastructure sustainment. Nuclear Command and Control is addressed next. We then examine sustaining core nuclear expertise in the context of DoD downsizing activities and maintaining critical skills in nuclear weapons-related technology. This is followed by a discussion of DoD organizational issues. Finally, we present the working group's conclusions.

The Forces

The following paragraphs examine each element of the nuclear force structure: SLBMs, ICBMs, and bombers and cruise missiles. We address each in terms of the lifespan of current systems, the efforts now under way to sustain them, possible requirements for follow-on systems, and the challenges to keeping an infrastructure to sustain the deterrent.

SLBM Infrastructure

Management of the SLBM program resides, as it has since the program's inception, with the Navy's Strategic Systems Programs office. This office has complete lifecycle responsibility for the submarine-launched ballistic missile weapons systems, and its Director is also the Program Executive Officer for the associated TRIDENT SSBN program. Ship systems program management is conducted by an office in the Naval Sea Systems Command, which is responsible both to Naval Sea Systems Command and Strategic Systems Programs. The Strategic Systems Programs office manages its program through a unique long-term teaming arrangement with its industrial partners, which requires the close sharing of technical information and periodic meetings of government/industry leadership (known as the Steering Task Group). Additionally, Strategic Systems Programs reserves the Strategic Weapons System integration effort to itself, ensuring that the Program Manager always is well informed.

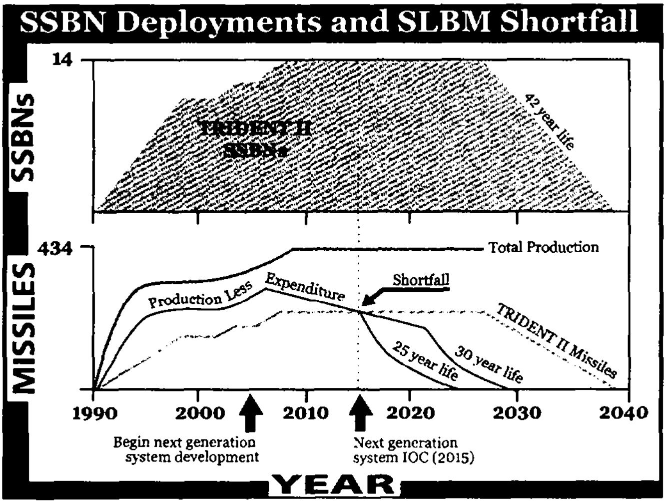
Despite corporate sales and mergers, the groups that work on the major subsystems of the Strategic Weapons System have remained the same since the earliest days of the fleet ballistic missile program. The management stability of this team has been one of the essential factors in the continued success of the program.

Strategic Systems Program's strategy to sustain the SLBM infrastructure seeks to maintain the essential SLBM capability of viable strategic forces for the foreseeable future. Thus, the current generation of TRIDENT II (D5) missiles and their associated warheads must be maintained well into the next millennium. Simultaneously, the critical knowledge and experience needed to replace, in whole or in part, the elements of these weapons in the future must be preserved. Furthermore, sufficient skills in engineering and manufacturing must be maintained to ensure the ability to maintain the essential characteristics of the SLBM force, namely stealthy, survivable, effective, and robust capabilities provided by a highly reliable and safe weapon system.

Background

The deployable lifetime of the current TRIDENT ballistic missile submarines (SSBNs) that carry the TRIDENT II (D5) weapons system has been extended to 42 years. The first ship extended will retire in 2026; the last, in 2039. The missiles were originally planned to last at least 20 years. The Navy now expects to deploy these missiles for about 30 years. This means that the last rocket motors poured will be in the inventory until 2033. This time period is well beyond the experience base with solid rocket motors of this type, but still several years short of the life of the submarines.

The result of this mismatch between achievable TRIDENT lifetimes and expected D5 missile lifetimes is additional missile outload requirements in the 2015 to 2039 time frame, as shown in the figure below. These needs will have to be met by (1) production of follow-on missiles or significant life extension of age-limited D5 components, including the missile's solid propellant rocket motors, and (2) new production of additional components.



Platform Sustainment

The United States needs a robust program to investigate potential future antisubmarine warfare threats and assure the survivability of the SSBNs in order to sustain the Fleet Ballistic Missile concept. Maintenance of such a program, which has received too little attention in recent years, will preserve the basic property that makes SSBNs the core of the U.S. strategic deterrent—their survivability.

Tactical Upgrades. Historically, tactical weapon and sensor system upgrades have had a lower priority than similar upgrades for nuclear-powered attack submarines (SSNs). This priority has led to inadequate maintenance of TRIDENT submarine defensive capabilities against evolving threats. For example, some TRIDENTs currently field an acoustic detection system that was deployed in the late 1970s and is not effective against submarines with modern quieting technology. Current and foreseeable budgetary pressures must not be permitted to allow the TRIDENT force to continue to lag contemporary attack submarine capabilities. Communications connectivity to the National Command Authorities needs attention and is addressed in a separate section of this paper.

Ship Control. Some TRIDENT ship control system components are based on older electronics and will not be supportable after 2003 or 2004. No funded plan to replace these components currently exists. Current funding priorities have pushed this need below current funding thresholds. Today, this situation poses only low risk to the ability of the TRIDENT force to execute its mission. However, as aging continues without replacement, there is a real possibility that unexpected developments could occur, revealing that systems key to the operation of the ship are no longer reliable. Planners must consider establishing a modest program to review proactively and identify those systems that need timely upgrade.

SSBN Navigation. The rest of the world is rapidly adopting the satellite global positioning system (GPS) for precision navigation. Motivated by the need to preserve stealth and accuracy, and to minimize external observables, the SSBN force continues to use high-precision inertial navigators. This fact heightens the importance of the SSBN program's inertial navigation skills if, in an emergency, GPS is vulnerable or fails. The current generation of TRIDENT navigation components, which will need replacement in the 2010 time frame, is very expensive to maintain. Several emerging technologies hold promise as low cost replacements. New inertial measurement systems based on fiber optic gyroscopes and accelerometer technologies, if combined with sufficient thermal control approaches, would provide a lower cost replacement for SSBN navigation suites (and potentially for SSNs as well). These concepts, which leverage work ongoing for other inertial navigation applications, move the strategic systems away from specialized instruments and associated support infrastructure.

Additionally, investment in low-cost versions of instruments already demonstrated for completely passive, gravity-based (and hence completely covert) navigation should be a high priority in the mid-term. This approach will free SSBNs from the need to obtain either GPS fixes or active sonar terrain-matching fixes, each of which may be exploited by future anti-submarine warfare forces. This technology, like the investments in new, low-cost instruments, has significant dual-use potential for covert SSN operations as well.

Submarine Design Expertise. Submarine design expertise is a complex, highly specialized set of skills that simply cannot be sustained without activity that applies those skills. Currently, only SSN development sustains this critical capability. No new SSBN work is foreseen for the next 20 years. Engineering staffs in many areas are only one deep and graying. Archival activity is insufficient to preserve the knowledge base. This lack of expertise will affect the maintenance of current and future forces. This problem can be solved with funding and time.

Missile Systems

Underwater Launch. Certain aspects of SLBM systems are unique to the design of these weapons. The underwater launch of 100,000+ pound missiles is a good example. Knowledge and engineering understanding of the phenomenology and environments associated with underwater launch is rapidly eroding. Without a new development program in the near term, a very real danger exists that this expertise, which is critical to the fundamental survivability of the strategic deterrent, may be lost. Re-creating this knowledge in the future will be both expensive and time-consuming and may involve unacceptably high technical risks.

A robust program designed to capture this knowledge, preserve understanding, train new engineers in the future, and facilitate the development of better models and simulations to reduce future development costs is critical. The Navy has defined such a program. It is very important that this program be funded in the near term.

Propulsion. Solid rocket motor propulsion is the single most expensive component of TRIDENT systems. The D5 rocket motors use highly optimized, high-performance propellants designed to achieve range-payload performance requirements. These rocket propellants, which involve complex chemical formulations, also suffer from difficult-to-predict changes over time, which ultimately impact their safety and reliability. In the future, there may be reduced range/ payload requirements that could allow the use of slightly less energetic (but much less expensive) propellants that may have commercial application as well. A program is needed to develop these new, low-cost propellants with the necessary physical properties for SLBM/ICBM and tactical uses. Three initiatives are considered critical to reducing the cost of future large rocket motor designs. First, work is under way to examine solid rocket motor aging issues. A high-power computing initiative needs to focus on issues unique to the design, aging, and operation predictions for large solid boosters. Second, alternatives to current expensive thrust vector control designs are needed and efforts to define these should be funded. Magneto-hydrodynamic steering, although currently high risk, may provide this alternative. Third, less costly means of producing case insulators are needed. Insulators for TRIDENT motor casings are currently made using a time-consuming, tedious manual process. Alternative insulator manufacturing processes would incorporate more automation, eliminating much of the manual process.

These initiatives will involve some significant expenses, including the need to sufficiently flight test the rocket motors before deployment as part of the strategic nuclear force. Pursuit of such a program, however, would significantly bolster the shrinking and increasingly challenged solid propellant rocket motor industry and provide impetus for continued development of important national capabilities with multiple applications.

Nose Fairing. A material application unique to TRIDENT is the use of rare sitka spruce in the fabrication of the D5 nose fairing. This critical component actually supports the weight of the entire missile during handling operations. A lightweight replacement design would reduce costs.

Post Boost Control System. The Strategic Arms Reductions Treaty II (START II) mandates the elimination of all land-based missiles with multiple warheads. Upon entry into force of START II, the TRIDENT II system will be the only U.S. strategic system with a multiple independently targetable re-entry vehicle (MIRV) capability. MIRV technologies will thus become a unique Navy capability and must be addressed by a robust investment that includes the participation of the production partners.

Affordability constraints in the future will likely require the elimination of unique and high-cost materials and fabrication processes from the TRIDENT II post boost control system, which manages the positioning and release of reentry vehicles. The Air Force, under Department of Defense Research and Engineering sponsorship, has a Post Boost Control System Components initiative to examine means of eliminating unique materials and fabrication processes and to demonstrate alternatives, such as carbon-carbon composites and high-performance ceramic coatings. This effort may have limited utility for TRIDENT if the Air Force is actually limited to single reentry vehicle systems.

Re-entry Systems Application Program. Initiated at the recommendation of the U.S. Strategic Command Scientific Advisory Group, the Re-entry Systems Applications Program is an approach to sustaining critical skills and hedging replacement of highly specialized re-entry body components. The program, which is a closely coordinated activity involving both the Navy and the Air Force, focuses on replacement heat shield material (rayon, a commodity no longer available) and flight test instrumentation and includes the necessary flight testing to validate these approaches.

Despite the criticality of this area, this program has never been fully funded. A healthy program addressing re-entry systems technology is critical to sustainment of key technologies. This program should be fully funded (at $25 million per year) and should continue to focus on maintaining key skills within the contractor community.

Guidance Applications Program. Also initiated at the recommendation of the Scientific Advisory Group, the Guidance Applications Program is another well thought out, closely coordinated Air Force/Navy effort to sustain critical inertial guidance technologies and skills unique to the strategic missile environment. This program, which focuses on the future development of replacement components and reducing long-term costs through systems modeling and simulation, needs to be fully funded (at $25 million per year) to assure the long-term viability of inertial guided strategic missile systems. Like the Re-entry Systems Application Program, this effort should focus on sustainment of the contractor community in this unique area.

Other Re-entry Issues. In the long term, the current strategy of keeping re-entry systems for as long as possible means the United States must be prepared to replace most, if not all, component parts when they reach the end of their design life. Thus, there will be a need to fabricate replacement components for many re-entry subsystems. In some cases, technological obsolescence may preclude sub-component re-manufacture. One example is the fuse for the TRIDENT Mk 4 re-entry body, which can be re-manufactured only with new design replacement components because the original parts can no longer be procured.

The hypersonic wind tunnel test capability at White Oak, Maryland, is a critical facility for testing re-entry systems. This unique capability must be maintained to evaluate replacements for aging components.

Flight-Testing. Flight-testing is the primary method of assuring the safety and reliability of strategic missiles. Although the Services have significantly enhanced their ability to glean information from non-destructive testing, no amount of ground testing or modeling and simulation can completely replace the live firing of these systems. No methods exist to simulate accurately the harsh dynamic environment encountered during missile flight or to predict the behavior of these systems over time—particularly critical in light of U.S. plans to deploy these highly complex missiles for up to 30 years.

The SLBM program has already been reduced to the minimum number of flight tests per year needed to assure that the thresholds for reliability and safety are met. Continuing these tests and maintaining the infrastructure to carry them out at the Eastern Test Range is essential to the U.S. ability to field a safe and reliable strategic deterrent.

New Missile Design. When the time comes to design new missiles, the key to reduced costs and successful maintenance of the ballistic missile infrastructure may lie in increased commonality among ICBM and SLBM processes, technologies, components and subsystems. Achieving this increase is, however, a difficult challenge. Consider the Navy-unique environments in pier-side handling, high humidity, shock and vibration during deployment, launch pressures and accelerations, waterproofing, and cold launch flight dynamics. Combine all of these with the need to assure the safety of dockside personnel and the crew, who literally sleep with the missiles. Commonality may indeed be the right answer for cost reduction, but in-depth study will be needed to understand how to make it work without imposing unnecessary cost burdens on the ICBM force.

ICBM Infrastructure

Background

When the Cold War ended, the United States had an ICBM force that reflected four decades of investment in technology and engineering to produce a mature operational capability. Force size and structure have been modified since the late 1960s by a series of arms control agreements (first the Strategic Arms Limitation Talks (SALT) agreements and then START).

Current policy, based upon the Nuclear Posture Review and the subsequent Quadrennial Defense Review, is to retain a START II ICBM force of 500 modified Minuteman III missiles in silos at three wings. Pending Russian ratification of START II, the Air Force also is directed to maintain 50 Peacekeeper missiles at one wing. The Minuteman III currently is a MIRVed missile with three warheads; under START II it is to be de-MIRVed to a single warhead. The Peacekeeper is a MIRVed missile with ten warheads. Under START II, the Peacekeeper would be eliminated. Hence, the uncertain status of START II continues to be a major issue for managing the ICBM force.

Day-to-day management of the ICBM force has changed over the past several years. When the Strategic Air Command was dissolved, the ICBM force shifted first to Air Combat Command, then to Air Force Space Command. Air Staff oversight is conducted by the Directorate for Nuclear and Counterproliferation Matters (XON) at the two-star level, with responsibility and advocacy authority for the ICBM programs. The Air Force also has created a new field operating agency, the Nuclear Weapons and Counterproliferation Agency, reporting to XON. TRW is the prime contractor for managing the ICBM program and overseeing upgrades to Minuteman RV systems. TRW's partners include Thiokol/United Technologies Corporation (propulsion), Boeing (guidance), Lockheed Martin, BDM International, and MRJ Technology Solutions. The ICBM system program office remains at Hill Air Force Base, Utah, which is also the major depot facility for the ICBMs. Guidance repair is done at Newark, Ohio and has beenprivatized.

The Minuteman III Program

The current Minuteman III system is a mix of W62 warheads on the Mk 12 re-entry system and W78 warheads on the Mk 12A re-entry system. Under START II these MIRVed systems would be converted to a single warhead. There are no treaty limits on the specific warhead or re-entry system that can be chosen for retention. The Air Force has a program that would allow the Peacekeeper system (the W87 warhead on the Mk 21 re-entry system) to be adapted to a Minuteman platform.

The Minuteman III is projected, with current life extension activities, to have a life span through 2020. The following programs will essentially rebuild the missiles during the next decade:

Propulsion Replacement Program. Minuteman stage I has a steel case. Stage I will be completely remanufactured by "washing out" the propellant and replacing it with new propellant. Stages II and III both have titanium cases. These stages also are scheduled for remanufacture with the "washing out" procedure. This procedure is well known and has been used before in the Minuteman program.

Guidance Replacement Program. The Minuteman III has a 1960s guidance system that is being replaced in two phases: the first phase addresses electronics and the second phase the inertial system. This program is scheduled for completion in the first decade of the next century.

Minuteman III silos and launch control centers are addressed in the Minuteman Integrated Life Extension Program (Rivet Mile). These facilities, as refurbished by various life extension measures, are expected to last through 2020.

Minuteman operations depend upon a wide array of specialized test equipment and ground-support equipment and upon helicopters and vehicles to support wing activities such as warhead movements. The Air Force is currently reviewing the issue of helicopter replacement. The Air Force already has decided to procure a more heavily armored ground vehicle for warhead movements.

There are sufficient missiles available to support a testing program of three operational tests per year for a force of 500 Minuteman III missiles through the year 2020. With continuing, adequate funding, the programs in place will sustain the Minuteman III force through the year 2020, assuming no significant change in any adversary's ballistic missile defense capabilities and no policy decisions that mandate major changes in missile operations. If the United States were faced before the year 2020 with an opponent who could mount a significant boost-phase threat, for instance, or if policy decisions mandated significant changes in operations, planners would have to re-address requirements for Minuteman III.

The Peacekeeper Program

The Peacekeeper is the most advanced U.S. ICBM. As discussed above, this program is to be eliminated under START II. In accordance with the anticipated elimination schedule (assuming START II ratification), the Peacekeeper force is programmed through FY 2003 under the Nuclear Posture Review. The Peacekeeper life extension program is funded year-by-year, pending action on START II. Even if Peacekeeper is eliminated under START II, we believe it is important from an infrastructure perspective to preserve the W87 warhead, preferably as part of a diversified deployed force, but also to provide a reliable backup should the Minuteman III's W78 warhead develop major problems.

Issues

There are at least two major issues relevant to the Peacekeeper program. The first involves the Peacekeeper ICBM system. If START

II is not ratified and Peacekeepers are retained in the force, the United States must develop a long-term sustainment program. This requirement should present no more a challenge than the long-term sustainment program for the Minuteman system that already is in place.

The second major issue is more subtle and reflects the uncertainties involved in seeking to sustain an ICBM force when no follow-on ICBMs currently are in development or production. A new ICBM for the period beyond 2020, the end of life for Minuteman III, should be studied within the next several years. Concept exploration should begin, roughly in the year 2000, of a development and production program for a new ICBM to enter the force before the year 2020. Also worthy of study is whether, for technology or policy reasons, a different strategic delivery platform should succeed Minuteman III.

However, even with an ongoing ICBM development and production program, which does not yet exist, and even with a long-term roadmap, which also does not exist, several sub-issues arise. One issue is the viability of the ballistic missile industrial base over time. The industrial base is the combination of a U.S. government system program office; dedicated industrial companies acting as prime, sub, or associated contractors; and system depots and Service or national laboratories that perform all of the acquisition and support functions, from research and development to operations and maintenance and modification of a fielded weapon system. Performance of the industrial base during the Cold War reflected a culture in which follow-on systems always were in development or production. That now has changed.

Several years ago, the U.S. Strategic Command Scientific Advisory Group (SAG) conducted an SLBM and ICBM industrial base study, focusing on subsystem areas where special actions would be needed to assure viability of the industrial base. The SAG is currently updating that part of the study focused on propulsion subsystems. The study pointed overall to the need for close cooperation—which has since occurred among the Air

Force, the Navy, and OUSD (A&T)—in developing and funding an integrated strategy for certain focused sub-system programs (e.g., a re-entry advanced technology demonstration program).

Another issue is whether sufficient senior-level DoD attention can be focused on the ICBM program over the long term, outside of those offices directly responsible for ballistic missile activities and programs. Notwithstanding XON's advocacy skills, a spirit of cooperation and communication with the Navy's Strategic Systems Programs Office, and support from USD(A&T), the fact remains that DoD has nothing comparable to the DOE Stockpile Stewardship Management Plan within which to address and resolve issues related to sustaining ICBM programs beyond the projected life of the Minuteman III system. During the Cold War, the Air Force Chief of Staff could, on short notice, ask for a meeting with virtually any of the senior leadership in DoD to discuss ICBM issues and know that they would be working from a common body of assumptions and data, given the multiple occasions where ICBMs would be addressed in senior-level budget and management reviews. That is not true today. Recreating something comparable, absent development and/or production of a follow-on ICBM, is a considerable challenge.

Bomber and Air-Launched Cruise Missile Infrastructure

Background

In his 1997 Annual Report to the President and Congress, Secretary of Defense Cohen noted, "Although the risk of worldwide nuclear conflict is substantially lower today than during the Cold War, nuclear deterrence remains an important component of national security. The global attack capability of our nuclear capable bombers continues to provide the nation with an essential capability."

The nuclear bomber force consists of 71 B-52 and 21 B-2 heavy bombers. With no new nuclear bomber production under way, sustainment of current forces via modernization and maintenance will provide the vital air leg of the U.S. nuclear deterrent force for the foreseeable future.

B-52

The B-52, a priority program throughout the Cold War, has been a sustainment success. While the scale of activity has varied, technical effort to support modernization has been continuous from development through sustainment of currently deployed H-series aircraft. The B-52 program has undergone continuous modernization over the course of many decades; engines were replaced with new models, avionics and other electronics were updated or replaced with more modern technologies, and everything was managed as a limited-life component. The B-52 sustainment program has been a model of success.

All B-52Hs are to be retained under the START II agreement and the Air Force plans to keep the B-52 as a component of the strategic nuclear force through 2040, thus requiring several sustainment and engineering programs. Sustainment activities for the bomber include navigation (integrated with the Navstar Global Positioning System), communications, electro-optical viewing, and improvements to electronic countermeasure systems.

B-2

Upgrades to the B-2 force will be complete in FY 2000. Once completed, U.S. strategic nuclear forces will include 21 B-2 bombers. All are to be retained under the START II agreement. When fully combat capable, the B-2 will have the ability to employ the B61 and B83 nuclear gravity bombs and advanced conventional munitions.[4] The B-2's compatibility with these advanced conventional munitions will facilitate its compatibility with new nuclear weapons when they are developed.

4 These include the Mk 82, Mk 62, and CBM 87/89/97 bombs; GPS-Aided Munitions; the Joint Direct Attack Munitions (JDAM)and Joint Standoff Weapon (JSOW) missiles and, under current plans, the Joint Air-to-Surface Standoff Missile (JASSM).

Cruise Missiles

The Air Force is maintaining two cruise missiles capable of delivering a nuclear warhead. The AGM-86B, Air-Launched Cruise Missile (ALCM), has been operational since 1982. The AGM-129A, Advanced Cruise Missile (ACM) has been in service since 1986. In 1997, Air Combat Command initiated a Service Life Extension Program (SLEP) study for both missiles. The initial phase of the study indicated both missiles can be sustained to 2030 without significant technical risks. The Air Force has funded the recommendations for the SLEP starting in FY 2000.

Although no new nuclear air-delivered missile production is under way, conventional missile developments will preserve the technology base for seeker, warhead, propulsion integration, airframe survivability, and Global Positioning System/Inertial Navigation System for both conventional and nuclear cruise missiles.

B-1

The B-1, formerly with a nuclear capability, will complete its transition to a conventional role by the end of 1998. However, the Air Force will retain the ability to reconstitute the B-1 to a nuclear-capable role if warranted by a shift in the security environment. Conventional capabilities of the B-1 are being enhanced through the Conventional Mission Upgrade Program, which includes navigation (integrated with GPS), communications, advanced conventional weapons, and electronic countermeasure upgrades. The upgrade program started in 1994 and will be completed in 2002.

Dual-Capable Aircraft

Today, F-15E and some F-16 tactical fighters provide nuclear and conventional weapons capability for use in regional settings. (Similarly, TLAM/N deployed aboard attack submarines can provide nuclear strike capability through theater deployments.) In addition, there are considerable efforts under way to develop conventional tactical aircraft and weapons systems that would be applicable to any future requirements for new nuclear weapons platforms or systems. While there are no current plans to make any of these aircraft dual-capable, the Navy and Air Force are reviewing the issues associated with making the next generation tactical aircraft dual-capable. It is essential to maintain dual capability for future fighter aircraft (Joint Strike Fighter and/or F-22) to provide flexibility in nuclear delivery capability as well as to satisfy burden-sharing requirements in NATO.

Benefits From Conventional Sustainment

Reflecting the increased emphasis on non-nuclear operations and in light of the ability to sustain existing heavy bombers for the foreseeable future, bomber modernization efforts today are focused primarily on improving conventional war fighting capabilities. Strategic nuclear bomber sustainment, however, is synergistic with conventional bomber activities. This is also true of the relationship between nuclear and conventional cruise missile programs. Conventional bomber and missile modernization programs, such as the B-1 electronic countermeasure improvements and the JASSM, will contribute to sustaining technologies and industrial base capabilities of strategic nuclear bombers and cruise missiles.

The capabilities for strategic nuclear bombers are not unique. These capabilities are drawn from a broad aircraft industrial base with extensive overlap with other military and commercial aircraft. Companies that are nuclear bomber suppliers show great flexibility in that they typically support multiple military and commercial aircraft simultaneously, designing and/or producing many types of aircraft. A strong aircraft industry will improve the long-term health of suppliers that produce dual-capable or "cross-over" items for aircraft markets. Moreover, specialized aircraft industry capabilities currently engaged in developing the stealthy F-22 and Joint Strike Fighter, will also support any future design, development, and production needs for next generation strategic nuclear bomber programs. Ongoing conventional programs must assure adequate numbers of tankers for the nuclear role.

Conclusion

The United States will continue to maintain core technical capabilities for strategic system design, development, and production despite the absence of new bomber or cruise missile production. Ongoing strategic system modernization, operations and maintenance technical support, research and development efforts applicable to strategic systems, and the relevant improvements of conventional systems assure an effective nuclear bomber force into the next century.

Command and Control

Command and control will be the most stressed component of nuclear infrastructure because of the increased demands for flexibility, the potential need to respond to rapid changes in technology, and the specter of susceptibility to penetration and disruption attacks.

A future **vision** for nuclear command and control (NC^2) is discussed extensively in the Operations working group paper. This paper emphasizes that as technology evolves the overwhelming importance of NC^2 requires proceeding with caution toward the implementation of the vision. Today's already reduced infrastructure for dedicated hardened NC^2 systems must be maintained until potentially complementary commercial systems paired with "hardened" data have been demonstrated to provide the national leadership with assured control and responsiveness.

There are four prerequisites for nuclear command and control:

- The NC^2 system must be secure, ensuring friendly access to data while denying enemy access.

- The system must be survivable, providing uninterrupted access to uncorrupted data.

- The system must also be enduring, providing command and control for as long as each weapons system is expected to be operable.

- The system must be both responsive and timely. These characteristics are key to supporting the ability of the National Command Authorities to react to whatever situation arises.

The reduction of strategic forces raises issues regarding the adequacy of the NC^2 system, particularly with regard to TRIDENT, TLAM/N aboard attack submarines, and forward-based dual-capable aircraft. As the force grows smaller, the importance of ensuring high probability of correct message receipt increases, as does the potential need for NC^2 to accommodate real-time complex targeting information. It is a fallacy to believe that as force levels are reduced the need for robust NC^2 declines in some linear relation. Maintenance of systems that contribute to this assured capability must be sustained. With fewer TRIDENT submarines, true low probability of detection/low probability of intercept strike reporting for missile launch (to minimize submarine vulnerability) and fail safe reporting of SSBN loss (to maximize the overall effectiveness of subsequent operations) become critical. The implications for the future are the need for follow-on to the TACAMO command and control aircraft and passive, stealthy, receive-only force management command, control, and communications.[5]

Any additional de-alerting of nuclear forces will further stress NC^2 requirements if targeting requirements and procedures do not change. Some current concepts, like probability of correct message receipt, may need redefinition. Procedures and systems capable of ensuring survivable sustained message traffic will be needed, as will be the capability to terminate such transmissions. Increased need for Alert Exercise Periods is a likely outcome as well, to assure maintenance of capabilities.

5 One example is the very low-frequency fixed submarine broadcast system.

In the long run, the United States will need to determine how and to what extent NC^2 can be integrated into and operate with mainstream, high-priority non-nuclear communication capabilities while still ensuring the four prerequisites are met. There are several factors that will drive this change in NC^2:

- New national guidance has expanded the role of nuclear weapons as a deterrent against weapons of mass destruction other than nuclear weapons.

- The National Missile Defense and/or the Theater Missile Defense, if instituted, must be incorporated into (and subsequently will affect) the U.S. Nuclear Command and Control System infrastructure and procedures.

As distinctions between strategic and non-strategic nuclear forces disappear and communications platforms are consolidated, strategic connectivity assets will have to accomplish broader missions (e.g., TACAMO as the theater Airborne Command Post).

- Technology trends in commercial network bandwidth, mobile access, and wide use of encryption may offer new NC^2 opportunities.

Integrating NC^2 with commercial capabilities raises many issues, such as:

- What are the true cost factors? The National Command Authorities will have very little, if any, ability to dictate commercial system design. While the rapid changes that commercial systems bring can be beneficial, the same changes can bring large costs in retraining, updates to operating procedures, and new equipment, among other things. The same changes also raise the possibility of the potential loss of absolutely vital capabilities.

- How can relevant computer hardware, software, and firmware be protected given the increasing reliance on civilian technology and the increasing internationalization of the computer and information industries? Of special concern is the increasing use of foreign-developed software.

- Will the commercial sector development and production processes provide the requisite equipment for the bulk of the NC2 and will market dynamics ensure adequate availability of key components?

- How will the growing consolidation and foreign ownership of the telecommunications industry affect the Tactical Warning/Attack Assessment system and other aspects of NC2?

- How can foreign-designed/built equipment and components be certified for nuclear use?

- How can the vulnerability of commercial systems to existing electromagnetic pulse weapons and to new weapon threats (such as radio frequency weapons and information warfare) be measured? Information warfare is especially threatening because data encryption does not protect the system itself. The track record of commercial systems protecting themselves is very poor.

- Will the National Command Authorities be willing to equate de-cryption of a message with its authentication (a step without precedence)?

Future command and control architectures may need to be planned to support multi-mission platforms, increased targeting options, and much more adaptive planning. These systems must counter potential vulnerabilities that may result from dependence on commercial communications systems and software and non-hardened command and control facilities. It will be crucial for the United States to maintain capabilities to train operational forces, including testing (in benign environments) and modeling and assessments (for stressing environments).

Despite the growing dependence on commercial systems, there will be continued reliance on a "thin hard line" of dedicated military communications for assured response. This "thin hard line" is not new. For a number of years efforts to sustain the hardened command and control system increasingly have focused on fewer systems—the "thinning" of the "hard line." Some assessments have suggested that not much more "thinning" can take place. A major command and control infrastructure issue then is the retention of skilled specialists capable of taking the "thin hard line" concept even further and making it an operational reality. Unfortunately, expertise in NC^2 is dwindling as personnel experienced in NC^2 go to other technical areas for greater intellectual challenges and rewards.

In sum, strategic planning for NC^2 infrastructure needs to be an integral part of overall planning for sustaining deterrence to ensure that future NC^2 meets the needs of policy and force structure.

Sustaining Core Nuclear Expertise in the Military

Traditionally, the Department of Defense has required three broad kinds of nuclear expertise in order to carry out its deterrence mission: operators, planners/strategists, and nuclear weapon effects and system experts.

The Operator

The operators, the men and women who command, maintain, and operate U.S. nuclear weapons systems, must meet some of the most demanding standards of competence, personal reliability, and performance under stress of any military personnel at any time in history. Nuclear operations demand as close to a "zero-defects, zero-errors" environment as is humanly possible. Within this type of environment, there is a premium on continual training. To maintain the highest standards of safety, nuclear operators are trained to follow procedures meticulously but with sufficient initiative to strike an appropriate balance between positive control on the one hand and assured response to authorized commands. Expertise in nuclear operations is acquired over the course of an entire career.

Masters at this trade, like masters in other fields, emerge through a process not unlike apprenticeship, which exposes them to as many situations as possible relating to safe and reliable nuclear weapons operations under a variety of highly stressed conditions. Procedures are recorded in technical manuals, and the master operators are those who not only understand and can expeditiously follow established procedures, but who also understand why the procedures have been selected and why this set of procedures is prescribed instead of alternatives. The tacit knowledge reflected in such understanding is difficult to impart except through the long practice of performing nuclear operations.

The Planner and Strategist

Nuclear planners in the Services, on the Joint Staff, and on the staff at U.S. Strategic Command normally are former nuclear operators who move into planning jobs during the mid-phase of their career. Nuclear planning is a broad term covering several areas, especially research and development and operational test and evaluation planning, force planning, and operations planning. The skills needed for research and development and operational test and evaluation planning and for force planning are similar in the nuclear world to those in the non-nuclear world. As for operations planning, nuclear operations contingency planning normally has been subjected to tighter policy guidelines and closer scrutiny than other types of military contingency planning. During the Cold War, the Single Integrated Operations Plan and the nuclear annexes (national or alliance) to regional war plans reflected a type of planning that was relatively distinct from non-nuclear planning. That system is changing and there are moves under way to assure, for instance, that the computer-based planning tools used by nuclear and non-nuclear planners are more compatible. As many of the plans move away from set-piece formats to more adaptive structures, an argument can be made that nuclear planning is becoming more, not less complex in the post-Cold War era.

Military planners also are involved in the policy and arms control planning arenas. The expertise military planners should bring to these tasks includes that of an expert adviser (expertise in military operations and plans), but with sensitivity to the underlying issues and the conflicting imperatives involved in interagency policy planning.

Nuclear strategists are those members of the nuclear planning community who are most involved in the continuing effort to define the objectives of nuclear weapons and to reconcile nuclear planning with other types of policy and contingency planning. Ideally, a nuclear strategist should have a good grasp of the broad debate that takes place in academic and strategic studies circles on the roles of nuclear weapons, should understand the histories of a number of issues relating to nuclear weapons, and should have strong analytic skills.

The Nuclear Weapons Effects and Systems Experts

The highly technical nuclear weapons effects expertise required by DoD is complemented by the expertise found in the DOE nuclear weapons complex. DoD personnel with nuclear weapons effects and systems expertise frequently, but not always, have some experience in nuclear operations. Expertise in this area is not unlike expertise in other scientific and engineering disciplines; there is a high premium on tacit knowledge that tends not to be recorded in written records but is acquired through practice and long experience.

The Implications of Downsizing

No one should be surprised that nuclear expertise in the military has declined as the Services have downsized (in the U.S. Navy, a 34% reduction in personnel; U.S. Marine Corps, 15%; U.S. Air Force, 39%; U.S. Army, 38%), given the shift away from nuclear weapons in the post-Cold War world. From the standpoint of sustaining deterrence, the key question to answer is: has the U.S. fallen (or is it about to fall) below quantitative and qualitative levels in key areas that would jeopardize the ability to sustain the credibility of the nuclear deterrent?

As the above discussion makes clear, there is little overlap between the specialized knowledge and experience (which the country has counted on in the nuclear arena) and other military competencies in many areas. It seems unlikely that competence in nuclear matters can be sustained without careful career planning, including joint assignments with this objective in mind. Metrics need to be established by which the nuclear weapons-related experience of the personnel who will be responsible for nuclear weapons and nuclear forces can be measured. Among these metrics should be:

- *Ratios of assigned to authorized personnel.* Insufficient numbers of personnel within a particular nuclear weapon-related career field should trigger attention.

- *Re-enlistment rates.* Maintaining critical nuclear expertise means not only filling authorized positions, but having sufficient numbers of experienced second- and third-term personnel. A drop off in second- and third-term enlistment would indicate serious loss of expertise.

- *Junior officer retention rates.* The loss of highly trained junior officers with nuclear weapons-related experience implies far fewer senior commanders and staff officers at a later point in time.

- *Nuclear inspection failure rates.* Increasing failure rates during nuclear inspections should be an alarm bell about possible training or experience shortfalls.

- *Promotion rates for people with nuclear backgrounds.* If fewer opportunities exist for promotion later in the career path (as opposed to the early stages of an individual's career), there may be a problem sustaining interest in the nuclear area. Is there evidence that career advancement is being limited by an individual's choice of a nuclear career area?

We conclude that, despite some concerted efforts on behalf of the Services, more needs to be done to sustain military expertise in nuclear weapon-related areas.

Army

While the Army has eliminated its nuclear operational capability (artillery-fired projectiles, Lance and Pershing missiles), it nonetheless has maintained skills for assessing the effects of nuclear use on the ground war. The Army maintains a personnel functional area for individuals with nuclear research and operations expertise. In 1998, officers in this category exceeded the number required.[6] These officers receive two weeks' qualifying training at the Defense Nuclear Weapons School (DNWS). Additional courses are available as required. In addition to positions in the Army, these officers serve in OSD, the Joint Staff, DOE, CINC staffs, the former Defense Special Weapons Agency (now part of the Defense Threat Reduction Agency (DTRA)), and the United States Military Academy. The Army also assigns an additional skill identifier to a large number of officers who do not have specialized expertise but are able to assess targets in terms of nuclear effects.

Navy

The Navy has maintained its core nuclear capability and focus. The Navy transitioned its nuclear weapons capability to the submarine force, where "nuclear" was already a core competency, by shedding all non-submarine nuclear weapon capability. The move permitted the Navy to concentrate nuclear weapons skills in only a few ratings, some of which were already undergoing consolidation as the Service downsized. Navy personnel with nuclear weapons-related skills consist of officer, enlisted, and some civilian contractors. Training for all the

6 The Army's Functional Area 52 (Nuclear Research and Operations) Inventory/Authorized Positions for FY 1988 were 145/193. For FY 1998, figures are 92/88 (as opposed to 242 officers in the Field Artillery as a whole). FA 52s are advised and personally managed by their proponent. Both in FY 1988 and FY 1998, five of these officers possessed nuclear advanced degrees.

Navy nuclear weapons-related specialties is rigorous and routinely evaluated. Nearly all of the officers are either nuclear (propulsion) trained or Limited Duty Officers commissioned from the nuclear weapons-related enlisted ratings. Missile Technician, Fire Control Technician, and Machinist's Mate Submarine are the enlisted ratings associated with nuclear weapons-related skills.[7]

Another product of downsizing is that the Chief of Naval Operations' oversight for the strategic program has changed significantly in recent years. Where once there existed an individual branch at the two-star level tasked with developing policy for nuclear operations, only a vestige remains led by a Captain who is tasked with other major responsibilities. This reduced representation has limited the staff's ability to develop policy options.

Air Force

The Air Force's reorganization in response to force cuts adversely affected the way it managed its nuclear weapon-related specialty codes. Strategic Air Command was eliminated and its operational mission given to Air Combat Command and then to Space Command. Throughout the Air Force (including the nuclear weapon-related fields), detailed regulations took the form of instructions in order to give operators greater latitude. The Air Force also elected to broaden career fields so that its members performed many missions, with the nuclear mission becoming only a part of other career fields. As an unintended consequence, the Air Force's core nuclear expertise became dispersed across the force and harder to identify and track. Today, individuals with nuclear expertise can only be identified by examining their individual personnel folders.

Like the other Services, many experienced personnel have left the Air Force for a variety of reasons: quality of life issues, high operations tempo, an attractive outside economy, and in some cases, in response to separation incentives. Loss of first-term airmen is an ongoing problem in both the conventional and nuclear Air Force.

7 The Navy's Inventory/Authorization as of Jan 98 are: Missile Technician: 1,337/1,369 (97.7%); Fire Control Technician: 1,260/1,325 (95.1%); Machinist's Mate Submarine: 949/840 (113%).

Other Considerations

Joint Duty

The number of officers with operational nuclear weapons-related expertise on the Joint Staff and at the Major Commands has declined. Knowledge in technical areas such as weapon effects, nuclear physics, and electro-magnetic pulse would be beneficial, but is in decline. The emphasis on joint duty assignments means many of the officers who rotated through nuclear-related staff tours, while exceptional in all other respects, did not have in-depth nuclear backgrounds. Assigning officers to the national laboratories and to the newly formed Defense Threat Reduction Agency could provide opportunities for gaining knowledge in nuclear matters and the Services should place greater emphasis on such assignments.

Officer Education

Officers now receive less education in nuclear matters than they have in the past. Senior Service colleges spend less time on strategic nuclear planning and targeting and deterrence theory. Fewer officers receive advanced degrees in such nuclear disciplines as physics and weapon effects from the Air Force Institute of Technology and Naval Post-Graduate School.[8] Furthermore, there is a heavy bias in this educational system toward defining nuclear force requirements in terms of campaign analysis. While such a "war fighting" approach is a legitimate (indeed necessary) perspective to bring to bear, it does not necessarily shed light on the best deterrence solutions. The Service schools, and DoD generally, need to place a greater emphasis on the unique requirements for nuclear deterrence in a world in which weapons of mass destruction are widespread.

Service Initiatives

The Army has committed to keeping its nuclear expertise through training, education, and a viable career path.[9] The Army approach is

8 Service drawdowns have resulted in special issues. For example, the drawdown has reduced Permissive Action Link coders (individuals key to the assured control of nuclear weapons) by one-half. Such a small number (12 to16) with this coding expertise leaves little capability in the event of sudden retirements or the need to surge during reconstitution.

9 Officer Personnel Management System XXI, a new Army initiative, will allow officers to specialize as FA 52s after their eighth year.

designed to provide sufficient expertise in critical areas such as Nuclear Employment Augmentation Teams, which are trained and staffed to support and advise ground component commanders in critical nuclear areas during theater operations. In addition, the U.S. Army Nuclear and Chemical Agency shares its nuclear weapons targeting expertise through publications (e.g., the JCS Publication 3-12 series) and courses like the Joint Nuclear Operations and Targeting course at the Defense Nuclear Weapons School.

The Navy uses Navy Enlisted Classification codes to track its enlisted personnel skills, including nuclear weapon expertise. To ensure sufficient numbers of officer and enlisted nuclear personnel are recruited and retained, the Navy uses a relatively generous system of bonuses. Personnel in the nuclear career fields are carefully chosen, highly trained, and evaluated on a frequent basis. The Navy has recently completed a thorough review of its Limited Duty Officers (the technical experts of fleet-level operations). This program has been revised to place one Limited Duty Officer in the Weapons Department of each ship of its SSBN force (one for every two crews). This recent revision demonstrates the Navy's commitment to assuring the future health of the nuclear community. The Navy also uses outsourcing to maintain a long-term supply of nuclear expertise. Employees of Lockheed-Martin, supervised by an active duty officer, are central to the operation of the Navy's Special Weapons Facility Atlantic at King's Bay, Georgia. The comparable Pacific facility at Bangor, Washington, is manned by active duty personnel.

As discussed, it has been argued that the distribution of Air Force nuclear forces to various Major Commands resulted in a loss of nuclear expertise and focus that the single command once assured. This decline was evident to Air Force leadership, who made the issue a discussion topic on the general officer agenda in 1996. A major milestone was the establishment, in January 1997, of the Directorate of Nuclear and Counterproliferation Matters on the Air Staff to provide high-level leadership for the Air Force nuclear community. One of the most significant actions undertaken by XON was a review of institutional support provided to Air Force nuclear units. This study, directed by the Vice Chief of Staff in September 1997, focused on five specific areas—oversight, guidance, experience, training, and equipment—where the Air Force provides support. While the final report of this review is still under consideration, Major Command staffs as well as the Air Staff have begun efforts to rectify many of the shortfalls identified.

A key focus of the XON study was the nuclear experience levels of Air Force personnel. Currently, the Air Force has no systematic way of tracking nuclear experience and no mechanism exists to match experienced individuals with billets requiring nuclear expertise. In the past, the mere size of the nuclear forces, and the viable career opportunities that came with them, assured adequate numbers of nuclear-experienced personnel. Downsizing within the nuclear forces and dual-tasking units with nuclear and conventional operations have reduced opportunities and focus. Career Field Managers have defined what they believe to be sufficient nuclear experience for their personnel, and units have been tasked to identify "key" billets where previous nuclear experience is needed prior to assignment. Based on these assessments, the Air Force is developing a system to "tag" experienced personnel and match them against billets requiring their expertise.

The Air Force has also just concluded a Special Management Review examining nuclear weapon surety to include personnel issues. A retention office has been established on the Air Staff to track critical specialty codes, including those that are nuclear weapons-related. The Air Force also uses re-enlistment bonuses in critical skill areas.

The Defense Nuclear Weapons School offers several courses designed to further nuclear education, such as a nuclear weapons orientation course, a nuclear weapons technical inspection course, a nuclear emergency team operations course, a nuclear hazards training course, and nuclear accident courses. The school also offers opportunities for advanced degrees in the nuclear field. In addition, the Defense Special

Weapons Agency also had been working with professors at the Naval Post Graduate School over the past year to encourage students to focus their theses on nuclear subject matter. The Naval Post Graduate School offers masters of science programs in physics and applied physics with a specialization in weapons and their effects. The Department of Engineering Physics at the Air Force Institute of Technology offers a specialization in nuclear engineering.

Maintaining and Transferring Skills in Nuclear Weapons-Related Technology

Outside the military establishment, there are real problems maintaining skills related to nuclear weapons technology and transferring these skills to a new generation of qualified scientists and engineers. The current knowledge base that has been acquired through nuclear testing is being maintained by DoD, augmented with simulation techniques.

The ability to maintain this knowledge is directly related to the ability to attract talent to the nuclear community. Three potential ways of attracting talent are:

- Introducing appropriate elements of nuclear weapons-related technologies into undergraduate and graduate course curricula at participating universities and Service academies.

- Exploring career-development opportunities such as scholarships, post-doctoral programs, joint research projects, and faculty development programs for cooperative education and training with DoD organizations, the national laboratories, and participating universities and industries.

- Developing career-enhancement opportunities through cooperative training programs for both Service and industry personnel.

Expectations regarding knowledge transfer need to be realistic. While the Service academies can enrich science and engineering curricula to emphasize the intellectual challenges in nuclear weapons-related technology, it is highly unlikely that public or private engineering universities would do so. Because nuclear programs lack the visibility and prestige they held in the past, strong federal scholarship programs that naturally lead to work with the national laboratories or related organizations should be devised. Personnel rotation between DoD and DOE may be an important part of ensuring adequate skills. The Defense Special Weapons Agency started this under the Dual Revalidation Program, whereby it has offered six military officers (two to each DOE laboratory) the opportunity to work together with DOE. We recommend that DTRA continue this program. Funding of prototype developments may be the most effective method of training and retaining qualified scientists and engineers.

Ensuring transfer of nuclear skills and knowledge from generation to generation is not a process that is well understood. Gaining an understanding of this process should be a high priority for DoD in the next few years.

Managing the Sustainment of Deterrence

Organizations within the Defense Department with assigned nuclear responsibilities include the Under Secretary of Defense for Policy, which oversees policy development for strategy, forces, and operations; the Under Secretary of Defense for Acquisition and Technology, which oversees delivery platform acquisition programs; and the Assistant Secretary for Command, Control, Communications, and Intelligence, which is responsible for nuclear command and control and strategic intelligence functions. Prior to the Defense Reform Initiative, the Assistant to the Secretary of Defense for Nuclear, Chemical, and Biological Matters was the day-to-day focal point for OSD oversight of all nuclear weapons matters, oversaw some aspects of acquisition, and held some nuclear policy-related responsibilities. Nuclear weapons-related functions now have been added to the duties of the DDR&E.

The management of nuclear sustainment has been discussed at length in the Operations working group paper. The problems that must be addressed are clear: funding shortfalls, the lack of an overall plan for sustaining nuclear forces, an absence of vital institutional memory that can inform current decisions, and diffuse management attention within the DoD. These problems cannot be addressed piecemeal. They must be addressed as a complex of interrelated issues. Moreover, addressing them in a coherent way requires organizational change: the United States needs a high-level, full-time nuclear infrastructure advocate in the DoD responsible for integrating all facets of nuclear infrastructure—weapons, delivery systems, industrial and technology base, and NC^2.

We believe that the creation of a high-level, full-time nuclear infrastructure advocate in the acquisition structure reporting directly to the USD(A&T) is integral to sustaining the nuclear deterrent over the long term. Committed to sustaining the nuclear weapons infrastructure, the advocate would work with OSD Policy; the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence; U.S. Strategic Command, and the Military Service elements responsible for nuclear forces in creating a DoD Nuclear Forces Program Plan. This individual would also support the USD(A&T) in his capacity as Chairman of the Nuclear Weapons Council to ensure the correlation of DoD and DOE nuclear weapon sustainment planning.

One of the first responsibilities of this high-level advocate should be to articulate a vision, first for the Program Plan, and then for acquisition planning more broadly. This individual would also oversee the development of a DoD implementation document comparable to the DOE "Green Book," which embodies the totality of DOE's planned nuclear weapons-related programs. The high-level advocate could build profitably on the Defense Special Weapons Agency's recent work to heighten awareness of sustainment issues throughout DoD. These form the foundation for a process that could make a substantial contribution to sustainment planning. An important part of the high-level advocate's portfolio should be contingency planning for threats that may materialize sooner than expected or that are not part of mainstream planning.

Conclusions

Action must be taken to sustain the deterrent, but without the creation of a leadership position within DoD for nuclear-related infrastructure, broadly construed, reporting directly to USD(A&T), there will be little prospect for the kind of constructive change that is needed. It is hard to envision the creation of a coherent infrastructure sustainment plan absent focused attention.

It would be irresponsible to put priorities on specific investments in the absence of a coherent plan. Clearly, there are many areas in which defense program funding is not adequate and other areas where needed programs have not been defined. Priority must be given to the creation of a roadmap, and then it can be determined whether the entire nuclear infrastructure area is underfunded to meet declared national policy or whether priorities can be readjusted to maximize the return on investment for sustaining deterrence.

Command and control will be the most stressed component of infrastructure. This will come about as a result of the additional complexity associated with increasingly flexible employment options, the need to be prepared to respond to rapid changes in technology, and the susceptibility of command and control to penetration and disruption by physical or electronic means.

Several unique nuclear force infrastructure elements or requirements must be supported. Some of the areas that must be maintained or further developed are: knowledge of EMP and nuclear effects hardening, nuclear effects phenomenology, and nuclear operational testing and evaluation. Skills in developing and fabricating particular equipment items like large solid rocket motors, precision inertial navigation, guidance systems, and re-entry systems must be maintained as well. Several countermeasure programs central to ensuring that U.S. nuclear forces can carry out their missions in the face of a rapidly changing threat must be sustained. These programs relate to the dynamics of stealth retention and defeat, SSBN survivability, air defense penetration, information warfare survivability, and space asset survivability.

Three factors can greatly affect infrastructure planning, factors that can promote or undermine the plans however carefully crafted. The first is fiscal in the largest sense: without stability of funding over time, it is very unlikely that the United States can maintain adequate infrastructure. By its very nature, infrastructure does not respond well to funding shortages for a prolonged period of time followed by a larger, "catch-up" funding effort. Maintaining the infrastructure requires a steady, predictable funding level.

The second consideration concerns the efforts of the intelligence community. One of the tests for assessing infrastructure adequacy is its ability to support timely responses to changes in the threat. This presumes that the intelligence community, drawing on the expertise of the U.S. nuclear community, devotes considerable resources to tracking changes in the postures of all nuclear-capable states.

The third is arms control, which increasingly must be considered within an infrastructure context. There will be strong pressures to craft arms limitation regimes that include some aspects of infrastructure. Planning needs to take infrastructure into account when arms reduction measures are discussed. The need to take such factors into consideration in the policy process only reinforces the point that there must be a high-level advocate who can focus on the details of such proposals.

The Infrastructure Working Group has arrived at the following conclusions:

- Decades of investment in the current infrastructure and the existing management plans of the Navy and Air Force can sustain current nuclear forces to "2020" with modest but continuing investment, but only if the United States can keep competent people interested.

- Without focused management attention, it is unlikely that the infrastructure needed to sustain current forces, as they may be drawn down, will be sufficiently competent and capable to provide the kinds of nuclear forces required to deter in the 21st century. The United States must strive for a nuclear forces infrastructure that is smaller and cheaper but capable of responding, in production numbers and technological sophistication, more rapidly than any threat can be mounted.

- Theater nuclear forces, an important contributor to deterrence, are not receiving the attention needed to sustain the infrastructure for dual-capable tactical aircraft, submarine-launched land-attack cruise missiles, and possible other future systems.

- Nuclear Command and Control will be the most stressed component of the nuclear force posture because of the additional complexity associated with increased demands for flexibility, the potential need to respond to rapid changes in technology, and the susceptibility of U.S. forces to penetration and disruption attacks. Both the dedicated command and control (the "thin hard line") and the commercial communications infrastructure used for nuclear command and control will be stressed in meeting these challenges.

- Personnel competence in the military and civilian infrastructure is critical to the sustainment of deterrence. This competence arguably has eroded in some areas and is now on the mend, but will require attention to ensure there are no reversals. Other areas are fragile and require corrective action to prevent erosion. The entire personnel area will require sustained management attention. Pervasive symptoms of fragility are the overall tendency to place people who lack the needed experience and skills in positions previously held by those who do, and the sharp drop in interest and education in the military on nuclear issues.

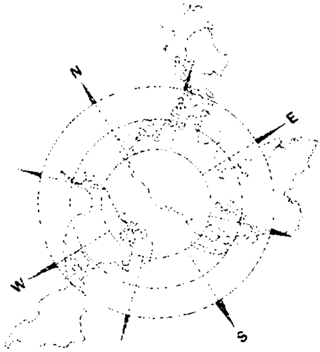
- A major deficiency that could undercut the U.S. deterrent is the lack of a comprehensive vision and roadmap that encompasses the entirety of nuclear capabilities that must be supported for the United States to have confidence in the deterrent up to and beyond the lifetime of currently deployed systems.

- The nuclear infrastructure needs to evolve to leverage commercial and general purpose forces infrastructure to the maximum extent practicable, while maintaining unique nuclear force infrastructure requirements (e.g., large solid rocket motors, re-entry vehicles, and personnel with nuclear competence).

- DoD needs: (1) a "Nuclear Vision 2010 and Beyond," (2) a stable, adequately funded "Nuclear Forces Program Plan" complementary to the DOE Stockpile Stewardship Program, and (3) a full-time nuclear advocate reporting directly to the USD(A&T), starting now, to promote deterrence beyond the lifetimes of currently deployed systems and to place the United States in a better position to respond to unanticipated threats that might arise sooner.

CHAPTER 5

THE NUCLEAR STOCKPILE



Introduction

This paper is the product of a working group[1] that met during the winter and spring of 1998 to discuss issues concerning the maintenance of the U.S. stockpile of nuclear weapons, including subsystems and components, as well as issues relevant to the research, development, and manufacturing complex associated with the U.S. nuclear arsenal. These activities are generally within the purview of the Department of Energy (DOE).

The nuclear weapons stockpile has been significantly affected by the prohibition of underground nuclear tests, as mandated by national policy and codified when the United States signed the Comprehensive Test Ban Treaty (CTBT) in 1996 (although the Senate has not yet considered the Treaty's ratification). Underground testing was the cornerstone for the development and certification of nuclear weapons. The United States currently is not developing new nuclear weapon designs (although this is not prohibited under either U.S. law or the CTBT). A strategy for assuring the continuing safety and reliability of the existing nuclear weapons stockpile without nuclear testing was not enumerated until well after the United States entered into a nuclear testing moratorium with Russia and the United Kingdom in 1992. France and China conducted nuclear tests in anticipation of an international ban on nuclear testing (although the degree of their success is not known).

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1 Members of the Stockpile working group were: Dr. William Schneider, Jr., Chairman; Dr. Michael Anastasio; Dr. William Graham; Dr. George Miller; and Dr. John Nuckolls. Government observers included Ms. Judyt Mandel; and RADM James Metzger, USN. The views expressed in this paper are not necessarily shared by all members of the group and are not intended to be representative of members or organizations of the Department of Defense or the Department of Energy

U. S. nuclear weapons were not designed and developed on the basis of a specific life expectancy. During the Cold War, the United States designed and developed new systems so that older systems could be replaced before specific aging problems occurred. The rapid change in the world order at the end of the 1980s mitigated the need for new systems. Nevertheless, the restructured nuclear stockpile is expected to sustain deterrence indefinitely. This expectation, coupled with the prohibition of underground tests (UGTs), required the infrastructure responsible for providing the system of nuclear weapons to change in a dramatic manner. The sustainment of nuclear deterrence, as articulated in the Strategy and Policy working group paper, would include enhanced surveillance of the stockpile and a predictive, science-based stewardship program to determine how changes, intentional or otherwise (e.g., aging), would affect the weapon's performance, safety, and reliability.

The first section of this paper discusses the major issues surrounding the maintenance of the enduring stockpile, specifically, the evaluation of aging and other changes in warhead systems, as well as the ability of the nuclear weapons infrastructure to respond to these changes to ensure the safety and reliability of the stockpile. The next section will discuss the nuclear weapons stockpile and the infrastructure required to maintain and certify this system. Later sections will discuss the mix of weapons in the stockpile and how this mix relates to policy for use; how arms control affects the nuclear stockpile, both its size and composition; and the stewardship program, including an assessment of the certification process as well as the manufacturing complex. The final section outlines the resources needed to implement the stewardship program.

Nuclear Weapons Stockpile: Definitions and Dependencies

An understanding of the definition of the nuclear weapons stockpile is central to organizing the resources needed for its successful long-term management. Unlike conventional munitions whose development and manufacturing complex is structured to support an operational, consumable military item, the nuclear weapons stockpile is intended to support a deterrent force posture. The Nuclear Weapons Stockpile Plan (NWSP) specifies stockpile quantities, including those needed to support logistics operations. The NWSP is updated each year, and approved by the President. Production quantities and weapon safety/reliability characteristics are linked to deterrent scenarios for specific delivery systems (e.g., aircraft, cruise/ballistic missiles). The NWSP specifies the retention of a reserve of additional weapons and components to support safety and reliability testing and manufacturing requirements over the planned life of a particular nuclear weapon system, as well as additional "Inactive Stockpile" weapons for possible future force augmentation or reliability replacement purposes.

A number of terms frequently used to describe various components of a "nuclear weapon" tend to confuse the definition. There is a "nuclear physics package" within a nuclear bomb or warhead. There are the critical nuclear components and material, and the associated packaging, sensors, and electronics which "weaponize" the nuclear physics package. There are the nuclear delivery vehicles, and the launchers which enable the delivery vehicle to carry the weapon to its target. The section below defines the stockpile to include enabling aspects of the military applications of nuclear explosives.

Definition of the Nuclear Weapon Stockpile

The U.S. nuclear weapon stockpile is the aggregate quantity of nuclear weapons, weapon-associated subsystems, and weapon components needed to sustain a specific nuclear weapon deterrent posture defined by the President in the Nuclear Weapons Stockpile Plan. The deterrent posture is constrained by arms control agreements and other international commitments and the judgement of the President about the number and characteristics of nuclear weapons needed to sustain deterrence. On August 11, 1995, President Clinton expressed U.S. national security strategy with respect to the nuclear weapons stockpile as follows:

> *As part of our national security strategy, the United States must and will retain strategic nuclear forces sufficient to deter any future hostile foreign leadership with access to strategic nuclear forces. In this regard, I consider maintenance of a safe and reliable nuclear stockpile to be a supreme national interest of the United States.*

To maintain a given number of nuclear weapons on "alert" status, an operational infrastructure (maintained by the Department of Defense), and a scientific and industrial infrastructure (maintained by the Department of Energy) are required to support these weapons over their life. As a consequence of the absence of underground testing, the United States requires additional scientific (i.e., computational and experimental technologies) and industrial (i.e., monitoring and remanufacturing) capabilities to provide enduring confidence in the safety and reliability of the stockpile.

Weapons on alert status (on intercontinental ballistic missiles (ICBMs), bomber aircraft, and submarine- launched ballistic missiles (SLBMs)) make up only a portion of the full set of weapons,

Custodial Responsibilities of the DoD and DOE

Constituents of the Nuclear Weapon Stockpile	Departmental Custody
• Active stockpile	
- Deployed "on-alert" warheads	DoD
- Deployed warheads "off alert"	DoD
- Non-deployed warheads "off alert"	DoD
• Inactive stockpile and retired warheads	DoD/DOE
• Components	
- Plutonium pits—strategic reserve	DOE
- Other stored pits	DOE
- Canned subassemblies, cases, etc.—strategic reserve	DOE
- Other stored components	DOE

Table 1

subsystems, and components necessary to sustain a given nuclear posture. For both policy and analytic purposes, it is necessary to consider all the constituent components of the nuclear weapons stockpile, including active, inactive, and retired warheads, and components from (partially) dismantled weapons. Because the DoD and the DOE share responsibility for the nuclear weapons program, it is also desirable separately to identify the custodial responsibilities of the two Executive Departments as well (Table 1).

The quantities associated with the active stockpile have declined sharply as a result of arms control arrangements and fundamental changes in the international security environment as a result of the collapse of the Soviet Union. Quantities of inactive but not retired warheads have grown, and are planned to increase dramatically if the Strategic Arms Reductions Treaty II (START II) delivery vehicle constraints enter into force. The number of stored components has grown rapidly, since plutonium and uranium components are no longer being recycled into newwarheads. A fraction of these components has been designated as a strategic reserve not currently subject to disposition.

A dimension of U.S. government policy concerning the management of the stockpile that becomes particularly important in a warhead-counting arms control regime is the extent to which the active stockpile and the strategic reserve of components can serve as a hedge against unanticipated future requirements. The inactive stockpile is already viewed as a source of replacement warheads in the event of a system-wide failure of an active weapon type. In addition, however, previously tested weapons or weapon components might be combined in the future to meet a nuclear weapon requirement that cannot be met by the existing stockpile. For example, if there were a future national requirement for an anti-ballistic missile warhead with enhanced radiation characteristics (ER) or a weapon designed as an earth-penetrator, retention of components from retired weapons, especially those difficult or costly to manufacture, could provide a constructive hedge to meet such a requirement.

There are a number of inter-related issues inherent in the need to hedge against future contingencies. The United States currently does not require a high rate of series production of nuclear warheads. However, such a requirement could emerge, for example, from a change in operational requirements, or the need to remanufacture a specific nuclear weapon type if flaws developed that undermine confidence in the safety, reliability, or performance of the weapon. This type of stockpile contingency could also change the number of weapons to be held as reliability replacements in the event that physical change in a specific weapon type affected some, but not all of the weapons of that type held in the inventory.

Stockpile Safety and Reliability Issues

The unique character of nuclear weapons poses special safety and reliability concerns. The requirement that a set of nuclear weapons be retained indefinitely with undiminished safety and reliability of performance is extremely demanding; there is no national defense precedent. Because of the demands for new weapon designs during the Cold War period, the safety and reliability implications of protracted reliance on specific nuclear weapon types were not measured. Moreover, suspected safety and reliability issues with specific stockpile weapons could be assessed, and the effects of changes measured through underground testing. The circumstances of the post-Cold War security and arms control environment now make it inevitable that long-term issues associated with stockpile safety and reliability will have to be addressed.

Elimination of Underground Testing

As a matter of national policy, underground testing was suspended by statute in 1992, and later by executive decision; the suspension is now presumed permanent (with the exception of the Safeguard F escape clause) because of the Comprehensive Test Ban Treaty of 1996. While most faults in stockpile weapons have historically been detected through the surveillance process, a significant number of problems with the nuclear physics package were discovered by underground testing. Nuclear tests were also available to provide confidence that any repairs retained a high order of weapon safety, reliability, and performance. The United States conducted more than 150 tests of modern weapons, including types currently in the inventory, over the past two decades. Over the past half-century, the United States conducted more than 1,000 nuclear tests in which weapon safety and reliability assurance were a significant part. The absence of underground testing as an option for weapon safety and reliability assurance has made it necessary to create a new set of calculational and experimental tools as well as improved surveillance and remanufacturing technology. The design of these new tools aspires to approach the confidence previously invested in the safety and reliability of the stockpile as a result of underground testing.

Tritium Production

Today's tritium needs are being met from recycled material from dismantled weapons. The United States has not produced tritium since 1988, and the existing stock of this limited-life material will need to be replenished by 2005 to maintain the START I stockpile and current reserve requirements. The long-term needs of the nuclear weapons program will require a reliable source of tritium. The United States is investigating both light-water reactor and accelerator production of tritium. There are no serious technical issues associated with the reactor approach, but there are regulatory and licensing questions. For the accelerator approach, several technology issues need to be demonstrated at near-production levels, and costs need to be better defined. By the end of 1998, in consultation with the DoD, the DOE intends to select one of these two approaches as the primary production method. The other will be held in reserve as a backup capability. In addition, the DOE is maintaining its Fast Flux Test Facility in a "warm standby" condition for a potential role in producing tritium.

Stockpile Aging

The average age of U.S. nuclear weapons in the stockpile is 14 years—older on average than at any time in the past half-century. While this figure compares favorably to some nuclear delivery systems, the oldest stockpile weapon type (the W62) has already exceeded its anticipated deployment life, and the average weapon age will be greater than its "design life" (typically 20 years) soon after the turn of the century. The long-term implications for nuclear weapon safety and reliability—including the effects of thermal cycling, long-term vibrations, and the radiation environment experienced by both nuclear and non-nuclear components—are not known. In the past, aging properties occasionally affected nuclear weapon safety and performance, but design or remanufacturing changes could be validated by underground tests, and typical weapons did not remain in the stockpile long enough for serious aging problems to develop. Now that indefinitely long deployment periods are planned, and the nuclear weapons infrastructure is being reduced in size and capacity, the United States is developing new technologies to support the Stockpile Stewardship Program (SSP) in order to better understand the aging process and to evaluate changes in the weapons needed to assure compliance with requirements. The understanding of the weapons aging process developed through the SSP will also provide data to support subsequent weapon refurbishment or remanufacturing as needed.

Diminished Stockpile Diversity

A decade ago, the U.S. nuclear weapon stockpile included more than two dozen different nuclear weapon types. This diversity was required by the different missions assigned to nuclear weapons during the Cold War period. Since the end of the Cold War, a number of missions for nuclear weapons have been eliminated. The elimination of these missions has permitted a sharp reduction in the number of deployed nuclear weapon types, and accounts for the bulk of the dismantlement now under way in the nuclear weapons complex. In addition, arms control agreements have converged to reduce allowable deployments or proscribe several types of delivery systems for nuclear weapons.

These circumstances have also contributed to diminished stockpile diversity and reduced aggregate numbers of nuclear weapons required to meet national security needs. The nuclear weapon missions eliminated include:

- Air Defense
- Artillery Fired Atomic Projectiles
- Anti-Submarine Warfare
- Atomic Demolition Munitions
- Ground-Launched Cruise Missiles
- Short-range Cruise Missiles
- Intermediate-range Ballistic Missiles.

Stockpile Sustainability Dependencies

Without underground testing the United States must depend on a few critical elements to sustain the stockpile. The small number of weapon types remaining in the inventory (eight deployed and one in reserve) poses the risk of single-point failures if undetected problems propagate throughout the nuclear weapons stockpile and cannot be resolved due to technical inadequacies or lack of manufacturing capacity. As a result, the United States must better understand the critical elements so that the risks can be assessed and managed.

Diagnostic Technologies

The SSP contains an integrated system of new diagnostic or assessment technologies. These technologies are illustrated by the National Ignition Facility; the Dual-Axis Radiographic Hydrodynamic Test Facility; advanced computer simulation (the "Accelerated Strategic Computing Initiative"); a variety of facilities for gamma, X-ray, and neutron testing; and a new procedure to conduct subcritical experiments at the Nevada Test Site.

These advanced capabilities will exploit the existing database derived from the legacy of nuclear tests conducted by the United States between 1945 and 1992. Nevertheless, these advanced technologies are undergoing tests or are still in the construction phase. Their ability to contribute to sustaining the credibility of the stockpile will be established when the technologies come into general use (beginning in the early years of the next decade). Dependence on these new technologies is acute since underground tests are not available to ascertain (1) whether changes observed in nuclear weapons will affect weapon safety or reliability, and (2) whether modifications, refurbished components, or remanufacturing solutions will impair weapon performance.

Nuclear Weapon Production Complex

The lack of requirements for new nuclear weapon designs and the reduced need for high serial production rates of existing nuclear weapon types have allowed the DOE to restructure the nuclear weapons manufacturing process. To reduce costs, a downsized production complex has refocused on a small-capacity, capability-based complex using alternative manufacturing processes (when original manufacturing processes are prohibited by law, regulation, or cost) to meet normal refurbishment, remanufacturing and contingency requirements. The use of alternative manufacturing processes is fraught with risk. A decision to use alternative manufacturing techniques is likely to require a painstaking review before such changes are undertaken. Such a review is in progress for new pits planned for the W88 (Trident submarine-launched ballistic missile warhead) in 2002. Nevertheless, certain refurbishment actions will clearly be required at some time.

Manufacturing documentation on stockpile weapons is, in many cases, insufficient to permit remanufacturing, while in other cases, remanufacturing to original specifications is no longer practical as a consequence of changes in environmental regulations or in industrial practice. Because underground tests to validate manufacturing or design changes in nuclear weapons were available in the past, the absence of complete documentation was of only limited concern.

Weapon design and manufacturing specialists experienced in nuclear weapon design that was validated by underground testing are within a decade of retirement. The cumulative effects of these circumstances superimposed on the need to maintain a weapon stockpile long beyond its original design life drive the need for advanced evaluation and manufacturing technologies.

Nuclear Weapon R&D and Manufacturing Personnel

The nuclear weapon development and manufacturing complex has depended on a core staff of professionals with long experience in the complete development, manufacturing, and test process. The ability to conduct underground tests provided a rigorous and visible "pass-fail" measure of the success of the nuclear weapons establishment in producing nuclear weapons that met national safety, reliability, and performance criteria.

The substantial reduction in the number of scientists and engineers in the nuclear weapons program has further diminished both the development and manufacturing core staff. New personnel must be trained and their competence validated. These demanding circumstances require a special effort to inculcate new personnel with the experience attained by professional weapon design and manufacturing personnel still working in the nuclear weapons complex. Effective transfer of knowledge through modern archiving techniques is essential to sustain the stockpile.

Nuclear Weapon R&D Facilities

To assure the safety, reliability, and performance of existing nuclear weapons, the United States must develop an integrated program to address enhanced stockpile surveillance, service life extension, and the implications of the aging process. New assessment capabilities will, in some cases, require the construction of new facilities, while modernization of existing facilities will be sufficient in other cases. If nuclear weapons remain an element of U.S. national security policy or decades, it is possible that yet-to-be-invented diagnostic and manufacturing technologies will be needed to sustain stockpile confidence. Because nuclear weapons are less visible in the national military strategy since the end of the Cold War, the responsible Executive Departments and Congress may be tempted to underfund facilities critical to sustaining the credibility of the nuclear deterrent. Underfunding would magnify the uncertainty in the highest-risk component of the nuclear deterrent posture—the Stockpile Stewardship Program.

Policy Assumptions Related to Stockpile Safety and Reliability

Existing plans for sustaining deterrence derive from the need for a credible nuclear weapons posture with defined characteristics. These characteristics reflect the legacy of residual Cold War-era delivery systems, target characteristics, safety requirements, and other assumptions. These are not immutable, and changes over time could influence nuclear weapon stockpile management requirements. This paper does not attempt to quantify how changes would affect these assumptions; rather, the assumptions are explicated to acknowledge their potential influence in future stockpile management.

Weapon Mix

The United States has retained nine different nuclear warhead types (eight deployed and one in reserve) in its active and inactive inventory. These weapons are available for the existing delivery systems: ICBMs, SLBMs, manned bombers (including both cruise missiles and gravity bombs), Nuclear Land-Attack Tomahawk (TLAM/N), and dual-capable aircraft. The reduction in the number of weapon types by a factor of three over the past decade reflects the fact that several military missions no longer have nuclear weapon requirements.

Deploying fewer weapon types could increase the risk of single-point failures in weapon safety and reliability, and impose more demanding diagnostic requirements on the nuclear weapons R&D and manufacturing complex. However, having fewer weapon types could also diminish the demands on the manufacturing complex. With a less diverse stockpile mix, fewer separate sets of weapon-specific technologies would need to be retained.

Safety and Reliability Certification

Over time, U.S. policy has called for increasing weapon safety and reliability certification requirements, such as the incorporation of safety enhancements in "new" nuclear weapons designs through incorporation of insensitive high explosive, fire resistant pits, enhanced nuclear detonation safety, advanced security devices (e.g., permissive action links), and similar initiatives. These enhancements are largely independent of the details of nuclear force deployment and the level of readiness of the delivery systems.

National policy requires that nuclear weapons be as safe and reliable in an environment without underground testing as was the case before such testing ended. Whether this policy concerning safety certification will be maintained in the long term, in the face of unknown changes in the nuclear weapon stockpile derived from the aging process, is uncertain. However, there is no evidence that the public is prepared to relax current standards.

The issue of stockpile reliability is a more complex one. Non-nuclear components will continue to be tested at high enough rates to provide sufficient reliability values. Nuclear components have never been tested sufficiently to provide a statistically reliable value (in fact, the nuclear system is nearly always considered to be fully reliable in formal annual reports). Nuclear component performance has been assured in the past by establishing physical conditions sufficient to provide margins larger than any degradations caused by manufacturing variations, age, or environmental factors. Historically, when underground testing or surveillance identified a problem that threatened these margins, problems were corrected promptly rather than treated as a reliability degradation. The surviving stockpile designs are generally modern, and because they "push the envelope" from a performance perspective (smaller margins than might otherwise be possible), there is a concern that future degradation could create conditions for a high probability of weapon failure. Thus, circumstances that might be expected to increase the uncertainty in primary yield are more likely to produce a non-working weapon than one whose performance is marginally degraded. Because of the high order of manufacturing quality control in the production of stockpile weapons and components/subsystems, it is likely that a reliability failure would encompass an entire class of weapon.

Unique Role for Nuclear Weapons in Weapons of Mass Destruction (WMD) Deterrence

The U.S. government has formally abandoned the potential use of chemical or biological weapons to deter the threat or use of such weapons against U.S. territory, the territory of its allies, or against forward-deployed U.S. or allied forces. The United States continues to reserve the option to employ nuclear weapons in response to a chemical or biological weapons attack, although the circumstances when this might be done are calculatedly unspecified and a mbiguous. The "negative" security assurances associated with the Non-Proliferation Treaty (NPT) might inhibit the use of nuclear weapons in some circumstances. The option of a prompt response with nuclear weapons to a chemical or biological attack remains.

With regard to scale, U.S. officials have employed terms such as "overwhelming" to characterize a potential response to a chemical or biological weapons attack on U.S. interests. In this respect, the ability of nuclear weapons to hold even hardened targets at risk coupled with the sheer magnitude of their explosive force gives nuclear weapons their unique military and political effects.

It appears unlikely that nuclear weapons will be displaced by other technologies of mass destruction in the next quarter century. If other weapons were developed that could perform some of the missions now assigned to nuclear weapons, the impact on the stockpile would be proportional, especially concerning weapons whose primary mission relates to achieving area effects. However, the impact on the surrounding R&D and refurbishment/manufacturing infrastructure would be less extensive since a large fraction of the overhead is "fixed" and is largely independent of the size of the stockpile (within the range between a few hundred and a few thousand nuclear warheads). The R&D infrastructure is also largely a "fixed" cost, although some facilities may be less frequently employed in maintaining a smaller stockpile.

The Role of the Reciprocal Threat of Retaliation for Deterrence

Efforts by the United States and other nations to create international norms against the use of WMD in any form may challenge the role of nuclear weapons for deterrence, hence, the requirements for the management of the nuclear weapons stockpile. While the threat of reciprocal retaliation was at the heart of the Soviet-American strategic nuclear stalemate through the 1980s, it is not clear that this model of competitive equilibrium can endure. This may particularly be the case when nuclear weapons ownership can only be achieved by flouting international norms concerning WMD.

Nuclear weapons are increasingly seen by some critics as illegitimate for all nations, even the five powers who possessed them before the Nuclear Non-Proliferation Treaty of 1968. Nevertheless, the scientific, industrial, and financial barriers to WMD have largely disappeared. The primary inhibitions to the development, manufacturing, testing, deployment, and use of WMD are political, not financial or technical. While the costs of developing an indigenous production capability for special nuclear material are by no means trivial, the ability of three of the world's most poverty-stricken nations (e.g., India, North Korea, and Pakistan) to develop an indigenous special nuclear material production base suggests that the ability to do so is likely to be within the means of many nations in the 21st Century.

Theater Use of Nuclear Weapons

Diminished requirements for theater nuclear weapons to counter overwhelmingly larger conventional forces do not necessarily preclude the evolution of new requirements for theater nuclear weapons. New approaches to deterring WMD use or threats may require weapons with different characteristics than the types currently in the U.S. nuclear weapons inventory. The emergence of new tactical requirements for theater nuclear weapons could significantly affect the management of the stockpile since reconstituting earlier theater designs, or the development of new designs, would be required, and new delivery systems may be required as well.

New Weapon Designs

The uncertain nature of future nuclear weapon requirements to sustain deterrence makes it necessary for the Stockpile Stewardship Program to retain an ability to develop new designs for a future stockpile and modify current designs as required. The legacy designs from Cold War requirements may not meet future deterrent needs. Without nuclear testing, the laboratories are limited in the type of new designs that can be developed and certified to the satisfaction of the technical defense community.

Modifications to non-nuclear components are currently in progress on a number of weapon types, including the B83 (changes in radar, spin rocket motors, other parts) and the B61-Mod 11 air-delivered bombs for which an earth penetrator case has replaced the original bomb case. Careful analysis has been required on this latter design to confirm that any impact on performance is acceptable. In the future, other changes to delivery vehicles or stockpile-to-target conditions for existing warheads may be proposed, and must be evaluated on a case-by-case basis, but are clearly possible within some limits. Modifications to the physics package using existing or tested nuclear components and components with small perturbations from tested designs are possible. Small modifications to the W87 design are currently in final development phase and will be certified. The SLBM Warhead Protection Program pit reuse project is a prototype design activity that uses previously tested components in a new (Navy Mk 5) delivery vehicle. This project has the goal of producing a certifiable design. Other designs for future special applications are possible. For example, development of a warhead for theater missile defense appears feasible, particularly if the interceptor warhead volume and launch environments are compatible with several on-the-shelf designs. New designs based on standard technology but with large performance margins may also be possible. A small design effort based on this approach is in progress.

The Nuclear Posture Review and the Presidential Decision Directive that implements its recommendations require the DOE to retain the ability to design new warheads, even in the absence of current requirements. This capability must continue to be developed in programs like the SLBM Warhead Protection Program, since the analysis of small design modifications to existing designs does not exercise the full range of skills needed for new weapon design. The highly integrated nature of U.S. nuclear weapon designs severely limits the scope for wholly new designs or substantial changes made to existing systems in the absence of underground nuclear testing.

Nuclear Weapon Delivery Force Structure and Modernization

Appropriately, most attention focused on the problem of sustaining deterrence of the threat or use of WMD has emphasized the ability to sustain the U.S. nuclear weapon posture for an indefinite period. Nevertheless, the nuclear weapons are delivered by a finite set of delivery platforms—heavy bombers, dual-capable aircraft (F-15E and F-16C/D), air- and sea-launched cruise missiles, and submarine-launched ballistic missiles and land-based ICBMs. Although the SLBM and cruise missile delivery systems are relatively new, they were designed for a different strategic environment. The B-2 bomber is still being deployed, but the B-52 bomber is approaching a half-century of operation. There are no development programs or plans to replace these delivery systems at this time.

Heavy bombers, dual-capable aircraft, and cruise missiles can be replicated or have their operational life extended through service life extension programs. Trident-class submarines will have their service life extended from 30 to 42 years. The U.S. Air Force has several programs to extend the life of the ICBM inventory, including a propulsion replacement program, a guidance replacement program, and C3 modernization. Although there are service life extension programs in place, there are no current plans for a replacement of either the ICBMs or SLBMs. This differs from Russian and Chinese practice; both nations are developing a new generation of ICBMs and SLBMs. This poses a question for the future force structure supporting the deterrence mission. The eventual deterioration of the delivery system infrastructure for specific types of nuclear weapons would *de facto* eliminate some nuclear weapon types from operational use.

Arms Control

Bilateral and multilateral arms control arrangements could be an important constraint on the freedom of action of the U.S. government to manage its nuclear weapons stockpile. The post-Cold War environment for arms control remains bifurcated between the inertia derived from the Soviet-American arms control dialog which continues to play out in a series of bilateral arrangements and aspirations for further agreements, and non-proliferation objectives in the multilateral arena.

Arms control aspirations, especially in the bilateral U.S.-Russia context, are notably less well focused than was the case during the Cold War. The alternatives for arms control objectives cover a considerable range. Alternatives include minimalist or "near abolitionist" (and at the extreme, delegitimization of nuclear weapons) stockpile objectives calling for a small number of weapons, separated from their delivery systems, with forces employed for nuclear weapons delivery maintained at a very low level of readiness, to incremental reductions in delivery systems through the Strategic Arms Reduction process. Embedded within some arms control concepts are approaches that could have a direct impact on the management of the stockpile. They will be addressed here.

Nuclear Warheads as an Object for Arms Control

Bilateral arms control agreements between the United States and the former Soviet Union emphasized (1) control over the number of launchers, (2) details of the configuration of the launchers in terms of the number of platforms and warheads carried, and, (3) the nominal operational range of the weapon system (in the case of land-based missiles or aircraft). Launchers were seen as the decisive metric of strategic nuclear power, and warhead quantities treated as a derivative of the launcher count. Moreover, in an environment where high standards of compliance were required with monitoring accomplished through national technical means of verification, explicit limitations on the nuclear stockpiles of the signatories were not susceptible to high confidence verification of compliance. With the evolution of multilateral arms control arrangements, where lower standards of compliance have become acceptable, or as an inevitable consequence of the nature of the agreement (e.g., the Conventional Forces in Europe Treaty, the Chemical Weapons Convention, and the Biological Weapons Convention), some see opportunities with respect to incorporating nuclear weapons stockpiles into arms control arrangements.

The Intermediate-range Nuclear Forces Treaty opened a new approach to arms control compliance monitoring through on-site verification—a precedent that has been extended to other agreements. Detailed declaration procedures, designated deployment areas, and similar measures that contribute to confidence in on-site inspection arrangements have been introduced. These approaches could, in principle, provide a means to incorporating nuclear warheads per se into broader arms control arrangements.

If such an approach is taken in future arms control agreements, there are several implications for nuclear stockpile management that could affect the capability of the United States to preserve its nuclear deterrent. Among the issues of concern are:

- The degree to which such an arms control approach incorporated the entirety of the elements associated with operational nuclear weapon deployments including non-deployed weapons, spare components, weapons being refurbished or remanufactured, and similar aspects of the U.S. nuclear posture;

- How such a regime would affect the readiness of U.S. nuclear forces to meet operational requirements to sustain deterrence;

- The impact of such constraints on the ability of the United States to perform stockpile stewardship functions on those weapons controlled by an agreement in order to assure their safety, reliability, and performance; and

- Maintaining security and containing costs associated with the consequences for the nuclear weapon complex of such arms control arrangements.

How Warhead Controls Would Affect DOE Planning

Arms control agreements that would limit numbers of warheads and subsequent internal plans that may limit warhead types have important implications for DOE planning. The principal effects fall into three classes: manufacturing and maintenance infrastructure, tritium production, and dismantlement/disposition procedures. In addition, there would be some effects on the SSP activities at the laboratories, although the need for improved experimental and calculational capabilities in the absence of nuclear testing in support of assessment activities remains unchanged.

With fewer warhead types in the stockpile, there would be a reduced burden on the production complex and a somewhat diminished burden on the laboratories to support weapon-specific operations; this could ease the burden on training, process development, and the purchase and maintenance of unique equipment. For the production complex, a reduction in warhead numbers (including a reduction in numbers for most if not all remaining types) should reduce the time required to execute a refurbishment action on a given warhead type, if current plans for facility sizing remain the same. This is likely to be the case, since current planned capacity numbers for single-shift operation are, in most cases, capability driven. That is, simply having the capability to execute a given operation provides a baselinc capacity. It is important that a rapid response capability be maintained, since any stockpile problem is more likely to affect a larger fraction of the warheads in a reduced stockpile. It should be noted, however, that the time to respond to an issue includes the evaluation of the problem and the design and development of a solution. This interval, typically at least several years, is determined by laboratory capability and may be comparable to or greater than the production time.

For the United States (with its limited production complex) the size and composition of the inactive stockpile will still be the major determinant of a reconstitution capability. The inactive stockpile also can provide a reserve of backup warheads to allow wholesale replacement, either temporary or permanent, of some warhead types with problems difficult or impossible to correct. An asymmetry exists between the United States and Russia, which has retained a sizeable manufacturing capability because of its policy of frequent remanufacturing to avoid aging problems. This asymmetry potentially complicates the arms control process.

Institution of a verifiable warhead counting regime could add significant complications to current DOE dismantlement procedures, and to procedures for inactive stockpile storage. These costs must be included in any future analysis of potential cost savings provided to the DOE by a reduced stockpile.

Special Nuclear Materials (SNM)

The SNM used in nuclear weapons has been the subject of unilateral constraint for more than three decades. There are many possible forms for including SNM in future arms control agreements, although the arms control benefits of such restrictions for the five NPT nuclear weapon states are not readily apparent. In an environment where the nuclear arms competition among the five nuclear states has been constrained by other means, the arms control benefits of such restrictions would seem to be derived primarily from a control regime for non-nuclear states as a nonproliferation objective.

Retention of nuclear weapons will require attention to tritium production. Tritium, although not a special nuclear material, is essential for the performance reliability of all types of nuclear weapons in the existing U.S. nuclear stockpile. The relatively short half-life of tritium (12.4 years) makes it necessary to replenish stocks from time to time. Current budget plans do not include funds for a future tritium source. This significant shortfall must be addressed to maintain weapons performance. At current force levels, the United States needs to resume tritium production in significant quantities by 2005 to avoid depletion of the small strategic reserve. Reductions to START II levels delay this deadline by at least half a decade, if current policy of not providing tritium for the inactive stockpile is retained. Note that this policy is at odds with use of the inactive stockpile for rapid reconstitution. Reductions to suggested START III levels, particularly to the lower end of the levels being discussed, would provide additional delay for resumption of tritium production, although the reconstitution concern would remain.

Employment Constraints

Although an extensive set of multilateral employment constraints has been imposed on conventional weapons, and additional unilateral constraints have been imposed on U.S. conventional forces, little has been done in the nuclear arena. The United States government has found that sustained ambiguity concerning nuclear employment has enhanced deterrence. Hence, the United States has consistently refused to promulgate no-first-use declarations, and has abstained from excluding any specific target set from potential nuclear attack. Moreover, during the Chemical Weapons Convention ratification debate, Clinton Administration representatives suggested that the United States might be prepared to respond with nuclear weapons to an attack by a non-nuclear state if it employed other weapons of mass destruction (i.e., chemical or biological weapons).

Nevertheless, the "near-abolitionist" position expressed in a recent National Academy of Sciences study (*The Future of Nuclear Weapons Policy*, June 1997) argues in favor of a no-first-use declaration and an employment restriction on nuclear weapons that would constrain their use solely to a response to a nuclear attack on the United States. Similarly, a de-alerting approach suggested by the study would significantly diminish the readiness of nuclear forces and their deterrent value.

There are many employment constraints that would not, *per se*, have a significant impact on the nuclear stockpile. However, there are also alternatives that could significantly increase the cost of stockpile maintenance, while diminishing confidence in the safety and reliability of the stockpile.

Stockpile Stewardship Program

The end of the Cold War and the collapse of Soviet military power has fundamentally changed the international security environment. Even with this change, the role of nuclear weapons as a deterrent of the threat or use of nuclear and other weapons of mass destruction against the United States, its allies, and other interests has remained the same.

In parallel with the developments in international security affairs have been crucial changes in the U.S. nuclear weapons complex. If the United States is to retain its ability to protect its supreme national interests, it will have to assess the impact of these changes on the nuclear stockpile, and mitigate them to the extent possible. Among the most important changes the United States faces in maintaining the stockpile are:

- *Prohibition on nuclear testing:* Underground nuclear tests provided the final assurance that the stockpile of nuclear weapons was safe and reliable. In the past, problems that emerged during the life of a stockpiled weapon were addressed through modifications, and the result subjected to underground tests. This option is no longer available as a result of the CTBT. Moreover, as a result of a test moratorium from 1992-96, the United States did not develop the data and diagnostic technology necessary to assure nuclear weapon safety and reliability in the absence of underground tests.

- *Aging stockpile:* Because the demand for new nuclear weapon designs during the Cold War period, older designs were frequently replaced with new systems. This process retained a relatively low average age of the nuclear stockpile. Due to the rapid turnover of weapon types, the aging process did not affect confidence in the safety and reliability of nuclear weapons. This situation no longer exists. Under current plans, no new weapon types are to be developed, and the number remaining in the stockpile has been reduced from 32 types in the 1980s to only 8 today (plus the W84 in the strategic reserve). The average age of weapons has grown to 14 years (the typical design life for nuclear weapons is 20 years). In the past, the average age of the stockpile did not exceeded 13 years. The aging of the stockpile is an important issue because of the unique environment within and around a nuclear weapon. Materials change over time, through radioactive decay, embrittlement, and corrosion. The exotic as well as the common materials and sophisticated electronics in the weapon are subjected to a nuclear radiation environment whose effects on weapon safety and reliability over a long period of time are beyond U.S. experience. While some aging phenomena do not affect warhead safety, reliability and performance, others do. Previously unencountered aging-related problems are likely to emerge as a result of the indefinite retention of the existing stockpile.

- *Diminished stockpile diversity:* The reduction in the number of weapon types exposes the remaining stockpile to the risk of common aging processes that can produce en bloc component failures that jeopardize weapon safety and reliability.

- *Human capital in the nuclear weapons complex:* The expertise associated with the nuclear weapons establishment is unique. This establishment has depended heavily on an experienced cadre of specialists. The leadership of the weapons complex, with their nuclear weapon development, manufacturing, and support experience based on nuclear testing, are within a decade of retirement. In the post-underground nuclear testing environment, the future nuclear weapons leadership will be called upon to determine whether the nuclear stockpile is safe and reliable without underground nuclear testing. This human capital needs to be renewed quickly, while those with testing experience can interact with the incoming generation of nuclear weapon specialists who will have no underground testing experience. This subject is of serious concern and is part of a congressionally mandated study to permit a better understanding of this crucial need.

- *Maintenance of a nuclear weapons manufacturing complex:* The nuclear weapons manufacturing complex reflects the legacy of half a century of producing nuclear weapons in quantities geared to Cold War requirements. This complex, too large for post-Cold War needs, has been downsized. Ironically, the manufacturing complex must now be able to respond to a more diverse, and less predictable range of contingencies than was the case during the Cold War. If the DOE National Laboratories, the Departments of Defense and Energy, and the military users determine that new manufacturing processes are need to assure weapon safety, reliability, and performance, these processes will need to be integrated into and funded in the SSP.

- *No requirements for new-design warheads:* Without new production programs, warheads will remain in the stockpile well in excess of their anticipated lifetimes, and beyond the U.S. base of experience. Moreover, without requirements for new warheads, existing warheads will have to be refurbished, modified, and remanufactured to extend their stockpile lifetimes to meet changing military requirements.

Nuclear Weapons Physics Pertinent to the SSP

A thermonuclear weapon goes through several distinct phases in order to produce the desired output—explosive energy (nuclear yield) customarily expressed in equivalent tons of TNT. The Figure below is a schematic representation of the process and the relationship of diagnostic and experimental facilities in the SSP to various phases of the nuclear explosive process.

Modern thermonuclear weapons consist of two stages, a primary and a secondary, plus a radiation case that channels energy from one to the other. The primary stage functions by compressing a shell of

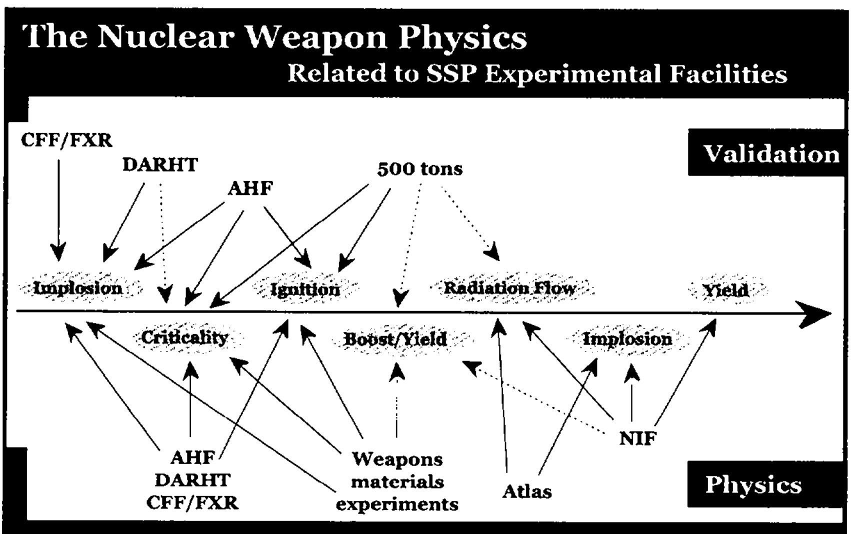

Figure 1

fissile material (often plutonium) with a high explosive charge. The initial subcritical assembly of fissile nuclear material, called a *pit*, is symmetrically imploded. In this subcritical phase, there is no nuclear yield. Nuclear phenomena crucial to the performance of the weapon take place at low levels of yield—500 tons or less. In the primary stage, the overall density increases following detonation and becomes high enough that the nuclear material reaches a supercritical state. At the proper time, neutrons from a neutron generator are injected into the pit to initiate exponential growth in the neutron population and energy production. In a boosted primary, a cavity in the center of the pit is filled with deuterium and tritium gas. During implosion, this gas is compressed and heated until it undergoes fusion, and neutrons from the fusion process flood the compressed pit. This pulse of additional neutrons in the supercritical pit greatly increases or "boosts" the fission yield.

Most weapons in the stockpile have a thermonuclear secondary stage. The last operational phases of a thermonuclear device involve the implosion and ignition of this stage. Radiation from the hot exploding primary stage is channeled by the radiation case to the secondary. This compresses and ignites the secondary stage, which produces fusion energy from the lithium deuteride fuel. Fusion neutrons are captured by the secondary stage, producing tritium which subsequently undergoes fusion reactions with the deuterium in the fuel.

The functioning of a nuclear weapon is highly complex and well beyond the capabilities of the most sophisticated computing facilities to model it in its entirety. This limitation posed no risk to the credibility of nuclear deterrence when underground tests were available. Problems that emerged in the stockpile could ultimately be subjected to explosive testing to validate changes that might have to be made in the original weapon design, components, subsystems, or manufacturing.

In the absence of underground nuclear testing, however, efforts to sustain confidence in the stockpile as it ages beyond a basis in experience make it necessary to develop and apply advanced technologies to attempt to validate the safety, reliability, and performance of the stockpile through a science-based approach to the physics of a nuclear weapon. Each phase in the explosive sequence of modern nuclear weapons (in the case of two-stage thermonuclear weapons, these phases include primary implosion, criticality, ignition, boost/yield, radiation flow and secondary implosion, and ultimate nuclear yield) must be subject to new diagnostic technologies linked through high performance computing to integrate data from experimental facilities in the Stockpile Stewardship Program.

This approach, because it has not been validated by underground tests, has a degree of risk. Some of the facilities needed for the SSP are still in the process of development. In the future as the stockpile ages decades beyond its original design concept, new diagnostic and experimental technologies may be required. The SSP represents the minimum programmatic basis for sustaining confidence in the stockpile. The risk inherent in the current program may be mitigated to a degree by other measures described elsewhere in this paper.

The DOE stockpile stewardship strategy seeks to maintain the stockpile through an integrated and continuous process of surveillance, assessment, and manufacturing linked throughout by computational modeling and prediction. The aim of this strategy is to sustain confidence in the weapons themselves, in the systems that maintain the weapons, and in the judgement of the specialists who assess the weapons. In place of the process of UGTs as the ultimate arbiter of stockpile confidence, with a structure of peer review among weapon specialists in the national laboratories, a new structure has been put in place. This structure includes a formal dual-validation review process among two independent teams from the national laboratories, and an annual certification process by the Secretaries of Defense and Energy.

The Stockpile Stewardship Program Presents a Risk to Sustained Deterrence

The SSP is the highest-risk element of the national effort to sustain deterrence in the absence of underground nuclear tests.

In an effort to approach the previous confidence in the safety, reliability, and performance of the nuclear weapons stockpile, the DOE is creating a network of diagnostic and experimental facilities under the SSP. This network is science-based, employing advanced capabilities to monitor stockpiled nuclear weapons and assess their ability to meet their performance standards, safely and reliably. The facilities and diagnostic capabilities are designed to allow assessment of the effects of aging phenomena, re-manufacturing and refurbishment, and other elements of the stockpile surveillance and maintenance process on weapon safety, reliability, and performance. Because this effort cannot recapture the confidence in nuclear weapon safety, reliability, and performance that underground testing provided, success is not assured. As the stockpile encounters extreme aging, DOE may require further advances in scientific knowledge and, potentially, additional resources to create more capable experimental facilities. The major experimental facilities in the SSP will not be completed until the latter half of the first decade of the 21st Century—more than a decade after the last U.S. underground nuclear test was conducted. Personnel in the laboratory and manufacturing complex who have substantial underground nuclear testing experience will be out of the work force when the most difficult assessments will have to be made.

As a consequence, the present structure of the SSP—its facilities and associated costs—can only be considered an estimate based on current expectations of nuclear weapon specialists. Extreme aging phenomena of nuclear weapons are beyond the experience of the U.S. nuclear weapons R&D and manufacturing sector. It cannot now be foreseen whether increases in "inputs" in the form of additional resources will produce a concomitant increase in scientific and industrial knowledge of the state of stockpiled weapons sufficient to sustain this "supreme national interest," the stockpile, without a resumption of underground nuclear testing. This dilemma reflects the risk inherent in the Stockpile Stewardship Program.

Elements of the SSP

The SSP as developed by the DOE is designed to assure the safety and reliability of the enduring stockpile without the ability to test the nuclear portion of the weapon through UGTs. In addition, this program has been designed to assure that the United States can extend indefinitely the life of the nuclear weapons that make up the stockpile—a mission defined by the President as a "supreme national interest" of the United States. Finally, this program must maintain the expertise responsible for the stockpile and keep open the option to resume new design and testing should this become a requirement of national policy. Because the success of the SSP remains critically dependent on program elements still being developed, the SSP is not without risk. The integrated SSP has two major components.

- *Surveillance, manufacturing,* and operations, which focus on monitoring the condition of the existing stockpile, and provide the capability to refurbish, rebuild, or modify the warheads if necessary. Without a successful enhanced surveillance program, the manufacturing complex would have to be sized to be able to conduct a costly emergency remanufacture of a critical weapon type over a brief period; and

- *Assessment and certification,* which include all of the design and research efforts necessary to certify the safety, reliability, and performance of the existing or refurbished warheads—and the processes which produce them.

All of the activities associated with the SSP can be categorized according to one of these two elements.

Because the United States can no longer subject warheads to UGTs, and because these weapons must remain in the stockpile for a much longer time than originally anticipated, the SSP must maintain a much-strengthened surveillance effort. Moreover, the surveillance of the warheads must look for changes at a much more detailed level than previously needed when UGTs were available. The surveillance must work hand-in-hand with the assessment and certification activities to evaluate the consequences of abnormal conditions, as well as to be aware of potentially malignant conditions that might pose a risk to the safety, reliability, or performance of the nuclear weapons.

In addition, the manufacturing element of the SSP must perform routine maintenance of the remaining warheads, and be able to refurbish or remanufacture the warheads when necessary. This last task may be complicated because materials and manufacturing processes used in the original production of the warheads may no longer be available due to contemporary environmental safety and health laws and regulations, or antiquated materials used in the original design. This manufacturing capability must also include the production of a limited number of pits per year (as these are consumed in the regular surveillance process), as well as the ability to deliver tritium in the quantities required for the enduring stockpile.

Decisions about the size of the manufacturing complex will depend upon the success of the surveillance program. If the surveillance program can find emerging problems early so that the manufacturing complex can build replacements over an extended period of time (as is now planned for in the SSP), a relatively small manufacturing complex will suffice. However, if surveillance does not find problems until they are serious and pervasive, the manufacturing program will have to be sized for a substantial emergency remanufacturing effort. However, since even the most advanced "laboratory test" facilities can simulate only a small aspect of the performance/operation of a nuclear weapon, a number of facilities will be required to validate the new codes and physical models, as well as to measure the behavior of the warhead in the "pre-nuclear" regime.

As in the past, the "science" component (i.e., the assessment and certification program of the stewardship program) must be integrated with the manufacturing component to ensure that the stockpile is always safe, reliable, and performs as specified. Changes or abnormalities uncovered in the surveillance program must be analyzed in detail to ensure that the system meets specified safety, reliability, and performance standards. Any remaining doubt must be resolved through warhead modification in the manufacturing complex.

The system of manufacturing facilities—"the plants" which provide the materials, and assemble, disassemble, and inspect the warheads—has changed dramatically over the past several years. Some of the plants have been shut down, and their functions consolidated at the remaining facilities, both plants and laboratories. Table 2 shows

Original Manufacturing Complex

Facility	Location	Function
Hanford Site	Richland, WA	Plutonium production
Idaho National Eng. Lab	Idaho Falls, ID	R&D
Rocky Flats Plant	Golden, CO	Pit production
Kansas City Plant	Kansas City, MO	Non-nuclear components
Pantex Plant	Amarillo, TX	HE; final assembly
Mound Plant	Miamisburg, OH	Non-nuclear components
Fernald Plant	Fernald, OH	Uranium components
Y-12 Plant	Oak Ridge, TN	Uranium components
Savannah River Plant	Aiken, SC	Tritium, Plutonium
Pinellas Plant	Largo, FL	Neuron generators, thermal batteries

Table 2

the structure of the nuclear weapons manufacturing complex as it existed a decade ago. This infrastructure was needed to support the requirement for high rates of serial production of nuclear weapons. The process of replacing older systems with new designs, often long before an existing weapon approached its design life expectancy, created a continuing requirement for a large manufacturing complex. The new approach to manufacturing now being implemented seeks through the Advanced Design and Production Initiative to achieve a manufacturing capability that will support more limited needs primarily related to refurbishment and remanufacturing. A hedge against a larger manufacturing requirement is needed as well to cope with the manufacturing implications of a single-point failure of an entire weapon type now in the stockpile, and a future need to develop and manufacture an entirely new weapon design. The plants are currently underfunded which limits the ability of the manufacturing complex to meet national requirements to sustain deterrence.

Ten different facilities handled the material processing and manufacturing. Due to downsizing and consolidation, those same functions now take place at six locations. Five of the original plants have been shut down. Idaho National Engineering Laboratory is no longer in the nuclear weapons production complex. Four of the original ten plants are still in operation and some of the functions previously performed by the manufacturing complex have been transferred to two of the R&D laboratories. Table 3 summarizes the

Current Manufacturing Complex

Facility	Location	Function
Y-12 Plant	Oak Ridge, TN	Uranium components
Savannah River Plant	Aiken, SC	Tritium, Plutonium
Kansas City Plant	Kansas City, MO	Non-nuclear components
Pantex Plant	Amarillo, TX	High explosive, final assembly
Sandia National Lab.	Albuquerque, NM	Neutron generators
Los Alamos National Lab.	Los Alamos, NM	Pit production

Table 3

restructuring of the manufacturing complex. This restructured capability must manage a diminished number of pit builds and the replacement of limited life components and also must provide the required amount of tritium for the enduring stockpile.

To some degree, the "hedge" function for the manufacturing complex may be mitigated by not disassembling retired weapons. Retention of older, but proven designs could offset the risk implied by the failure of a specific stockpile type in some circumstances. This subject – "virtual manufacturing" – is discussed in more detail later in this paper.

In the past, nuclear warheads were routinely removed from the stockpile and inspected for abnormalities. The impact of any irregularities found could ultimately be subjected to underground nuclear testing. Furthermore, the resulting draw-down of the stockpile from these destructive evaluations could be addressed by the robust manufacturing capabilities of the complex. Although weapon samples are still taken, the impact of abnormalities in the sample can no longer be subjected to underground testing. Rather, the effect of these irregularities must be determined in above-ground experiments, or through detailed numerical simulations. Simply looking for changes in the weapons themselves will no longer be adequate. By the time a change is required, it may be too late to respond. In some cases, change must be anticipated, and the precursors to these changes must be monitored. For example, the fissile material in the weapon's primary stage, plutonium, undergoes alpha-decay. These alpha particles, which are the nuclei of helium atoms, produce vacancies in the plutonium and can cause the material to swell. This problem is exacerbated over time. In the past when warheads were not expected to remain in the stockpile for more than their design life, this sort of issue was of little concern. However, warheads are now expected to remain in the stockpile indefinitely. Will this swelling ultimately affect the safety, reliability, or performance of the weapon? To obtain answers to this question, and many like it, the enhanced surveillance program seeks to monitor the development of these vacancies as the plutonium ages. The results of this investigation are used in developing aging models for plutonium. The effects of this aging must be tested in sophisticated numerical simulations to determine or estimate the consequences.

The laboratory structure to support the stockpile has also been downsized in parallel with the manufacturing plants. Although none of the weapon labs has been closed, their defense-related activities have been reduced in size by 50 percent. Additionally, the activities at these laboratories have changed dramatically. Although the laboratories are now responsible for the integrity of the enduring stockpile, they lack the ability to actually test the weapons. Accomplishing this daunting task will require tests, using highly sophisticated simulations of the weapons, that do not result in criticality of the fissile material. Thus, the two major elements of the assessment and certification program are the advanced simulation capability and an experimental program able to test the non-nuclear performance of the warhead and validate the new simulations.

DOE created the Advanced Strategic Computing Initiative (ASCI) to develop the next generation of computers and simulations that would be needed to validate the stockpile. The major thrusts of this program are the development of very high performance computational tools and the corresponding development of new computer codes to simulate weapon performance. One of the ASCI goals is to produce a 100 Teraflop computer by 2004. This is an increase of two orders of magnitude in computational speed from today's most capable computers. The simulations will include (1) better models of the physical properties of the materials used in the warhead, (2) high spatial resolution, and (3) three-dimensional computations of nuclear components and systems. The improved models of the physical properties are needed to simulate, *a priori*, the dynamics of the warhead from the detonation of the high explosive through the detonation of the weapon's secondary stage. These physical properties include material strength, equation-of-state, and material opacity. Highly detailed simulations are required to study the evolution of specific phenomena. For example, the hydrodynamic evolution of a particular warhead component from its initial conditions through its final configuration before detonation is of fundamental importance to determining whether a specific weapon will be safe and reliable, and will perform as specified.

Finally, the SSP needs a full three-dimensional simulation to allow investigation of specific engineering or aging features that cannot be evaluated in two dimensions. When the computer codes have been validated (in the absence of testing, they can only be partially validated), they can be used to estimate the long-term effects of warhead aging or the impact of engineering changes to the device. In the past, codes used to design the nuclear device were "calibrated" against UGTs and empirical parameters were adjusted to match the results of the test. Without testing, this former method of computer code development is no longer possible.

The other critical aspect of the assessment and certification program is experimental activities. These experiments must provide the data on the material properties in the warhead as well as the behavior of the warhead before the fissile material achieves critical mass. In addition, experiments that simulate, in a scaled manner, and without achieving fissile material criticality, the behavior of a nuclear device are crucial to ensure that the new codes are correctly predicting the actual performance of the warhead. These experiments must investigate the phenomena associated with a nuclear explosion without actually detonating a nuclear weapon.

The facilities required to obtain these crucial data are highly diverse and vary in size from table-top instruments that measure surface roughness in materials, to very large, costly, and complex facilities that generate conditions which approach those in a nuclear explosion. Unlike the ASCI program where one computer can, in principle, be used to do all of the simulations, the necessary experimental facilities are often designed to acquire a certain type of information and cannot be applied to a different problem. The major facilities required to execute the experimental program include those that address hydrodynamic phenomena associated with the primary stage of the weapon; high energy-density facilities that access regimes close to those attained during a nuclear explosion; and facilities required to study material properties. In addition, a unique set of experiments—

the "sub-critical" experiments conducted at the Nevada Test Site—are studying properties of plutonium when subjected to conditions encountered in the early stages of the primary's performance, before criticality of the fissile material is achieved.

Hydrodynamic facilities are used to study the dynamic behavior of full-scale primaries (and the surrounding materials) but without fissile material during the detonation of the high explosive. The ability to predict this behavior is crucial to model properly the performance of the weapon primary stage. Failure of the primary will result in the failure of the entire device. Hydrodynamic testing of these mock primaries has always been an integral part of the design and test program. Facilities at both Los Alamos National Laboratory (LANL) and the Lawrence Livermore National Laboratory (LLNL) have been used to radiograph the imploded mock-primary at a single point in time during the implosion. These facilities, known as the FXR at LLNL and PHERMEX at LANL, are still used for hydrodynamic testing. Without UGTs, the codes used to model the primary stage will require even more detailed information on the primary's behavior. The Dual Axis Radiographic Hydrodynamic Test Facility is currently being built at LANL to provide two views of the implosion with the possibility of obtaining multiple times on one of the views. This is a significant improvement over the one-time/one-view (two dimensional) information available from current facilities. Analysis is currently under way to define exactly how much information is required to model accurately the dynamics of primary performance. The facility that would provide this detailed level of information is called the Advanced Hydrotest Facility. The requirements for this facility arc currently being defined. Laser facilities (NOVA to be replaced by the National Ignition Facility) and pulse-power facilities such as PAGASUS and ATLAS are also being used to investigate implosion dynamics. None of these facilities can provide all of the information on a primary's performance—only its behavior up to and immediately prior to fissile material criticality. This information must be incorporated into the advanced computer codes which estimate the weapon's ultimate performance.

During and after detonation of the weapon's primary stage takes place, conditions are achieved in the weapon which are truly unique on earth. Temperatures and material densities result in extremely high energy densities. The behavior of materials in these high energy-density conditions can only be studied in a nuclear explosion. However these high energy-density regimes can only be approached in certain types of facilities—and then only for very brief periods of time within the fraction of the time in which a nuclear explosion takes place. The National Ignition Facility, currently under construction at LLNL, will provide information on material properties (equations-of-state and opacity) and material behavior (hydrodynamics) as well as radiation transport that can be integrated into computer simulation codes. In the NIF, the energy from an array of laser beams is focused into a small cavity to generate very high energy densities. This machine was designed to produce a sufficiently high energy density to implode a small capsule of deuterium-tritium material to ignition as in a primary stage of a nuclear weapon. This phenomenon in itself will allow the validation of some of the aspects of the weapon computer code performance relating to primary ignition and thermonuclear burn as well as to test the designers' skills. This test will provide useful data even though it cannot simulate thermonuclear burn under weapon conditions. An alternative path to achieving these high energy densities is being pursued at Sandia National Laboratory using a pulsed-power machine. Other pulsed-power machines at LANL are designed to generate pressures relevant to the weapon's primary stage and to study material properties and behavior in that regime.

Finally, facilities are required to investigate the details of material composition and behavior. These facilities include gas guns and particle accelerators such as those at the Los Alamos Neutron Science Center. These facilities will provide critical information on material properties and aging.

In the past, validation of the stockpile relied on integrated UGTs at the Nevada Test Site. Today, assessments leading to stockpile certification must rely heavily on experiments at a variety of facilities that provide information on elements of weapon performance. This information will be integrated in next-generation design codes currently being developed.

The information archived from past test programs comprising data from over 1,000 nuclear tests will serve as the ultimate arbiter of the SSP's ability to predict nuclear weapon performance. Although in many cases, certain data are incomplete or non-existent, these data were derived from tests that produced measurable yield. The tools of the SSP will ultimately be tested on their ability to model accurately these past events.

Activities of the SSP

To assure the national leadership that the enduring stockpile continues to be safe and reliable and will perform as specified, the DOE has put in place a number of formal activities to evaluate systematically the warheads in the stockpile. On top of the standard surveillance program that inspects sample warheads, an annual certification program requires that the design laboratory (i.e., the lab originally responsible for a particular warhead design) evaluate the findings of the surveillance, and re-examine the warhead's status. Independent evaluations by DoD also examine the integrity of the stockpile. Based on the results of these evaluations, the Secretaries of Defense and Energy send a notice on the status of the stockpile to the President each year.

The dual revalidation process represents a formal certification of a warhead's conformance with its required military characteristics. Two separate teams of weapons experts, one from each laboratory, independently assess the warhead. These review teams combine new computational and experimental investigations with stockpile surveillance results, predictive analysis, and data from past nuclear and non-nuclear tests. The first dual-revalidation effort is now under way. The W76 warhead is being scrutinized by an Original Design

Team (LANL/SNL/New Mexico) and an Independent Review Team (LLNL/SNL/California). The process is expected to last two to three years for each warhead design.

In addition to the formal activities that seek to assure the integrity of the existing stockpile, certain elements of the stockpile are subject to upgrades and modifications. Two examples of such modifications include the W87 Service Life Extension Program and the conversion of the B61-Mod 7 air-delivered weapon to the B61-Mod 11 configuration. The W87 Service Life Extension Program incorporates design changes to enhance the structural integrity of the warhead. Engineering development is proceeding and includes a program of above-ground experiments and high-fidelity flight testing. LLNL is addressing the effects of the proposed design changes on the warhead's performance using the latest computational models supported by the existing nuclear and non-nuclear test database and laboratory experiments. The W87 program is also serving as a model for life extension programs for other stockpile warheads. Experience gained in the W87 refurbishment will guide future life extension activities of other weapons.

Replacement of the B53 with the B61-Mod 11 weapon has improved the inherent safety of the U.S. stockpile. The B53 air-delivered gravity bomb was the oldest weapon in the stockpile, and produced before modern safety features were developed. Conversion of the B61-Mod 7 to Mod 11s (both configurations are air-delivered) requires replacement of the radar nose and center case with a one-piece hardened steel nose and replacement of the parachute in the bomb's tail assembly with steel ballast parts and a drag flare to change the flight characteristics of the weapon. By modifying a small fraction of the existing B61-Mod 7 bombs, the DoD was able to retire the B53 from the stockpile while still meeting mission requirements.

Teams from the production plants and the responsible laboratories (LANL and SNL/New Mexico) addressed and resolved the design and manufacturing issues early in the retrofit process. They made extensive use of computer-aided design systems to develop the component part designs and the production processes concurrently. They also defined appropriate qualification tests and analyses for certification of the acceptability of the retrofitted warhead and its new delivery conditions. A number of successful flight tests confirmed that the modified device will perform as expected and thus can be deployed as a B53 replacement.

The conversion of the B61-Mod 7s to Mod 11s demonstrated several aspects of the Stockpile Stewardship Program. Integration of design and production engineering was a crucial factor in the timely completion of the effort. Because specialists with nuclear test and weapon design experience were available at both the plants and in the laboratories, the B61 Mod 11 could be certified and put into the stockpile in about one year. In the past, such an effort would have required two to three years and a UGT. The approach appears to be promising as a template for the ability to sustain the stockpile in the future.

Mitigating SSP Risk

The Stockpile Stewardship Program proposed by the Administration is acknowledged to be the minimum credible program necessary to support U.S. national security policy aims. It also underpins the CTBT safeguards offered by the Administration as part of their CTBT ratification initiative. The risk inherent in relying on yet-to-be-developed technologies and facilities is reflected in the cautious remarks of officials responsible for the program. The SSP has been described as "credible but not assured" by the DOE weapon labs directors and "not without risk" by the DOE Assistant Secretary for Defense Programs, the official with the primary responsibility for implementing the SSP.

In Congressional testimony the Directors of the national weapon laboratories have indicated that their support for SSP is conditional on the program being fully funded. Concern about the adequacy of resources for the SSP has stimulated questions as to whether the

current SSP provides an adequate hedge against a failure of the SSP as currently structured to meet its objectives. Both Administration policy and congressional direction call for a hedge against future changes in the arms control and international security environments. Further, the DOE has been directed to retain a core intellectual competence in nuclear weapons technology and expertise, sufficient to design new weapons and return to full-scale nuclear testing if national policy so requires. Maintaining such a hedge is now a low priority within a restricted budget and constrained policy environment of the SSP.
The need to modify existing weapon designs in some manner is inevitable (consider the B61-Mod 11 case). Yet, the public rhetoric (concerning whether the modification constituted a "new design") surrounding this program has tended to obscure the intent to retain redesign and configuration flexibility if the ability of the U.S. government to sustain nuclear deterrence so requires.

Although the SSP includes a credible technical plan for enhanced surveillance and manufacturing/refurbishment, this element of the program is underfunded to permit resource allocation to the higher priority assessment and certification program. As a result, the time required for bringing an operating production capability on line is being extended. Concern for the early funding of the assessment and certification program of the SSP places other elements of the SSP at risk. This risk can be mitigated with higher resource levels.

Even if all these issues could be assured of a solution and a commitment to solve them, there exists the "window of vulnerability" inherent to the SSP plan. The elimination of the nuclear testing option (and closed production facilities) 15 years before the fully functional SSP could be brought on line has created the risk inherent in the baseline SSP. The risk of a failure of the SSP, from either a technical perspective or from a delay in its timely completion, is apparent. These concerns raise the question of how the SSP could be enhanced to mitigate the risk to national security inherent in the SSP baseline.

Risk Reduction Strategies

Ultimately, SSP risk reduction strategies fall into three categories: correcting resource shortfalls, expanding the scope for experiments, and offsetting necessary reduction of the manufacturing complex by halting the dismantlement of certain weapons. Additional resources will be needed to permit the acquisition of the technical capability in a timely manner before the experts retire and before the weapons aging process overwhelms the technical capability to assure the deterrent credibility of the stockpile. Broadening the scope of permitted experiments to achieve a low level of permissible nuclear yield allows the ability to validate and test with less risk-prone extrapolation to the actual weapon configuration or operating environment(s) of the stockpile weapons, and to validate the new tools for the SSP. Constraining dismantlement increases the "virtual remanufacturing capability" contained in a reserve stockpile during the period that new production capabilities are being brought on line and validated.

- *Resources:* The SSP is underfunded. Estimates to fund fully the plan described in the *Stockpile Stewardship and Management Plan* (the "Green Book") could require up to $2 billion per year more than is currently reflected in the budget, especially in the early years of the program. Additional resources would allow parallel paths on technology development and aggressive balanced approaches to assessment and production, experiments and computation, as well as industrial and R&D facilities. An aggressive, balanced, and parallel effort would reduce both technical risk and the time required to implement the program. The risk posed by the program resource shortfall is that implementation of the program could be materially delayed, extending the window of vulnerability. Additionally, the risk of increased overall program cost could expose the SSP to further political vulnerability. The program could be delayed as a consequence of a resource shortfall so long that it will fail because the expertise required to validate the new system will no longer exist. Additional resources could accelerate the completion of the construction and implementation of the assessment and validation tools required to both assess current problems in the stockpile and later to validate the functional capability of the production complex. The value of these tools will be significantly diminished if they are not implemented before the current pool of experienced personnel exit the labor force. Moreover, additional resources would allow for acceleration of the start-up of the production complex and appropriate sizing to cope successfully with an emergency weapon rebuild initiative in the interim before the advance surveillance technologies and their complementary production complex are validated. Additional resources at this time will also permit an improved appreciation of the cost of risk mitigation in a CTBT environment. From a public policy perspective, doing so now is preferable to a decision a future President would have to make to exercise the "supreme national interest" provision of the CTBT, should the SSP not achieve its objectives.

- *Increasing the scope of permitted experiments:* Restrictions on the scope of permitted experiments under the CTBT increase the cost and risk of the SSP. Several reviews concluded that broadening the scope to conduct experiments within the SSP to include very low levels of nuclear yield (between 4 pounds and 500 tons) would significantly mitigate the risk of failure in the SSP. Employing the SSP's baseline technology plus permissible experiments with 4 pounds of nuclear yield would increase confidence in the ability to rebuild aging weapons and allow certifiable stockpile replacements in some (though not all) cases. Increasing the yield in permitted experiments to 500 tons would produce higher confidence in several aspects of weapon safety, and many issues of maintenance and assessment of the stockpile. While such an initiative is not on the current political agenda, a recognition of the impact of such flexibility on the cost of the SSP and confidence reposed in the stockpile makes the issue a pertinent dimension of the public policy debate over the CTBT.

- *"Virtual manufacturing":* Curtailing the process of weapon dismantling is a low-cost means of reducing near-term cost in manufacturing complex readiness. Existing stockpile weapons are the only source of additional "proven" designs. The weapons in the inactive or retired stockpile today constitute the only high-confidence hedge against a loss of confidence in weapons currently in the stockpile. Moreover, if national policy requires additional weapon types, "retired, but not yet dismantled" weapons are the least costly and most responsive means of addressing a national contingency. For example, if U.S. policy required an earth-penetrating nuclear weapon, a nuclear artillery round (one designed to operate when launched from an artillery tube) could be suitably modified to serve in this role. Similarly, if national policy so required, a low yield/low-residual-radiation design may be applicable to a biological agent destruction mission.

New Design Capability

The DOE SSP maintains the core intellectual capability for new design as a byproduct of its stockpile maintenance program. The intellectual skills necessary for surveying, assessing, refurbishing, and certifying the stockpile are fundamentally related to understanding the intended purpose of the weapons in the stockpile. The stewardship program therefore must maintain expertise and competence in the theory and practice of nuclear design.

However, without ongoing programs focused on actually developing and certifying new designs, the overall stewardship program will fail to develop an adequately flexible, robust, and responsive nuclear weapon design program. An example of this is that weapons are being retired and dismantled today without a rigorous assessment of their value to addressing design needs in the future.

Effective deterrence potential requires the ability to respond swiftly with a wide range of potential application/targets, including hard and deeply buried/hardened targets, the destruction of biological and chemical weapons and/or their components, and missile defense. Additionally, warheads must be able to be redesigned to adapt to evolving platforms and environments. To minimize the need to return to nuclear testing to meet these requirements, full advantage should be taken of existing designs, components, and weapons. The United States has already dismantled some weapons that have credible utility in the future and that could not be remanufactured with full confidence without underground testing.

An enhanced SSP would assure that a core reserve of all existing weapons be retained and an active design, development, and prototype program be initiated for several new systems while the current cadre of experts with design and test experience are still available. This activity would help identify the critical issues in new design challenges and identify what capabilities and materials/components/processes must be retained to maintain a credible design and developments capability.

A new design capability is also important for sustaining the SSP's human capital. New entrants into the SSP need to sharpen and sustain the skill-set necessary to manage the stockpile effectively. This can be accomplished by supporting a sustained "new design" effort within the scope of the SSP.

As with nuclear testing, nuclear design is a critical hedge capability that should be incorporated into and maintained within the SSP. During the Cold War the process of developing new weapon designs sustained the cadre of experts for half a century. Indeed, no area of science and engineering can be self-sustaining in the absence of an opportunity for scientific inquiry able to produce new designs.

Maintaining the Ability To Test

Nuclear testing is the only proven approach to providing the highest confidence in the safety, reliability, and performance of the U.S. stockpile. Even if successful, SSP cannot achieve the same level of confidence in weapon design or weapon modification, refurbishment or remanufacturing that was obtained when UGTs were authorized. A capability to resume full-scale nuclear testing is the only credible hedge to a failed SSP or a crisis that SSP is not designed to address, such as a need for a fundamentally new design or a need to achieve significantly higher safety standards.

The current implementation of the SSP is designed to maintain a three-year readiness-to-test status. The readiness program is based upon the core capabilities of the SSP stockpile maintenance program that supports the core intellectual capabilities of the weapons design program and the core experimental capabilities of the subcritical experiment program at the Nevada Test Site. In addition to this core stewardship program, there will have to be a program to archive test operation records and retain critical nuclear testing equipment and facilities. In fact, there is virtually no active program in operations readiness directed at a time-certain readiness status.

The U.S. Senate called for one-year test readiness status in its advice and consent to the ratification of the START II treaty. This readiness status has been rejected by the Administration as too costly in the current budget-constrained SSP even though compliance with the Senate standard could be achieved with approximately a 2 percent increase in SSP funding. Achieving a standard of one year to test readiness would not only provide a real hedge for sustained stewardship, it would magnify the effectiveness of the deterrent.

Nuclear testing remains the cheapest way to maintain the stockpile, the most rapid means of either building up or reducing the stockpile, and the clearest way to show the U.S. commitment to a unquestionable deterrent. The cost of maintaining real test readiness is small in comparison to the SSP. Doing so is not without risk, however, in an environment of an inadequately funded SSP. A requirement to finance a test readiness program if other SSP activities were underfunded could magnify the risk of emergence of an undetected aging problem in the stockpile.

The CTBT Safeguards

The role of post-treaty negotiation "safeguards" has a difficult history. The CTBT approval by the Chairman of the Joint Chiefs of Staff, the DOE, and the Directors of the weapon laboratories is conditional upon a set of national CTBT safeguards. The attachment of safeguards to strategic arms control agreements has not been effective in the past. The "test readiness" safeguard made in connection with the ratification of the Limited Test Ban Treaty of 1963 was eventually underfunded, then ignored. A similar fate has befallen "safeguards" reflected in the legislative history of the Senate ratification of the SALT I agreement in 1972.

Nevertheless, widespread agreement on and implementation of a set of safeguards could significantly diminish the risk to a gradual diminution in the quality of deterrence if the credibility of the nuclear stockpile declined. In an environment where accelerated proliferation of WMD and their means of delivery appears inevitable, widely supported stockpile safeguards could contribute to the ability of the United States to sustain deterrence in a threat environment quite unlike the bipolar world of the Soviet-American competition

While the SSP is a necessary dimension of a safeguards program, its inherent risk makes it insufficient for purposes of sustaining deterrence. Funding and implementation of additional safeguards are needed to offset the inherent risk in the structure of the existing SSP. Additional safeguards could include some or all of the following:

- Maintaining inactive stockpiles until manufacturing is proven;
- No further weapon dismantlements until SSP is proven;
- Delay of the entry into force of the CTBT until tritium production is under way to provide confidence that a reliable source is available to sustain the stockpile;

- Increase the scope of permitted experiments;
- Full-scale test readiness exercise every five years;
- Removal of legislative restriction on low-yield nuclear testing before another nation conducts tests.

Institutionalizing these and similar safeguards could have a constructive impact on the incentives for proliferation in the potentially dangerous early decades of the 21st Century. Institutionalizing the resolve of the United States to use its nuclear posture to sustain deterrence in the absence of nuclear testing, might constrain the proliferation impulse, which otherwise appears destined to be one of the most dangerous dimensions of the future.

Resources

An enduring irony of arms control arrangements has been that they tend to increase costs, at least in the short- and medium-term. This is the case with respect to sustaining a safe and reliable nuclear weapon stockpile in the absence of testing. The smaller stockpile occasioned by the implementation of arms control arrangements and the fundamental change in the international security environment have permitted substantial downsizing of the entire nuclear weapons complex. However, creating a technical capability to sustain perpetual confidence that approaches the confidence in the safety and reliability of the stockpile possible when UGTs were authorized is costly.

The DOE Defense Program (DP) budget peaked in the mid-1980s at nearly $10 billion, driven by both new development and production costs. However, the average DP expenditure over four decades has been $5 to 6 billion per year in FY98 constant dollars. The SSP budget is currently $4.5 billion and is anticipated to remain at this level in nominal terms (i.e., declining expenditure in real terms) for as long as a decade—well below historical experience.

The SSP budget is dominated by programmatic efforts that are indifferent to whether UGTs are permitted or not. Of the $4.5 billion SSP budget, $2 billion is required to maintain the manufacturing base (i.e., stockpile management functions), while an additional $2 billion is required for maintaining the core assessment and certification capabilities (i.e., stockpile stewardship). The incremental cost associated with the effort to sustain stockpile confidence without UGTs is approximately $500 million per year. This incremental figure finances the new activities, diagnostic and assessment technologies, and facilities needed to demonstrate stockpile assessment and certification in the absence of full-scale nuclear testing. Of the $500 million incremental annual cost for the SSP to cope with the absence of testing, approximately $200 million is required for new experimental facilities, while the remaining $300 million is to accelerate the acquisition of advanced computational capabilities. Unknown future cost increments may arise as a consequence of a need to develop new diagnostic, assessment, and experimental facilities to understand the impact of extreme aging phenomena on stockpile safety, reliability, and performance. The $500 million incremental cost of the SSP for an environment of no testing can be contrasted with a $200 to $300 million annual cost of a UGT program of 10 to 15 tests per year. Testing is likely to always be less costly than seeking to sustain the stockpile through the SSP.

The structure and content of the SSP has been described elsewhere in this paper. There are other costs likely to emerge in the long run concerning the modernization of delivery systems, the command-and-control system, and related costs of operating the nuclear deterrent force that will eventually require recapitalization. While this is not a near-term requirement, the cost of doing so has not been reflected in long-term R&D and procurement planing. While the heavy bomber force is subject to protracted service life extension, of greater concern is the ballistic missile delivery systems. Specially configured submarines have a service life of 20 to 25 years, which is difficult to extend significantly. Ballistic missiles, both land- and sea-based, can be remanufactured. However, the design of the existing missiles reflected Cold War priorities that are not likely to be reflected in post-2020 requirements. Without attempting to be specific, the recapitalization of the nuclear delivery systems of whatever the force structure requirements are at the time will require the investment of DoD funds that is not currently reflected in resource planning.

Uncertainties prevail, especially in the long-term, concerning the resource requirements of stockpile stewardship. As noted, the program currently under way will come into operation as most of the U.S. nuclear weapon stockpile will pass its design life expectancy—20 years. Models of aging phenomena for weapons of 10 or more years beyond their design life do not exist, which creates uncertainty about the physical phenomena that will place stockpile safety and reliability at risk. Stockpile surveillance may eventually require new diagnostic technology yet to be invented. Similar uncertainties with attendant resource implications could affect the refurbishment and remanufacturing process, as well as other elements of the weapons R&D and manufacturing complex.

While the threshold at which cumulative uncertainties about weapon safety and reliability would require the United States to resume UGTs has not been established, the political inhibitions to doing so could be significant. As a consequence, focusing more resources on replicating a confidence level approaching that available with UGTs is the most likely outcome. The level of the incremental resource requirements cannot be estimated at this early stage, but such costs could be significant.

DoD-DOE Resource Competition

The Budget Impoundment and Control Act of 1974 imposed a requirement for functional allocation of resources within the Federal budget. As a consequence, a number of national defense-related functions are included along with DoD military expenditures for resource allocation purposes. The functional categories (in this case, Budget Function 050, National Defense) are subject to firm limitations on Outlays and Budget Authority. DOE nuclear weapon program expenditures are incorporated in the 050 Budget Function, thereby creating a non-zero sum game between the two Departments. The DOE component of the 050 function is less than 5 percent of the total, but constitutes more than 12 percent of the DoD investment (RDT&E + procurement) accounts. The high fixed-cost component involved in sustaining the safety and reliability of the nuclear weapon stockpile makes it more difficult to manipulate the nuclear weapons program BA/O than is the case for DoD military expenditure.

These circumstances could produce a long-term risk to the resource base to support the nuclear deterrent. The political imperative of supporting the nuclear weapons program as the Congress moves toward addressing the ratification of the CTBT has tended to obscure longer term resource issues since the SSP is appropriately funded in the short term. It remains to be seen whether a future DoD-DOE resource competition within the 050 Budget Function will encounter the kind of struggle that has adversely affected the intelligence community in the post-Cold War resource environment.

Resource Allocation Decision Process

The reorganization of the Office of the Secretary of Defense (OSD) proposed in November 1997 seeks to promote management and cost efficiencies in OSD by reducing the number of offices and personnel reporting to the Secretary. As a consequence, extensive consolidation has been proposed, which decouples the DoD nuclear weapons program leadership from a direct reporting relationship to the Secretary of Defense.

Although the nuclear deterrent remains a "supreme national interest" of the United States, this does not necessarily translate to centrality in bureaucratic terms. The direct reporting relationship to the Secretary in the DoD nuclear weapons establishment (including the Nuclear Weapons Council) will be sharply curtailed. The impact on the resource allocation process is yet to be tested. However, the lengthening of the bureaucratic distance between the Secretary and DoD officials concerned with nuclear weapons issues bodes ill for a resource allocation process that will directly engage the Secretary. This process is likely to be paralleled by a similar distancing of uniformed officers in the JCS and Service command chains as well. The cumulative effect of the reorganization is likely to change the resource allocation decision process significantly from its Cold War-era model. Senior-level DoD involvement in the nuclear weapons program will be diminished further if the direct reporting relationship is changed Although the resource allocation process for the nuclear weapons program remains an interagency one due to the divided responsibility for execution of the program with the Department of Energy, the government-wide decision process remains unclear. There is no evidence that the White House role in decision-making will be directly affected by the organizational changes in the Department of Defense. The stability in the White House role may reflect the impact of both its statutory mandates and its policy perspective, which holds the "maintenance of a safe and reliable nuclear stockpile to be a supreme national interest of the United States."

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