Nuclear Weapons in the Twenty-First Century

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EXECUTIVE SUMMARY

The time is right for a fundamental rethinking of the role of nuclear weapons in national defense and of the composition of our nuclear forces. The Cold War is over, but it has been replaced by new threats to our national security. Technology, here and abroad, is inexorably advancing, creating both dangers and opportunities for the United States. This paper analyzes the future role of nuclear weapons in national security, describes the roles and limitations of advanced conventional weapons in meeting strategic needs, and suggests several alternate scenarios for future U.S. nuclear forces.

The principal role of nuclear weapons is to deter potential adversaries from an attack on the United States, our allies, or our vital interests. Russia maintains very large strategic and tactical nuclear forces. China is actively modernizing its nuclear arsenal. India and Pakistan have dramatically demonstrated the ability of midlevel technology states to develop or acquire nuclear weapons. There are grave concerns about the future proliferation of nuclear weapons among such countries as North Korea, Iraq, and Iran. The nuclear age is far from over.

Advances in conventional weapons technology suggest that by 2020 precision long-range conventional weapons may be capable of performing some of the missions currently assigned to nuclear weapons. Today, uncertainty in the location of road mobile missiles carrying weapons of mass destruction might require a nuclear weapon for assured destruction. Future real-time imagery and battle management, combined with precision strike long-range missiles, may mean that a conventional weapon could effectively destroy such targets.

Some targets require the energy of a nuclear weapon for their destruction. However, precision targeting can greatly reduce the nuclear yield required to destroy such targets. Only a relatively few targets require high nuclear yields. Advantages of lower yields include reduced collateral damage, arms control advantages to the United States, and the possibility that such weapons could be maintained with higher confidence and at lower cost than our current nuclear arsenal.

Now is the time to reexamine the role and composition of our future nuclear forces. New technologies take at least a decade to move from the concept stage to the point where we can rely on them for our nation’s defense. And, advance planning is already under way for the replacements of our nuclear capable missiles, aircraft, and submarines. Prudent thought given to this crucial subject will reap great dividends for the United States and for peace in the world.

INTRODUCTION

Nuclear weapons played a pivotal role in international security during the latter half of the twentieth century. Despite rapid increases in communications, transportation, and weapons technology, there has been no large-scale strategic conflict since the Second World War. Nuclear weapons, as the most destructive instruments ever invented, had a stabilizing effect on superpower relations by making any conflict unacceptably costly. However, geopolitical change and the evolution of military technology suggest that the composition of our nuclear forces and our strategy for their employment may be different in the twenty-first century. The time is right for a fundamental rethinking of our expectations and requirements for these unique weapons.

Nuclear weapons are one component of an integrated defense strategy that includes diplomacy and conventional forces. The principal role of nuclear weapons was and continues to be that of deterring any potential adversaries from an attack on America or our vital interests. This role is expected to continue for as long as nuclear weapons hold the appellation of "supreme" instruments of military force. However, this does not mean that their role in military planning will not change at all. Changes in the geopolitical environment and the inexorable advance of military technology here and abroad suggest that the position of nuclear weapons in national security policy will evolve with time. Given the unique destructive power of nuclear weapons, it is essential that this evolution be planned, to the extent possible, with due consideration of the integration of strategic nuclear forces into a consistent and comprehensive policy for national security.

Even with the dramatic changes that have occurred in the world during the past decade, nuclear warplanning today is similar in many respects to what it was during the Cold War. The Single Integrated Operational Plan (SIOP) is focused on a massive counterattack strategy that aims to eliminate the ability of an adversary to inflict further damage to American interests. Nuclear weapons provide an assured retaliatory capability to convince any adversary that aggression or coercion would be met with a response that would be certain, overwhelming, and devastating. It is often, but not universally, thought that nuclear weapons would be used only in extremis, when the nation is in the gravest danger. While there has been some discussion of "single weapon" strikes against isolated targets, such as sites of weapons of mass destruction, most of the attention in nuclear strategy has been and is directed toward large-scale engagements. This may not be true in the future.

The advance of conventional weapons technology may result in the ability of conventional weapons to perform some of the missions currently assigned to nuclear weapons. For example, take the case of a road mobile ballistic missile. If one knows the location of such a target and if one can place a conventional weapon on that target

with meter-scale accuracy, then it can be destroyed without a nuclear weapon. On the other hand, if one does not know the location of the target to within many kilometers then even a nuclear weapon may not destroy it. The key parameters required for target destruction are intelligence and precision delivery, not the explosive force of the weapon. However, even if a weapon is precisely delivered to the correct target point, countermeasures as simple as steel netting, boulder fields, or decoys complicate reliance on conventional weapons with limited radii of destruction.

The role of nuclear weaponry as the ultimate deterrent to aggression and the ultimate destructive force in combat will likely lead to the retention of at least some nuclear forces for decades to come. However, the composition of our nuclear arsenal may undergo significant modification to respond to changing conditions, changing military needs, and changes in our confidence in our ability to maintain credible nuclear forces without nuclear testing or large-scale weapons production. Options for precision delivery of nuclear weapons may reduce the requirement for high yield. Lower yield weapons could be produced as modifications of existing weapons designs, or they could employ more rugged and simpler designs that might be developed and maintained with high confidence without nuclear testing and with a smaller nuclear weapons complex than we envision is required to maintain our current nuclear forces.

This paper attempts to look forward to the role that nuclear weapons might play in the twenty-first century, starting about 2020. A twenty-year horizon was chosen because over this time scale it is possible to make reasonable projections of technology and some assumptions about the probable threat situation. It takes about twenty years for substantially new weapons technologies to be developed and fielded into dependable military systems. Since this is true for other countries as well as the United States, one can project the development of potential adversarial capabilities to some degree. Of course, changes in governments could occur quickly compared to this time scale, but the technology that would be employed against the United States would proceed more slowly. This paper focuses on state-to-state defense and does not explicitly consider terrorism or the rapid evolution of entirely new state threats. It is unlikely that an emergent power would be able to develop the technology necessary to confront the United States on a time scale faster than two decades without some obvious indicators that would enable our technological or diplomatic response.

Why is this an important issue now? Current plans call for the deployment of the “next generation” of strategic forces in about 2020, including replacements for intercontinental ballistic missiles (ICBMs), the Ohio-class ballistic missile submarine, and perhaps even the venerable B52 bomber. This strategic modernization will be expensive, and it is not too soon to begin the debate over what kinds of strategic forces are needed to meet future needs.

It takes at least a decade to deploy a new technology, and if research and development are required, additional time may be needed. For such a key component of national defense, it is not sufficient to merely demonstrate that new systems work. There must be sufficient time to shake out the inevitable problems associated with new systems so as to make them dependable beyond reasonable doubt of our own government and the governments of potential adversaries. Time must also be allowed for the negotiation of treaties or other international agreements that support the new force structure and that preclude the marginalization of our forces by either a massive breakout or any other action that would reduce the effectiveness of our forces. Finally, the twentieth century repeatedly demonstrated that sweeping geopolitical changes occur on a short time scale compared to our ability to respond with new technologies or doctrines. It is imperative to consider the widest range of potential options before a crisis develops and to maintain a sufficiently robust research and development base to enable a response at that time.

The development of naval air power during the 1930s is a prime example of the need to evaluate the role of new technologies well before any anticipated engagement. The development of radar and ballistic missiles during the 1940s is an example of technologies developed during a conflict using preexisting foundations of research and technology. Some investment in thinking about future strategic forces now could reap significant dividends in the future.

Planning for future strategic defense is a highly complex affair that requires the consideration of many possible contingencies. This paper is not intended to be a complete analysis of such a complex topic. Rather, its purpose is to stimulate thinking about changes in the international environment and technology that might be expected to influence the makeup of our strategic warfighting capability.

In order to set the stage, I first present a brief overview of the geopolitical situation that might reasonably be expected to influence defense strategy in 2020. This is followed by a discussion of what weapons technology might be available to the United States and other countries. Next, a discussion is given of some force structures, including weapons and supporting infrastructure, that might satisfy future defense needs. The paper concludes with a summary and suggestions for further work.

THE INTERNATIONAL SITUATION IN THE TWENTY-FIRST CENTURY

Before one can rationally discuss future defense needs, it is necessary to know what one is defending against. The past decade has demonstrated the difficulty and danger of predicting the geopolitical future, but there are some forecasts that can be made with reasonable confidence and which can be used to guide further discussion.

Strategic Threats to U.S. National Security in the Twenty-First Century

Future national security threats to the United States might be divided into three major categories: major power conflicts, especially those involving Russia and China; regional conflicts, including potential nuclear states such as Iran, Iraq, or North Korea; and conflicts involving terrorist groups and other nonstate organizations. Only the first two major categories will be considered here, since it is arguable whether there is any role for strategic nuclear forces in dealing with terrorism and substate threats. However, strategic conflicts can be sparked by terrorist acts, as was the case in the First World War and other conflicts.

Russia — During the past 200 years European Russia has sustained a series of catastrophes including the invasion of Napoleon, the Crimean War, the First World War, the Revolution, the Second World War, and now the transition from a communist state to something else. In each case the country recovered within a generation. Even after the Second World War, when the country was essentially in ruins, it came back to launch Sputnik within twelve years. While one cannot predict what will happen in a country so volatile as Russia, it is not unreasonable to assume that it will endeavor to return to a conventional military power while continuing to rely on a significant nuclear capability. It is clear from Russia's investment in conventional military technology that it wishes to reassert its status in this area and to continue a lucrative business in the international arms trade.

China — China's international aims are in development, but their long stated intention to "reunify" Taiwan into the mainland and their territorial moves in the South China Sea indicate that they plan to play a broader role on the international stage. China has a small nuclear arsenal but one capable of inflicting unacceptable damage on American territory and interests. It is unclear at present what, if any, impact alleged Chinese nuclear espionage will have on the modernization of its nuclear arsenal. However, it is worth noting that China has several nuclear weapons systems in the advanced development stage including a new cruise missile, which presumably can carry a nuclear warhead, and new land-launched and sea-launched ballistic missiles. Road mobile nuclear capable missiles add a degree of survivability to China's limited nuclear arsenal. The desire to develop an operational ballistic missile submarine is another suggestion that China is concerned about the survivability of its nuclear forces and perhaps is a comment on its future goals of power projection outside of the immediate Pacific area.

Other Countries — The nuclear tests of India and Pakistan again demonstrate that countries will act in their own perceived national interests, sometimes in direct opposition to the wishes of the United States or to previous treaty commitments or arrangements. Continued tensions in South Asia, including Sino-Indian tensions, bear

close monitoring, but they may not directly involve the United States. The Middle East will continue to be a problem area due to the misalignment of ethnic, cultural, and national borders. The prospects for Arab or Islamic unification do not appear imminent at present, but historically this unification has relied on a charismatic leader, whose advent is difficult to predict. Continued problems in the Balkans and elsewhere in the world may tax American and allied conventional capabilities, but such conflicts are not expected to assume a nuclear dimension in the foreseeable future. North Korea is presumed to have at least some nuclear capability and has demonstrated remarkable progress in ballistic missile technology, despite its perilous economic condition. Japan and South Korea look upon North Korea's nuclear ambitions with concern and could pursue their own nuclear programs if they felt uncertainty in the American nuclear umbrella. Similar concerns could apply to Taiwan in light of recent statements made by the People's Republic of China.

Nuclear engagement scenarios are not necessarily binary. Third countries may feel compelled to intervene in disputes between nuclear states or in conflicts involving weapons of mass destruction that could spill over into their territory or interests. For example, China may feel a need to act in a nuclear exchange between India and Pakistan. Similarly, Israel may feel a need to act in a major conflict of its neighbors that involved weapons of mass destruction.

FOREIGN WEAPONS TECHNOLOGY IN THE TWENTY-FIRST CENTURY

Trends evident today suggest that by 2020 many countries in the world will have access to several important technologies.

- Weapons of mass destruction: India and Pakistan graphically demonstrated the ability of midlevel technology states to construct or obtain nuclear weapons. Chemical and biological weapons are assumed to be within the reach of many countries today.

- Long-range ballistic missile technology: It is apparent that countries like North Korea, Iran, India, Pakistan, and other countries have or will soon have the capability to project force at intercontinental distances. The developing international marketplace in these technologies may make long-range missiles available to almost any country that has the money and the basic technical capability to acquire and use them. Although such missiles may lack the precision of current U.S. weapons, they might be entirely adequate for the delivery of weapons of mass destruction.

- Space imaging: Commercial services already provide high-resolution images from space. The technical capability to provide these images in real time to customers around the world should be expected to develop. Whether international agreements

will be enacted to prevent collection against sensitive sites remains to be seen. At some point, Third World countries will have the capability to launch their own intelligence satellites or will pay others to launch them, thus bypassing the need for commercial services.

- Russian weapons technology: Despite its economic troubles, Russia is committing significant resources to the research and development of advanced conventional weapons. Part of the reason for this is certainly to provide a credible defense of Russia and its vital interests. However, Russia also sees a lucrative international arms market that appreciates the low cost and operational simplicity of its weapons. One might expect more countries to have access to "last generation" but quite capable Russian military technology including missiles, air defenses, submarines, tanks, and other systems.

- Advanced communications and computer technology: The spread of communications and computer technology will serve as a force multiplier for a growing number of countries. The ability to effectively employ a small number of electronic weapons against a technologically and/or numerically superior enemy is a cost-effective force-leveling tactic.

The United States will enjoy superiority in conventional and nuclear weapons as long as adequate investments are made in research and development and in the deployment of the resulting weapons systems. However, we should expect other countries to employ many of our ideas in their own defense strategy including the simple copying of our technology and doctrines, or the use of our technology to develop weapons systems of their own. They may also attempt to exploit weaknesses in our advanced technology through means such as electromagnetic weapons, chemical and/or biological weapons, and other "asymmetric means."

U.S. DEFENSE TECHNOLOGIES IN THE TWENTY-FIRST CENTURY

Conventional Military Technology

Advances in military technology have been much discussed in the literature and are said to be leading toward a revolution in military affairs. Relevant to the present discussion, there are several advances in conventional weapons technology that deserve mention.

- Advanced precision munitions: It is already possible for cruise missiles to deliver payloads to targets hundreds of miles from their launch point with few meter accuracy. High precision for intercontinental missiles, either land- or sea-launched, is also possible. Given that ballistic missile reentry vehicles arrive on target with

velocities of thousands of meters per second, it is not necessary to have explosive payloads to destroy some classes of targets.

- Advanced real-time imagery and data fusion: Data collection from satellites and from unmanned forward platforms will enable real-time remote battle management, including the direction of precision munitions to distant, even mobile, targets.

- Antiballistic missile technology will mature if the appropriate investment is made, enabling some defense against limited missile attacks. Analogous defenses could be developed against cruise missiles and aircraft, although these threats are in many ways a tougher problem due to the greater number of potential entry points and the availability of stealth technology.

- Information warfare may develop in such a fashion to enable the United States to interdict enemy command, control, and communications.

There has been much discussion of other advanced conventional technologies including unmanned aircraft, sensor technology, beam weapons, and so on. In this paper we will focus on those technologies that could have a strategic impact and that are related to the changing role of nuclear weapons. The importance of considering future defense against ballistic missiles, cruise missiles, and aircraft cannot be overestimated. The inexorable advance of technology will eventually make such defenses feasible and will put them within the grasp of any country that wishes to have them. Such is the case now with reasonably sophisticated air defenses. Long range strategic planners must at least consider the return of a traditional “armor /antiarmor” competition even for strategic forces. Stealth technologies, advanced countermeasures, and new technologies will affect these trades but will not change the fundamental ability of defense technologies to influence strategic thinking.

Nuclear Weapons–Related Technology

Nuclear weapons pack incredible destructive force into a small, deliverable package. In addition to their psychological deterrent value, they are the only current means of holding at risk several classes of targets.

- Mobile targets, such as road mobile and rail mobile missiles

- Fixed moderately hard targets, such as missile silos

- Distributed targets, such as airfields or naval bases

- Hard targets, such as deeply buried command structures

- Superhard targets, such as facilities located beneath mountains

Conventional weapons might be able to address some of the missions currently assigned to nuclear weapons, but not all of them. Some targets, like missile silos and command and control structures, are sufficiently hard that no conventional weapon will have the energy to defeat them. Other targets, such as airfields and naval bases, are sufficiently dispersed that a massive amount of conventional explosives would be required for their destruction. Even though conventional weapons could damage or destroy such targets, they could do so today only over an extended time frame and with the use of limited resources that may be required in other theaters of operation. Future conventional weapons designs may change this, but there are still limits on the amount of damage that can be caused with a given quantity of high explosive. For these and other reasons, nuclear weapons are expected to continue to play a role in strategic doctrine, independent of their role as a psychological deterrent to aggression.

The United States employs a counterforce strategy that targets military assets that could inflict damage to our national interests. We do not threaten cities or populations as in a countervalue policy, although there is an implicit threat of doing so that is a potent element of the deterrent calculus. American nuclear weapons systems are designed to hold specific classes of targets at risk, using the minimum explosive forces necessary to accomplish the mission. However, a sizable factor governing the explosive force required to defeat a target of given hardness is the precision with which weapons can be delivered. The evolution of accurate delivery systems could change engagement strategies for nuclear weapons, in some cases reducing the required yield or even eliminating the need for an explosion at all. Once again, the use of conventional weapons presumes a level of detailed information on the location and characteristics of the target that has so far eluded military planners. A reliance on precision conventional munitions for some strategic missions presumes a major investment in intelligence collection and analysis tools, including accurate means of assessing target damage following an attack. This is particularly important for strategic targets such as mobile missiles or weapons of mass destruction that could, if they survive, inflict significant damage.

Advances in military technology may change the makeup and use of our strategic forces in several ways.

- Some important classes of targets, such as mobile missiles, might be effectively dealt with by long-range precision conventional weapons. One can envision submarine-launched ballistic missiles (SLBMs) and intercontinental ballistic missiles (ICBMs), loaded with such precision weapons, which could be directed by real-time intelligence to targets anywhere on the planet within 30 minutes. Maneuvering reentry vehicles could enable these weapons to follow and destroy moving targets.

- A 5-kiloton (kt) nuclear explosive detonated on a 30-foot-thick missile silo door will vaporize that door, destroying the missile inside. With precision delivery many hard targets might be able to be defeated with nuclear explosives having lower yield than we might currently employ. Such lower-yield weapons could use simpler and/or more robust designs than we have in our current arsenal. Simpler, more robust designs, in turn, might allow the nuclear arsenal to be maintained with a smaller maintenance and production complex than is required to support the sophisticated, highly optimized weapons in our stockpile. As in the case of advanced conventional weapons, the use of lower-yield nuclear weapons against hardened targets could be made problematic through the use of relatively simple countermeasures. In the example of a silo door, shielding could be used to separate the blast from the door area, reducing the effectiveness of the weapon.

- Widely dispersed targets require energy (yield) for assured destruction. Several dispersed lower-yield weapons will produce the same effect as a single higher-yield weapon. Using multiple weapons on a single target assumes that fratricide effects can be dealt with in planning multiple nuclear bursts in a single target area. Such an approach also requires a larger number of weapons, a factor that would be more challenging if deep cuts in weapons numbers are negotiated. A benefit of lower-yield weapons is that the collateral damage sustained by the near-target area may be reduced, an important factor in attacks near urban areas.

- Some very hard targets require high yield to destroy them. No application of conventional explosives or even lower-yield nuclear explosives will destroy such targets, which might include hardened structures buried beneath hundreds of feet of earth or rock. For such purposes it might be desirable to retain a small number of higher-yield nuclear weapons in the arsenal as deterrents against enemy confidence in the survival of such targets.

- Superhard targets, such as those found under certain Russian mountains, may not be able to be defeated reliably by even high-yield nuclear weapons. In this case, one might use a different strategy such as “functional defeat” in which power, communications, or other vital functions are eliminated or denied without the physical destruction of the main target. Alternately, one might use negotiations to eliminate a target, bargaining away a limited set of special targets for concessions on our part.

These proposals are a departure from conventional thinking on nuclear issues. For example, our ability to negotiate away superhard targets would be very difficult at best. Others, such as the ability of precision advanced conventional munitions to hold at risk mobile and other soft-point targets, are more realistic and require only projections of current technology. In the latter case, a challenge may come from arms control concerns of other countries that see their own nuclear forces made marginal. Also,

potential adversaries may use “asymmetric means” to counter our advanced technology.

An important consideration in thinking about lower-yield nuclear forces for most of our strategic nuclear requirements is that such weapons could be much simpler than our current highly optimized nuclear designs. Given sufficient throw-weight on our missiles, we could use gun-assembled or other simple, rugged designs that might be maintained with high confidence without nuclear testing. Such designs would require a significantly smaller industrial plant for their maintenance than our current forces. If based on uranium weapons designs, a much smaller plutonium infrastructure would be required. Other technologies specific to high-yield nuclear weapons could be placed in a standby mode rather than a production mode. Finally, simpler weapons might be maintained with higher confidence for longer periods by a weapons staff that has little or no direct experience with nuclear testing. However, should the country elect to follow such a path it will still be necessary to retain expertise in more sophisticated nuclear designs as a hedge against changing conditions in the future.

There is an additional, nontechnical, consideration that will influence future nuclear policy. Given current and projected scientific capabilities, it is difficult or impossible to confidently field a new, highly optimized, nuclear warhead design without nuclear testing. For this and other reasons, the United States intends to maintain its existing nuclear designs into the indefinite future. This is a fundamental change in how we maintain our arsenal. Recent concerns about espionage in the weapons program raise questions about our ability to keep weapons designs secret over many decades. Some in the intelligence community contend that a fixed target, such as our nuclear designs, will be compromised by a determined adversary given sufficient time. Information about our designs could provide important guidance to countries that wish to improve their own nuclear arsenals. Such information would also be advantageous to countries attempting to optimize some future ballistic missile defense system of their own for use against our systems. Finally, it could assist potential adversaries in deploying their strategic forces in a manner designed to make it difficult for us to assure their destruction.

Planners need to consider what we will do when, and not if, the details of our nuclear forces become known by a potential adversary. There are several paths that could be employed here, including disinformation, counterintelligence, etc. One path that has been proven to work has been to change our forces on a regular basis in response to evolving military requirements and technology options. The certification of substantially new nuclear weapons designs is difficult or impossible to do with high confidence without underground nuclear testing. However, the United States has a large archive of previously tested designs that might be fielded with reasonable

confidence to meet evolving military needs. In addition, the current stockpile has significant flexibility for modification for new requirements. Such flexibility was most recently evidenced by the modification of the B61 bomb to provide earth-penetrating capability. A move toward a mixed force of long-range conventional and lower-yield nuclear weapons with improved accuracy would be another means of meeting this need. Such decisions need not be exclusive. It may be wisest to employ multiple technologies, both nuclear and nonnuclear, to create a robust future strategic posture.

STRATEGIC FORCES TO MEET FUTURE DEFENSE NEEDS

Planning strategic forces is a highly complicated affair that must include technical, geopolitical, and military considerations. A full analysis is not attempted here. The purpose of this section is to suggest some broad options that can be used as starting points for more detailed treatment. Although this section concentrates on strategic forces, it is worth noting that several countries possess potent "nonstrategic" nuclear forces that are designed for tactical engagements. Nonstrategic forces include nuclear artillery shells, atomic demolition munitions, short-range missiles, and air-delivered bombs. While such weapons are typically lower in yield than most strategic bombs and warheads, they are still nuclear explosives with destructive power vastly greater than conventional weapons. One might expect the division between "tactical" and "strategic" weapons to blur in the future, especially if significant reductions in strategic arsenals occur.

Scenario 1: Status Quo

Nuclear weapons represent the ultimate defense of the nation, a deterrent against any and all potential adversaries. Combined with diplomacy and conventional military capabilities, nuclear weapons have helped to avoid a large-scale conflict between leading world powers for over fifty years. This is an astonishing achievement given the acceleration in communications and transportation that took place during this time.

When the Cold War ended, the U.S. nuclear stockpile consisted of a set of highly optimized warheads and bombs on highly reliable missiles and aircraft. These weapons systems were designed primarily to counter the massive Soviet threat. They were and are the most advanced of their kind in the world. Current plans call for them to be retained essentially indefinitely. There are several good reasons for this.

- These weapons are safe, reliable, and meet performance requirements.
- We have nuclear test data that support our understanding of their operation.
- New warheads of comparable capability are difficult or impossible to field without nuclear testing.

- They can be modified in many ways to respond to changing military requirements, as was done when the B61 bomb was modified to give it an earth-penetrating capability.

This scenario maintains a triad of ICBMs, SLBMs, and bombers. More than one type of weapon is maintained in each leg of the triad to provide backup capability should one weapon type encounter a problem. This strategy served us well during the Cold War. Given the rapidity with which the geopolitical situation can change, there is merit in following a prudent and conservative path for future nuclear forces.

There are several potential disadvantages to maintaining the existing stockpile indefinitely. Over time such highly optimized systems may be less well suited to military requirements. Refurbishment and other changes will be made to aging warheads and bombs, changes that might be difficult to certify without nuclear testing. Also, the cost of maintaining these weapons is high for both DoD and DOE. In the case of DOE, an extensive infrastructure of laboratories and plants is required for the Stockpile Stewardship program, including a new manufacturing capability for plutonium pits. Finally, the current stockpile may not be credible against some set of potential adversaries. For example, if a national emergency were to develop that involved the imminent use of weapons of mass destruction against American interests, would an adversary consider our threat of a multiwarhead attack by the Peacekeeper ICBM or a Trident SLBM as overkill and hence not a realistic threat? Such a reliance on high-yield strategic weapons could lead to "self-deterrence," a limitation on strategic options, and consequently a lessening of the stabilizing effect of nuclear weapons.

Scenario 2: Reduced Stockpile of Existing Designs

This scenario assumes that arms control initiatives have make it advantageous to the United States to greatly reduce our stockpile of existing nuclear weapons. It is similar to Scenario 1 with lower force levels. One can debate the merit of eliminating one arm of the strategic triad or the nonstrategic (i.e. tactical) nuclear forces under such circumstances, depending on the depth of the reductions. Cost savings associated with reduced numbers are not directly proportional to the number of weapons since a significant infrastructure is required to support any type of modern nuclear design. The cost advantage would be in the size of the required production plant and not in the diversity of technical capabilities that are required.

At very low stockpile numbers it may be useful to explicitly consider a "flexible stockpile" strategy that takes advantage of the flexibility inherent in current nuclear weapon designs. The United States could have a mixed force of weapons based upon

current types suitably modified to meet evolving military needs. Special consideration might be given to maneuvering reentry vehicles that can deal effectively with enemy defenses. One could consider tailored output weapons for special applications such as those that produce an enhanced electromagnetic pulse for the disabling of electronics or those that produce enhanced radiation for the destruction of chemical or biological weapons with minimum collateral damage. (There is serious doubt in the nuclear weapons community as to whether such systems could be introduced into the stockpile without additional nuclear testing.) Careful consideration must be given to single-point failure in a reduced stockpile. For example, the use of a common missile or a common warhead for ICBMs and SLBMs would save money but would introduce a potential single-point failure in the majority of strategic forces.

In selecting weapons that would be maintained in a smaller force structure, consideration might be given to those that are the most rugged, the easiest and cheapest to maintain, and the most flexible. Highly optimized weapons may be more efficient, but efficiency can come at the cost of complexity of maintenance. Without nuclear testing, small changes caused by natural aging or required component replacements will introduce some uncertainty into the stockpile, uncertainty that must be figured into military strategy. Understanding such uncertainty is especially important if the number of weapons types is reduced, admitting the possibility of single-point failure of a large part of the force. It may be advisable to view ruggedness and ease of maintenance as principal criteria for the selection of the types and distribution of weapons within a reduced stockpile. Given the uncertainty of future military needs, the ability of a weapon to be maintained, modified, and/or certified without nuclear testing may also be an important element in the decision process.

Scenario 3: Mixed Conventional and Nuclear Strategic Forces

Reasonable assumptions about the development of advanced conventional munitions leads to a scenario where the strategic workload is carried by a combination of nuclear and nonnuclear forces. It is possible to envision nonnuclear components to each of the arms of the strategic triad. Using conventional ICBMs and SLBMs, or their projected replacements, one could design reentry warheads to achieve high accuracy. These warheads would contain “smart” guidance systems that would receive intelligence handoffs from satellites or other sources before and/or during flight. Such systems would know that a target exists in a general area, be aware of its potential movement and signatures, and be able to home in on it. Given the kinetic energy of a reentering warhead, it might not be necessary for the system to contain high explosives. Hitting the target might be sufficient to destroy it. Similar warheads could be developed for cruise missiles that could be launched from bombers, submarines, or surface warships. In the case of cruise missiles, the lower velocity of delivery would require a high-explosive warhead.

A nonnuclear long-range weapon would be especially useful against limited numbers of time-urgent weapons of mass destruction targets such as biological weapons warheads that were in preparation for use against U.S. forces. Long-range nonnuclear weapons would enable such targets to be destroyed without causing the United States to be the first to employ nuclear weapons in a conflict. The use of nonnuclear strategic weapons against Russia, China, or other nuclear states would require care, since the appearance of such a weapon on long-range sensors might be indistinguishable from a nuclear attack by the United States.

A word of caution is needed on the use of precision munitions for high-value strategic targeting: The Kosovo conflict demonstrated very clearly that just the ability to place a weapon on the designated aim point is not enough to ensure mission success. Inaccurate target coordinates provided to pilots sometimes resulted in weapons being delivered very precisely to the wrong spot. Effective utilization of precision munitions demand that a premium be placed on the collection and the analysis of target information. This includes postattack damage assessments that determine the need for follow-on attacks and the ability of the adversary to use its weapons for offense or defense.

The nuclear component in this scenario could take one of several forms. First, one could employ a small number of existing weapons designs to retain a traditional counterforce deterrent strategy. Second, one could modify existing designs to reduce their yield, relying on precision delivery to help achieve military objectives. In this case one could use existing reentry warheads or develop new ones with the precision guidance necessary to destroy moderately-hard-point targets with low yield. Third, one could design and deploy a new set of nuclear weapons that do not require nuclear testing to be certified. Such weapons might be, but do not need to be, based on simple gun-assembled uranium designs that do not require a plutonium infrastructure and that do not require the same sophistication in nuclear weapons science and engineering as our current stockpile. However, nothing comes for free, and one must recognize that such simple weapons have important, perhaps fatal, tactical limitations that would preclude their use in some engagement scenarios. Also, such simple devices would be based on a very limited nuclear test database and would require extensive and expensive flight testing to assure that they could be delivered with the required precision. Fourth, one could consider a combination of new or modified low-yield warheads and some existing higher-yield designs to be retained against the possibility of unexpected developments in adversaries' defenses or of the need to hold very hard targets at risk. In this case one would need to retain much of the infrastructure of the current stockpile to ensure the continued performance of these highly optimized weapons. Savings could be achieved in the size of the plant complex required to remanufacture components and complete weapons.

Scenario 4: Prospects for Wholly Nonnuclear Strategic Forces

It is almost impossible to conceive of technological and political developments that would enable the United States to meet its defense needs in 2020 without nuclear weapons. There are several reasons for this. First, nuclear weapons continue to play a vital role in deterring other countries from launching significant military strikes against America, our allies, or our vital interests. The real threat of not just military defeat but national annihilation is a potent deterrent now and should be expected to remain so for at least the next few decades. Second, it does not appear possible with current or projected technology to assure ourselves that there are no—and never will be any—nuclear weapons in the hands of potential adversaries. Given the unique destructive power of nuclear weapons, an asymmetry of this kind should be unacceptable to American military planners. Third, the development of antiballistic missile defense is encouraging, but the assumption that a leak-proof shield can be fielded by 2020 is debatable. Fourth, some targets will not be able to be held at risk by any type of conventional weapon because of their extreme hardness. Fifth, the ability of an adversary to deliver a nuclear weapon by aircraft, cruise missile, naval vessel, or by clandestine insertion into this country are additional concerns beyond the long-range ballistic missile threat. Lacking the ability to deter such threats and to respond in kind would open up the country to blackmail.

It is critical in any discussion of strategic forces to consider the overall stability provided by technology and policy. Such calculations have become considerably more complex in the multipolar world that is expected to persist at least over the time scale addressed in this paper.

The future is unpredictable, but we can count on it to be dynamic. Strategic thinking must be flexible and must consider the evolution of several possible futures, each of which has branches that are contingent on the geopolitical situation and technological capabilities here and abroad. Countries will respond to technology and policy developments in the United States and elsewhere. We must be careful that any changes to our strategic position make the overall situation better and not worse.

Russia has already promised that it will use “asymmetric means” to counter advanced U.S. technology. Official Chinese publications indicate that China will likely follow a similar strategy. The capabilities of their own research and development complex should not be underestimated. While Russia cannot yet match the United States in the most sophisticated technology, it has shown a remarkable ability to achieve military objectives through cleverness and sometimes through brute force. Finally, the development of advanced conventional strategic weapons could push the Russians to an even greater reliance on high-yield nuclear weapons. Rather than an evolution

toward some fixed strategy, strategic thinking should be done along a flexible time line that recognizes changes in the world and in military technology. What may work at one time may not work at another time when the situation has substantially changed.

One “asymmetric” counter to advanced technology is cyber-warfare, including non-explosive weapons that could disable or render ineffective advanced conventional or even nuclear munitions. Precision kill requires sophisticated electronics, and electronics can be affected by various means such as radio frequency or microwave weapons. Russia’s electromagnetic weapons program is perhaps the most advanced in the world, and at least some of this technology has been shared with China. Given the uncertainty in future advanced weapons technology, the United States may wish to retain some higher-yield nuclear weapons as hedges against the development of potent point or area defenses. The development of antisatellite weapons would create a similar complication to the United States if we were to rely on advanced conventional weapons that require precise targeting information to be effective.

Arms control initiatives will play an important role in the planning of future strategic forces. Proposed deep reductions in nuclear stockpiles may be a motivation for using conventional weapons as part of the strategic weapons mix. Such a decision will strongly depend on whether warheads or launchers are the counted quantity. If nuclear warheads and not delivery vehicles are the counted quantity, then existing or new launchers can be equipped with advanced conventional warheads. If missiles and aircraft are the counted quantity, we will need to be careful about treaties that allow only one warhead, nuclear or conventional, on a missile. Maintaining an effective deterrent requires a minimum number of nuclear weapons, and the dilution of our forces with conventional weapons could drive us from a counterforce strategy (military targets) to a countervalue strategy (cities) with attendant ethical and perhaps legal problems.

Arms control agreements can assist in strategic planning by restricting certain classes of weapons or targets. If, in some scenario, our weapons are particularly susceptible to nuclear interceptors, then we may wish to negotiate the elimination of nuclear interceptors in return for some other concession. If we are unable to destroy one or more targets by any weapon in our arsenal, we may want to attempt to negotiate away the target in return for assurances that we will not construct similarly hard targets in the United States. Such negotiations are by nature complex because they involve giving up different commodities on each side. However, the advantages of reduced reliance on nuclear weapons, with their large radii of destruction, might be an incentive. Also, the development of new conventional strategic weapons, the use of which might be incorporated into nonnuclear war planning and that will not necessarily lead to national destruction, should be considered with care.

One of the features of nuclear weapons is that they are so destructive that their use is reserved for only the most extreme cases. Making strategic weapons more "usable" could start the United States on a path of escalation that could exacerbate and not reduce the potential for war. Conversely, lowering the threshold for using nuclear weapons in response to a strategic situation could raise the level of care with which countries interact. This points to the need for a detailed stability analysis to be performed as a prelude to any arms control negotiations. Such an analysis must explicitly include the balance of nuclear forces, the state and projected future of ballistic missile defenses, and the ability of advanced conventional weapons to perform missions formerly assigned to nuclear weapons. The weapons research and development programs of potential adversaries will provide input to this analysis by providing pointers to future defense capabilities. And, of course, any analysis of future strategic weapons needs must necessarily consider the possible geopolitical situation that will be present at the time of their deployment. Finally, the distinction between tactical and strategic nuclear weapons will fade for small stockpiles. Both types of weapons must be included in negotiations for overall stability to be maintained.

Another important consideration in planning future strategic forces is cost. Nuclear weapons systems are sometimes considered expensive to maintain due to their complexity, their unique characteristics, and the lack of private industry support of some components of their infrastructure. In fact, nuclear weapons are cheaper to develop and to maintain than very large conventional force structures. This was the reason why NATO chose to rely on nuclear weapons as a principal part of its defense against the massive Soviet conventional threat in Europe. Nuclear weapons are considered expensive today because they are primarily strategic in nature and we are in the midst of a "strategic pause" that has lessened the perceived need for strategic weapons.

For the DoD, costs include operations, maintenance, and the development of next generation capabilities that will replace current systems upon their obsolescence. For the DOE, costs include the operation of the weapons laboratories and production plants and the material costs associated with weapons refurbishment. To first order, the cost of maintaining the DOE nuclear weapons complex is independent of the number of weapons in the stockpile. Some capability in uranium, plutonium, and other special materials is required. Scientific capabilities must be maintained, especially in those classified areas unique to nuclear weapons, to enable informed decisions to be made on weapons aging, component replacements, and future modifications. Tritium has some variable cost, as it must be produced to support some fixed number of weapons. Plutonium pit production can be maintained at a small rate at Los Alamos, but any stockpile above about one thousand weapons will require the construction of a new large production plant to replace the Rocky Flats facility, which ceased production in 1989. Should the country go to a precision low-yield nuclear force that is based on

uranium rather than plutonium, the cost of the large pit-production facility could be avoided, and the remaining high-yield weapons that did employ plutonium pits could be supported by a modified Los Alamos plutonium facility.

SUMMARY

The end of the Cold War, the evolution of new regional threats to international security, and the stated desire of many countries to reduce or eliminate their nuclear arsenals suggest that the time is right for a fundamental rethinking of the role of nuclear weapons in national security. Nuclear weapons, as the most destructive instruments yet invented, must be considered as part of a coordinated national security program that employs diplomacy, arms control initiatives, and conventional forces to optimize stability and peace in the world.

Technology assessments suggest that advanced conventional weapons delivered by ballistic or cruise missiles could defeat many targets that are presently targeted by nuclear weapons. Precision delivery of nuclear weapons would enable some classes of hard targets to be defeated with much lower yields than are currently employed. Some number of current nuclear weapons designs might be retained in order to address very hard targets or for traditional deterrent roles. Simple, rugged nuclear weapons designs that might be maintained at relatively low cost and without the need for nuclear testing might be a part of such a strategy.

Nuclear weapons cannot be uninvented. Nor can we assume that their role in strategic deterrence will never change. Prudent thought given to the role of nuclear weapons in the twenty-first century will reap handsome dividends for the national security of the United States and for the stability of the whole world.

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