The Nuclear Asymptote
On Containing Nuclear Proliferation

Roger C. Molander,
Peter A. Wilson
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Supported by the Carnegie Corporation

Project on Avoiding Nuclear War:
Managing Conflict in the Nuclear Age

RAND/UCLA Center for Soviet Studies
This report is one of four that constitute the final output of the RAND project on “Avoiding Nuclear War: Managing Conflict in the Nuclear Age,” sponsored by the Carnegie Corporation of New York. The Carnegie Corporation made the original grant in 1985, when the issue of avoiding nuclear war was still very much in the context of the Cold War. The grant supported a wide range of reports, Ph.D. dissertations, conferences, and “crisis games” in that context, but when the Warsaw Pact crumbled in 1990 and the Soviet Union itself collapsed in 1991, it was decided to use the remaining funds to explore the new issues of a world without a Cold War but still with nuclear weapons.

This report discusses the results of an assessment of the long-term global implications of the continuing proliferation of nuclear weapons wherewithal. It should be of particular interest to strategists and policy analysts who are working on the framing, analysis, and presentation for decisionmaking of the national and global security problems attendant on the proliferation of the wherewithal to build nuclear warheads and associated modern delivery vehicles, and other so-called weapons of mass destruction.

The other reports are on control of Russian and other former Soviet nuclear weapons, on deterring first use of nuclear weapons, and on the Japanese plutonium stockpile.
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INTRODUCTION

The Cold War dominance of the first 50 years of the evolution of the nuclear age ended with the spectacular—and, by any historical measure, dramatically fast—collapse of the Soviet Union, creating a profound discontinuity in the international security environment. The unexpectedly abrupt disappearance of the bipolar international security framework that had guided national security thinking in so many countries for so long caught nations and alliances by surprise, wholly unprepared to consider the new menu of security options that events now thrust before them. Many nations, once secure in the framework and discipline of a bipolar Cold War standoff, are now being forced, by the survival instinct, to look not just at new alliances but also to reconsider self-reliance for security—and therefore to consider or reconsider obtaining nuclear weapons capability.

In its triggering events, the end of the Cold War also unleashed centrifugal forces that not only increased the number of nations possessing nuclear weapons by three, but also set in motion a virtually certain dispersion of nuclear-weapons-related know-how and personnel. The telltale signs of that dispersion are starting to appear and may surge into a world that already had the character (thanks to the global spread of commercial nuclear power) of a nuclear supersaturated system. In this virtual nuclear-weapons cloud chamber, the entry of a small team (and plausibly a single individual) from the former Soviet nuclear weapons and/or missile laboratory infrastructure could dramatically alter a nation's nuclear weapons capability and thus its strategic position regionally or globally.
Further complicating the challenge posed by this image of the future is what might be called “the legacy of Rio”—the inescapable worldwide turning away from fossil fuels that is dictated by deteriorating global atmospheric conditions, punctuated politically by the events at and leading up to The Earth Summit, the 1992 Rio de Janeiro global environmental summit. This “Why take the chance?” imperative to reduce dependence on fossil fuels occurs, unfortunately, in a context in which nuclear power is the only universally available alternative with the potential to meet projected energy and energy security demands in most parts of the developed and developing world.

It seems clear that within the next two or three decades, maybe four at the very outside, we will move rapidly as a civilization through what might be called the middle years of a learning-curve-shaped nuclear age. There is little doubt that ahead of us is a technological state, a planetary condition, in which virtually any industrialized nation will have the scientific infrastructure and other wherewithal to produce both nuclear weapons and associated modern delivery vehicles indigenously (and probably, if deemed necessary, covertly by current inspection standards), and at an affordable cost.

What number of nations will maintain nuclear arsenals “at the ready”—available for use in minutes or a day or two at most—when the planet reaches that state? What number will openly maintain “virtual nuclear arsenals,” arsenals that by plan can be reliably built or assembled inside a nation’s particular notional strategic warning time, presumably a matter of weeks or months, after the appearance of dire political-military threats? What military role or function will nations proclaim for their at-the-ready and/or consciously planned (and maybe very secret) virtual nuclear arsenals? What uncertainty will there be—and what might be “acceptable”—in the degree to which a nation is nuclear-armed?

THE FOUR ASYMPTOTES

This analysis of the situation proceeds from the premise that, for the future of conflict between human beings, the issue of choising and navigating toward a long-term goal for the nuclear age is a defining one. It is an issue that must be squarely faced now: The inexorable spread of nuclear weapons technology must be confronted and the
challenge implied in that confrontation must be taken on—taming or containing that tendency in the direction of a more favorable or preferred end state.

In this report, we refer to such an end state as an asymptote and stress that careful attention be given to the articulation and consideration of alternative nuclear asymptotes. Much like the line toward which a mathematical hyperbola tends, a particular asymptote in this report will be viewed as that line or goal toward which a combination of nuclear-weapons-related factors and world conditions may tend. Also emphasized is the ability of policymakers and nuclear-armed states to effect one or another of these possible futures. This report is directed to analytically and politically framing several such asymptotes, or alternative end states.

In the study, four illustrative alternative asymptotes are set forward for consideration (and by implication for interpolation and extrapolation):

- “High Entropy” Deterrence—a highly proliferated world with few “rules of the nuclear road,” save possibly a self-perpetuating (if successful) cultural taboo on nuclear use. Such a world would rely on, among other things, an expanding web of bipolar or multipolar (or “all-azimuth”) international deterrence relationships to keep the nuclear peace.

- An Ever-Slowly-Expanding Nuclear Club—acceptance of an inexorable slow growth in the number of nuclear-armed states, with new members of the “club” grudgingly (or sometimes willingly) integrated into the existing nuclear order and carefully educated to a set of nuclear norms of behavior and associated concepts of deterrence and balances.

- A Two-Tiered Static “Have-a-Lot/Have None” International System—a handful of “haves,” or nuclear-armed states, maintain substantial (but limited by treaty) at-the-ready nuclear arsenals and commit themselves individually or collectively (most likely through the United Nations [U.N.] Security Council) as explicitly as necessary to maintaining the security of the “have-nots,” those without nuclear arms.
The Virtual Abolition of Nuclear Arsenals—virtual elimination of existing at-the-ready nuclear arsenals (a handful of states maintain tens to hundreds of nuclear weapons at the ready) underwritten by an unprecedented comprehensive and highly intrusive regime of international inspection and collective enforcement.

"High Entropy" Deterrence

The "High Entropy" Deterrence state could well be the product of a post-Cold War era in which, among other things, the United States turns inward and away from forceful involvement in an increasingly turbulent world. Such a world could rapidly degenerate from the order of the Cold War into increased international, political, economic, and military fragmentation, wherein many states conclude that possession of nuclear weapons is a reasonable answer to the real or imagined threat of regional predators. Although some bilateral or multilateral nuclear-arms-control agreements might exist that seek to stabilize the size and character of nuclear arsenals, nations possessing nuclear arsenals would presumably go to great lengths to make such arsenals survivable against any adversary's effort to cripple the force with a preemptive attack. In turn, a number of small arsenals might be controlled by non-state entities, such as international criminal organizations, or political or religious groups—groups that benefit from inadequate state control of nuclear material or that might, in a crisis, such as the loss of central control in some nuclear-armed entity, appear out of nowhere. Defining international stability would be problematic.

The world of many nuclear-armed entities might emerge slowly over the next generation or two, but with no use of nuclear weapons in the transition period. In that case, there could be growing confidence in the "forever" viability, and the breadth of application, of nuclear-weapons-based deterrence.

Some variant of this end state might emerge from a dramatic demonstration of the military and political utility of nuclear weapons—for example, a war that left a clear "victor" thanks to nuclear weapon use, with no meaningful punitive response (and possibly quite the contrary) from the international community. In this situation,
nuclear weapons would be given a powerful legitimacy, especially if their use had not been catastrophic. Such an outcome would shatter any nuclear-use taboo and could trigger a period of hyper-proliferation as many states moved deliberately designed or inherent virtual arsenals much closer to an operational status.

An Ever-Slowly-Expanding Nuclear Club

By definition, the asymptote of an Ever-Slowly-Expanding Nuclear Club is a slow-growth curve along which the major powers of the international community slowly accept new nuclear-armed states. The fundamental assumption of this possible end state is that the process of nuclear proliferation can remain a slow-motion affair, with new entrants achieving acceptance in the nuclear club only after a protracted period.

In all cases, the security concerns of the new entrants to this alternative asymptote would take on broader legitimacy as the major powers (and, more important, the declared nuclear-weapons states) tolerated and even helped integrate such states politically and militarily into more stable security relationships.

To facilitate such a process of gradual expansion, a variety of regional arms-control arrangements might well be negotiated to achieve new regional nuclear-deterrence balances. The success of this strategy would be highly contingent upon the new entrants' acceptance of an internationally defined set of rules of the road and possibly some rationalized deterrence relationship or relationships.

An underlying rationale for considering this kind of asymptote is the perspective that the world may well be in the position of trying to make a virtue of necessity: The process of the proliferation of nuclear-armed states is inevitable, and especially so in situations where the United Nations or a U.S.-led coalition (or the United States alone) is not prepared to provide insecure states with credible, extended-deterrence guarantees. As with any multi-tiered system, the international political legitimacy of this "some will sit in judgment on others' needs" strategy is somewhat shaky and viable only insofar as it is tested by time and experience.
The obvious first step under this choice of asymptote would be to accept Pakistan, India, and Israel as official members of the nuclear club, legitimizing the Israeli and Pakistani arguments that a state without powerful and reliable allies should be able to compensate for its conventional military inferiority vis-à-vis some threat by deploying a nuclear arsenal. India would presumably find the rationale for its arsenal in classic bilateral nuclear-deterrence concepts vis-à-vis Pakistan and/or China.

Overt acceptance of Israel as a nuclear-armed state will undoubtedly further stimulate nuclear weapon programs among the Arab states and Iran, so that a predictable “second shoe waiting to drop” would be the eventual demand to grant legitimacy to, say, nuclear arsenals in Iraq and Iran. Crafting a three-party strategic nuclear balance among these three Greater Middle East regional adversaries (which rationalizes the sizes of their at-the-ready arsenals) presents a considerable challenge.

**A Two-Tiered Static Have-a-Lot/Have None International System**

A two-tiered static Have-a-Lot/Have None (hereinafter “Have”/ “Have-Not”) International System is the implicit goal (and somewhat shakily proclaimed status quo) of the current international non-proliferation regime. One fundamental problem of this two-tiered system as currently constituted is the fading legitimacy of its basis: The five major powers on the winning side in World War II and the Perm Five of the U.N. Security Council (United States, Russia, United Kingdom [UK], France, and China) are the five declared nuclear-armed states—the “haves” that this choice of preferred end state would presumably try to perpetuate. Thus, one key to the viability of the two-tiered system is the viability of the current arrangement of the Security Council.

The difficulty of changing that arrangement, e.g., by adding Japan, Germany, India, and Brazil as permanent members, will be made more complex by the nuclear arsenal issue.

In terms of the problems posed by India, Israel, and Pakistan, as a variant of the basic approach of this alternative asymptote, it might be possible to bring these three nations into the Non-Proliferation
Treaty (NPT) and maybe into an “NPT II.” in a second tier of “haves” that agree, for example, to highly restrictive limits on at-the-ready arsenal size, greater transparency in their nuclear programs (to limit their virtual-nuclear-arsenal mobilization potential), and a commitment to become a “have-not” in some long term. Whether the global community would insist on more explicit and restrictive limits on the size of the arsenals of the Perm Five (or greater transparency in their nuclear weapons programs) in such a context would remain to be seen. The existence of nuclear weapons in these nations is no longer questioned in public debate and discussion. Therefore, any strategy that attempts to ignore or finesse the existence of these arsenals seems politically implausible.

As to the ability of the Perm Five to enforce this kind of regime, the recent experience in dealing with Iraq after its defeat in the Persian Gulf War appears unique and may not hold the strength of a real precedent. The support of France, the UK, and Russia, and the neutrality of China (or some comparable action-permitting posture among the Perm Five) cannot necessarily be guaranteed in future regional crises of this character or on issues of challenging suspected violators. The only test would be time and cases.

The Virtual Abolition of Nuclear Arsenal

The Virtual Abolition option reflects a view that in the post–Cold War world, the United States and other nuclear-armed nations could—and maybe in their own long-term interests should—abandon their current degree of dependence on nuclear weapons. In the U.S. military, for example, there appears to be a rising belief that a United States properly armed with conventional weapons may not need to rely on a substantial number of at-the-ready nuclear weapons to satisfy its future defense and deterrence needs (assuming continued, however slow and erratic, improvement in the U.S.–Russian relationship). At the same time, looking to the future threat environment, there is a rapidly growing appreciation that a small nuclear arsenal in the hands of a regional predator (such as Iraq in 1991) would present any U.S. or U.S.–led military force with a daunting and possibly technically insoluble set of basic military problems. From this conjunction of factors there emerges an interest in exploring what it would take to profoundly deemphasize the role of at-the-ready nu-
clear arsenals in international security; in practice, to remove nuclear weapons as a characterizing, or flagship, element in the arsenals of great powers.

In such a context of nuclear deemphasis, one clear question is how much existing at-the-ready arsenals would need to be reduced to market the concept in relation to how much such arsenals can or should be reduced against stability concerns. One possible approach along such lines, an approach that could be characterized as “virtual abolition,” would be to eliminate all nuclear weapons save for very small nuclear arsenals (e.g., hundreds or even tens of weapons) in the hands of the U.N. Security Council Perm Five. In such a context, a body such as the U.N. Security Council would assume far-reaching and highly intrusive early-warning and enforcement responsibilities as part of a new grand bargain on the nuclear weapons dimension of international security.

Key to this approach is the downgrading of nuclear weapons as a flagship element of the military forces of the great powers—a clear message that, henceforth, nuclear weapons are not to be a central element in great-power status.

The residual constellation of very small (and highly survivable) nuclear arsenals would be designed to be “the lid on the jar,” a deterrent and hedge against even a well-planned nuclear arsenal breakout scenario, including one by a state with a large virtual nuclear arsenal. At the same time, much thought and attention would be given to planned “if necessary” virtual nuclear arsenals, whereby the United States and other major powers would plan to be able to rebuild large nuclear arsenals (even to thousands of warheads) in a relatively short time (e.g., months).

In such a context, the number of “have-nots” hoping to become “haves” would presumably decline, and the remaining “wannabes” could be isolated and dealt with—if necessary, forcibly and with conventional weapons—by the former major nuclear powers on behalf of the world community. Highly intrusive inspections would be designed to provide very early warning of illegal nuclear-weapons programs, giving the international community time to build a consensus for diplomatic and economic sanctions and, if necessary, military actions against the outlawed facilities.
The feasibility of this alternative end state rests on the notion that potential proliferators can be convinced that nuclear weapons are, in fact, unnecessary or not essential to ensure their national security; that under a nuclear-abolition asymptote, national security threats, both conventional and nuclear, would diminish; and that conventional defense and multifaceted security guarantees would prove to be viable means of maintaining security and independence.

ON CONTAINING NUCLEAR ENTROPY

A viable long-term effort to contain the entropy reflected in the ongoing spread of nuclear weapons know-how and wherewithal will require a major, sustained effort by the international community. It will also require a strong measure of leadership by key nations, such as the United States. Without such a major input of national and international energy, including expending the potential energy of existing national and international political leverage, the "natural" end state of the nuclear-age asymptote is almost assuredly high entropy, the wide diffusion of nuclear weapons into the hands of many states and probably some non-state actors in a dynamic "political soup." To contain this tendency toward mathematical conditions approaching chaos will require the development of a broad international consensus on some asymptotic goal that reflects, indeed bespeaks, a concept of containment of such entropic forces, and an associated strategy.

The alternative is to accept a highly entropic end state and work hard to construct viable nuclear-deterrence relationships and the strongest possible cultural taboo on nuclear use.

THE STRATEGIC ROADMAP

What, then, should be the strategy, the strategic roadmap from here to there? "Here" is the intersection, or intellectual and historical crashing together, of (1) the existing and somewhat tattered NPT-based nuclear non-proliferation regime and (2) the residual forces and concepts from the so-called strategic nuclear competition of the Cold War. "There," for example, is one of the four sample asymptotic states described above, or some interpolation or extrapolation from those states.
In all four of the above-described states, the 1995 NPT renewal conference looms large, if not enormous, as the key foreseeable forum or passage for revealing the direction that the world’s leading nations will take on the nuclear proliferation problem. If the 1995 conference is a repeat of 1990, 1985, and previous conferences, with the United States and other key nations largely paying homage to the NPT and the associated regime as is, then one can infer that a decision to acquiesce to the forces of nuclear entropy has essentially been made. If the lead-up to the conference is characterized by a strong effort to bring Israel, India, and Pakistan into the NPT, even as nuclear-weapons states (although possibly with their arsenals frozen), or no serious effort whatever is made to lobby or leverage these countries on NPT membership, then one can infer that the choice is an ever-slowly-expanding nuclear club.

If the lead-up to the conference is characterized by the following two conditions—(1) a strong international effort to persuade India and Pakistan to rein in their nuclear-arsenal-building programs “before it’s too late to turn back” (assuming that that state has not already been reached) and join the NPT as non–nuclear-weapons states in return for some new international security guarantees (e.g., for India with respect to its concerns over China, and for Pakistan with respect to India) and (2) a strong effort to forge a peace settlement in the Middle East within which Israel makes a commitment to forgo eventually at-the-ready nuclear weapons (although it may retain a significant, acknowledged, and well-planned virtual nuclear arsenal)—then one can infer that an effort is being made to hold the line on a goal for the foreseeable future of the Perm Five being the only nations with at-the-ready nuclear weapons.

Finally, if the lead-up to the conference is marked by seriously debated proposals within the U.N. Security Council Perm Five for radical reductions in nuclear arsenals, the extending of new or reinforced security guarantees by that body or its members to key, identifiably insecure nations, and the opening of those nations to the kind of intrusive inspection that would characterize a virtual abolition asymptote—and maybe at the conference a presentation of a new Perm Five interim nuclear-forces-reduction package (say, to 1,500 warheads apiece for the United States and Russia and 300 for each of the other three nations) and serious discussion of eventually moving to a global taboo on nuclear weapon use—then serious steps toward
setting an asymptotic goal of virtual abolition will probably have been taken.

But whatever one's preferences, it seems clear that national and international choices made in the next five to ten years, whether made through action or inaction, will chart a course that will likely determine the asymptote for this planet's nuclear age.
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DEFINITIONS

This is an assessment of the future of the nuclear age—and an attempt to force the story. Its perspective is that of early middle age in the life of a natural, evolutionary process. It is thus the vantage point of postadolescence, the beginning of the middle years of a now (suddenly) rapidly maturing nuclear age.

It is cast as a stepping back, an initial turning and looking back to the beginning and the first half century of the nuclear age (Chapters Two and Three); then as a confronting of the reality and character of the ongoing (and unanticipated) acceleration in its maturation (due largely to the end of the Cold War coming too fast and too late) (Chapter Four); and, finally, as a looking ahead to the paths we might chart to live better in a now clearly foreseeable, fully mature nuclear age (Chapter Five). How will, or could, this extraordinary begun-in-the-twentieth-century story play out?

The framework or template that has been chosen to effect this looking back and looking ahead is largely a combination of three frequently encountered (and often recognized) natural constructs: learning curves, asymptotes, and entropy, as represented in Figure 1.1.

The first, the learning curve portrayed by the curved line in the figure, is perhaps the most commonly encountered (and reencoun-
A learning curve is that elongated S-curve which reflects the general pace of learning as a function of time—at first slow but accelerating, building to a steep midpoint where acceleration goes to zero, and then decelerating to an ever slower pace toward "knowing it all." Source unknown.


Figure 1.1—Three Natural Constructs

tered) of the three constructs addressed here. Its topographical features are well known: the "swamps" at the low end, where one is trying just to get "a grasp on it"; the steep slopes one fights up to get above the tree line (or helps someone else to get there), where one can see more clearly (and where, for a while, the going gets a little easier); and, finally (but not all the time), the upper slopes, where the air is rarefied but progress, as at the beginning, is again slow.

The asymptotes of advanced algebra's hyperbolas and other functions are found in real life in the quantitative and qualitative limits to, for example, achieving complete understanding (the implied limit portrayed by the horizontal line above the learning curve in Figure 1.1) or perfection (your tennis serve), or "enough" (money? food?), or just the steady state that some process approaches ever closer over time but never quite gets to.
The word *entropy*, like *paradigm*, can almost be characterized as popular in the sense that this measure of disorder or chaos—and bulwark of the Second Law of Thermodynamics—is showing up with increasing frequency in descriptions and assessments of naturally encountered phenomenon, including in academic political science, well beyond its initial home in the turbulent flow of fluids.

One example of the use of the above constructs in this report is in the fundamental tenet of this report:

Nuclear weapons matters, if left to natural processes, or, better, lacking the input of high political activity or energy, tend toward a high level of entropy.

Such a limiting case (portrayed at the lower left of Figure 1.1 as the dimensions of the problem becoming multitudinous and, by implication, denying a simultaneous solution) is in fact one possible asymptotic state for the nuclear age.

**THE ISSUES**

It is clearly imperative that the issues attendant on a full maturing of the nuclear age be viewed in as millennial or even galactic a fashion as possible. The mere development of such powerful weapons—a single weapon can literally destroy a major city—is itself asymptotic in an evolution-of-weapons sense: the end of a long curve that began with sticks and stones, and, early on, bones, as the movie *2001* encourages us to believe. One can perhaps conceive of an asymptote of more powerful and destructive weapons, to be developed by physicists and brought into the arsenals of the world by politicians. However, for this planet, “improvement” in the destructive power of individual weapons beyond that of nuclear weapons—consider the estimated 58-megaton nuclear weapon that the Soviet Union exploded in the Arctic in 1961—seems beyond political requirements and unlikely. Already, arsenals of nuclear weapons have been consciously built to the size required effectively to destroy nations as large as the United States and the former Soviet Union and to present implications of the still-maturing but clearly sobering “nuclear winter” and like environmental impact calculations.
It is thus instructive and not wholly fanciful to imagine that, out there in the cosmos, there once was—or will be—another planet where, thanks maybe to some cataclysmic natural event such as that which may have killed the dinosaurs on this planet, some other species moves up the food chain from snack to dominator and in time accepts the challenge of taming nuclear fire. For such a species, the discovery of nuclear fission might well have come at a different historical time than it did for us: in the challenging context of a devastating world war in which, fortunately, "the good guys" got "the Bomb" first. It might have been much worse in another nuclear age, as might have been the case on this planet had Nazi Germany developed nuclear weapons by 1944 apace with the development of the V-2. Yet there is something seemingly immutable in the process of natural evolution that leads one to think that the challenge posed by a species' ascent to nuclear weapons capability would be no less a problem if it occurred in a period of relative global peace.

No matter the early character of the origin of another nuclear age or ours, the inexorable spread of the technology of nuclear weapons would still have eventually cast forth the fundamental issues embedded in the natural learning curve, asymptote, and entropy constructs as set forth here, to include the following:

- To what degree will weapons based on the release of nuclear energy be among the legitimized weapons the dominant species maintains in its various national arsenals, rationalizes, on occasion brandishes, and by implication is prepared to use forever?

- What number of nations will maintain nuclear arsenals at the ready, available for use in minutes or a day or two at most?

- What number will openly maintain virtual nuclear arsenals, arsenals that by plan can be built or assembled inside a nation's notional strategic warning time (the time between the first manifestation of a direct political and military threat to a nation's survival and the maturing of that threat to a "ready-to-use-against-you" state), presumably a matter of weeks or months, or possibly even longer?

- What military role or function will nations proclaim for their at-the-ready and/or consciously planned virtual nuclear arsenals (at least for those to which they admit, or even subtly brandish)?
• What uncertainty will there be—and what might be "acceptable"—in the degree to which a nation is nuclear-armed?

• What are, within the realm of the possible of politics, the nuclear-weapon-defined (or -confined) end states that, at this time, we might consider trying to navigate toward (or accept)?

• What are the key national and global "nuclear metrics," the flagship quantitative and qualitative characteristics of national and global nuclear arsenals, for describing and comparing such alternative end states or "goals to go for even if you never quite get there"?

Finally, we seek to answer the question of how to get from the middle point of the nuclear age to a particular asymptote—"from here to there"—the crucial matter of developing a strategic roadmap (Chapter Six). Just how, politically, can the human community effectively engage this fundamental evolutionary question, recognizing that time is of the essence. Options for proceeding politically and options for long-term outcomes may soon be wasted if the evolving post-Cold War security environment, especially its leadership, is characterized more by temporizing than by action.

The cardinal point, as discussed in more detail in Chapter Two, is that the abrupt end to the Cold War has created not just the prospect of an additional three nuclear-weapons states and an outflow of nuclear-weapons-related scientific knowledge, but, even more importantly, a profound discontinuity in the international security environment. Many nations, once secure in the framework and discipline of a bipolar Cold War standoff, are now forced by the survival instinct to look not just at new alliances but to reconsider self-reliance for security—and therein see a powerful attraction in nuclear weapons.

In this evolving and challenging context, no currently planned or foreseeable opportunity looms greater, or offers greater promise as a decisionmaking forum, than the upcoming 1995 Non-Proliferation Treaty (NPT) renewal conference. When that watershed conference is over, we will almost certainly be able to judge whether the driving natural force of entropy will likely be arrested and contained in the nuclear armaments realm. Will that conference show humanity's commitment to spend, not just for a few years but for an asymptotic
evermore, the very considerable energy necessary to combat or control nuclear entropy—and thereby, as a still further legacy, prevent nuclear war? In 1995, amidst the marking of the fiftieth anniversary of the end of World War II, and of Alamagordo and Hiroshima and Nagasaki, there might be no more fitting memorial to those who fought and died and worked behind the lines in that most devastating to date of human conflicts. The Epilogue to this report provides further perspective on such a prospect.
Chapter Two

STEPPING BACK

There is little question that the first 50 years, and the first phase, of the nuclear age (see Figure 2.1) was dominated by, and ended with the end of, the Cold War. The U.S.–Soviet nuclear relationship and competition in that period were internationally overwhelming and defining. Almost all other aspects of the global role of nuclear weapons for those decades—and countless worldwide security arrangements and understandings—were in some fashion dependent on that relationship.

In that same period, an irreversible spread of nuclear-weapons-related technology was proceeding apace, largely in the context of a

![Diagram](image)

*Figure 2.1—The Learning Curve of Global Nuclear Weapons Capability*
global quest for energy independence to be achieved through nuclear power. It was not of great significance as a security issue to any but a relatively small community worried about the long-term implications of nuclear weapons. While the number of nations that explicitly or implicitly acknowledged having nuclear arsenals grew slowly through this period, to a mere half dozen, the number of countries with nuclear power reactors and an associated nuclear infrastructure grew to over two dozen. At the same time, many more nations were sending some of their best students abroad to learn the details of a technology that had passed from high physics to the far more accessible realm of engineering. Unfortunately, with the knowledge of nuclear engineering for nuclear power came the know-how, given the availability of the right raw materials (increasingly recognized as a not insurmountable task), to engineer the production of a workable nuclear weapon.

The Cold War dominance of the first phase of the evolution, or maturing, of the nuclear age ended with the spectacular—and by any historical measure dramatically fast—collapse of the Soviet Union. The accompanying abrupt disappearance of the bipolar international security framework that had guided national security thinking in so many countries for so long caught nations and alliances by surprise, wholly unprepared to consider the menu of new security options that events had now thrust before them.

In its triggering events, the end of the Cold War also unleashed centrifugal forces that not only (in practical terms) increased the number of nations possessing nuclear weapons by three but also set in motion a virtually certain dispersal of nuclear-weapons-related know-how and personnel, the telltale signs of which are starting to appear (e.g., Russian scientists were taken off a plane bound for North Korea). That scattering may surge into a world that already has the character (thanks to the global spread of commercial nuclear power) of a nuclear supersaturated system, a virtual nuclear-weapons cloud chamber in which the entry of a small team (and plausibly a single individual) from the former Soviet nuclear weapons and/or missile laboratory infrastructure could dramatically alter a nation’s nuclear weapons capability and thus its regional or global strategic position.

Further complicating the challenge posed by this image of the future is what might be called “the legacy of Rio,” the inescapable turning
away from fossil fuels that is dictated by deteriorating global atmospheric conditions, a turning away punctuated by the events leading up to and at The Earth Summit, the 1992 Rio de Janeiro global environmental summit. It occurs, unfortunately, in a context in which nuclear power is the only universally available alternative with the potential to meet projected energy demands in most parts of the developed and developing world. No foreseeable political force is going to reverse this trend. The implications for nuclear proliferation of an almost inevitable resurgence of interest in nuclear power are not yet well understood but are certainly not positive.

It seems clear that within the next two or three decades, maybe four at the outside, we will move rapidly as a civilization through our nuclear middle age, Phase II of Figure 2.1, and reach a state where virtually any industrialized nation (meaning the majority of the nearly 200 nations on the planet) will have the scientific infrastructure and other wherewithal necessary to produce nuclear weapons indigenously and at a cost that is deemed affordable.

What asymptotic conditions might prevail when the planet reaches that state? What is the potential for humanity to consciously and profoundly shape the character and the key components of that asymptote against the constant and demanding force of entropy?

The premise of this report is that the human species is at a critical juncture for the future of nuclear weapons on the planet. Decisions made over roughly the next five to ten years could definitively chart that future. In their making or in their denying, such decisions will also clearly chart the future character of warfare as regards so-called weapons of mass destruction and, to some degree, conventional weapons. It would not be an exaggeration, then, to describe this upcoming period as the chance of a lifetime for this species and civilization, since opportunities that now present themselves could well be closed forever within this relatively brief period.

Proceeding from that premise, this report seeks to draw as broad an options assessment as possible for those long-term nuclear-weapons-related goals (and associated strategies and policies) that now warrant serious consideration in the United States and in many other nations. It next presents the character of the nuclear age, in Chapter Three.
In the immediate aftermath of the bombings of Hiroshima and Nagasaki, as the world confronted the implications of the development and use of "atomic bombs" to end World War II, it was poignantly clear to the Manhattan Project scientists that they stood at the origin of an inescapable global nuclear-weapons learning curve. There was considerable uncertainty about when that curve would steepen, and the number of nations with the indigenous wherewithal to build nuclear weapons rapidly increase; there was little doubt in their minds that humanity would, in time, whether over decades or generations, reach such a point. They clearly recognized that the biggest atomic secret of all, that weapons harnessing the energy of the atomic nucleus could actually be built, was out of the box with Alamagordo and demonstrated for all to see at Hiroshima. At the origin of the nuclear age as we have come to know it, these scientists could not help but wonder where it would end.

"TO BUILD OR NOT TO BUILD" A NUCLEAR ARSENAL

Beyond the question of the growth in indigenous capability, there was the obvious companion question of just how fast might be the growth in the number of nations that actually went ahead and built and maintained nuclear weapons at the ready, capable of almost immediate use in war. Further, there was the question of how many nations might not maintain at-the-ready arsenals but might consciously plan, if deemed necessary, to take a virtual nuclear arsenal to an at-the-ready state inside some notional strategic warning time. (Sweden, for example, is among the nations believed to have con-
sciously taken steps, starting in 1946, to acquire a virtual nuclear arsenal, with a response time today that is more likely measured in weeks than in months.) The amount of planning and other steps required to achieve such a capability will, over time, decrease dramatically, and the number of nations judged to have a strategically meaningful virtual nuclear arsenal will grow accordingly (see Figure 3.1).

In fact, with the likelihood of continued, if not growing, global reliance on nuclear power for the foreseeable future and the likelihood of ever-increasing numbers of nations indigenously capable of producing large numbers of modern strategic nuclear-weapons-delivery vehicles (such as ballistic missiles and cruise missiles), we may soon reach a point where a nation's virtual nuclear arsenal capability will be almost as important a metric as the capability it maintains at the ready. Figure 3.2 portrays the virtual-arsenal concept as a function of the time required to bring nuclear forces to a ready-to-shoot status.

Figure 3.3 highlights the prospect that Japan's growing plutonium stockpile (and associated handling facilities), married to its substantial and growing satellite launch capability, could form the basis for an impressive virtual nuclear arsenal within the next 20 to 30 years.
Figure 3.2—Sizing and Timelines for a Virtual Nuclear Arsenal

Figure 3.3—A Notional Comparison of U.S. and Japanese At-the-Ready and Virtual Nuclear Arsenals
(While not called out as such in Figure 3.3, a portion of the notional U.S. virtual nuclear arsenal would probably be available in a matter of weeks.)

The Manhattan Project's successful race against time—especially against the prospect that Nazi Germany might develop nuclear weapons first—and the success of nuclear weapons in quickly ending the war with Japan, drove home for everyone both the feasibility of nuclear weapons development and the value of such weapons. In the face of these inescapable realities, the United States immediately went to extraordinary ends, manifested in the 1946 Atomic Energy Act, to deny nuclear know-how to the rest of the world and delay for as long as possible the acquisition of nuclear weapons capability by other nations. The early outcome of that effort—marked by the Soviet nuclear test in 1949 and a British test in 1952—was discouraging, especially considering the economic conditions in both the Soviet Union and Great Britain in the years immediately after the war. It was clear that there was going to be no U.S. monopoly on nuclear weapons. Faced with this reality, nuclear weapons efforts in the United States shifted to establishing and maintaining clear superiority in this military realm.

Such unexpectedly early expansion of what became labeled "the nuclear club" (generally defined by practitioners as nations that acknowledge the possession of at-the-ready nuclear arsenals) caused the United States to put forward the idea that nations that might otherwise get on a nuclear weapons path could be enticed onto a more appealing commercial nuclear-power path through the utopian reward of energy "too cheap to meter." In retrospect, pursuit of this idea—manifested in the mid-1950s' U.S. Atoms for Peace plan—looks like one of the worst decisions of the nuclear age. Although Atoms for Peace did draw many nations into the world of commercial nuclear power, the promised yellow brick road to cheap power (and peace) faded with the recognition of the complexity and cost of producing "safe" nuclear power plants. The plan left in its wake a host of countries with a maturing nuclear infrastructure and, unfortunately, much of the basic nuclear know-how required to launch a serious nuclear weapons program. France unambiguously proved the dual-use value of this technology by exploding a nuclear weapon in 1960.
By the early 1960s, the Atoms for Peace boost to the maturing of the nuclear age had left U.S. policymakers and military strategists deeply concerned that the long-feared steepening of the at-the-ready nuclear arsenal curves of Figure 3.1 was about to take place. It did not. In spite of dire predictions of rapid growth, such as President Kennedy's oft-cited estimate (or admonition) that there could be as many as 20 nuclear-armed states in 20 years, a number of nations who might have launched nuclear weapons programs in this time frame were instead “bought off” or politically “fenced off” from such development by the U.S. deployment of theater nuclear weapons and the extended-deterrence guarantee of shelter under the U.S. nuclear umbrella—or under the nuclear umbrella of the Soviet-controlled Warsaw Pact.

A special concern in this regard had been Western Europe, where a number of nations in addition to Great Britain and France were clearly in a position to turn their rapidly expanding nuclear know-how toward nuclear weapons development—but did not. Rather, they and other nations were persuaded not only to keep their nuclear efforts directed to nuclear power, but also to join in a global effort, eventually labeled the nuclear non-proliferation regime, to erect a comprehensive set of limitations (treaties, export constraints, etc.) that would deny or restrain access to key nuclear-weapons-related technologies and materials.

The nuclear non-proliferation regime, anchored by the Nuclear Non-Proliferation Treaty completed in 1968, did its job, at least for a time. While China’s explosion of a nuclear weapon in 1964 was not good news, it was no real surprise that the Chinese had made this political commitment and were able to mount the scientific and industrial effort to achieve nuclear club status. That Israel in this same period was also achieving nuclear weapons capability and that Sweden was planning a virtual nuclear arsenal would have been more troubling and more of an intimation of things to come. But the Israeli and Swedish secrets were well kept.

India’s explosion of a nuclear device in 1974, clearly with the aid of technology and materials procured under the guise of a peaceful nuclear power program, was a profoundly troubling development. It demonstrated that a nation with a sound scientific infrastructure and a nuclear power program, even if economically strapped, could
covertly develop nuclear weapons. International pressure arrested the deployment of any operational arsenal, but the test provided a powerful stimulus to the initiation of the Pakistani nuclear weapons program. (Almost 20 years later, Iraq, well down the list of nations in terms of gross national product and burdened by the cost of a long and difficult war with Iran, proved that point even more starkly in the nuclear weapons program that it covertly brought to a highly advanced state in spite of being an NPT signator.)

In this same period, two other Asian nations, South Korea and Taiwan, also pursued serious nuclear weapons programs until they were leaned on heavily (through quiet political pressure) by the United States in the mid-1970s and the programs were halted, or at least went “underground.”

This latter prospect, that in spite of the NPT and International Atomic Energy Agency (IAEA) safeguards, other nations besides Iraq might have advanced covert nuclear weapons programs, is one of the intangible but worrisome problems of the steep part of the growth curve in the global spread of the ability to build nuclear weapons. Still further, the shock of the extraordinarily advanced character of the covert Iraqi program and the 1993 revelation of a successful South African nuclear weapons program have shattered confidence in the ability of IAEA and other existing nuclear-intelligence-collection capabilities to know just what is going on globally in this realm—a no-confidence condition that will be rectified among political (and military) leaders and publics only through repeated future detection “successes,” a daunting track record to have to establish.

In confronting the reality of the inexorable spread of nuclear weapons know-how, it is also critically important to recognize that the actual production of nuclear weapons is becoming monotonically easier: Largely as a consequence of improvements in technologies relating to commercial nuclear power, with every passing year it can be assumed that reductions can be made in the sizes of the key facilities, the number of scientists and technicians, the education level of this technical cohort, the amount of electrical power consumed, the release of telltale radio nuclides, and the time for each key step in the nuclear-weapons-development process. For example, a two-story centrifuge facility covering a single city block can annually produce enough highly enriched weapons-grade
uranium for roughly ten nuclear weapons—well within the size of facilities that can be hidden in mountain caves. Similarly, instead of the many hundreds of top physicists, chemists, mathematicians, and other scientists who staffed the Manhattan Project and its supporting efforts, a couple dozen well-educated engineers would be adequate to design and direct a full-blown nuclear weapons program.

THE IMPACT OF THE DIFFUSION OF MILITARY TECHNOLOGY

The Thesis and Clash of Military Revolutions

A central thesis of many commentators on contemporary military technique (doctrine, organization, training, and technology) is that a “third military revolution” of the twentieth century is now under way. The first was the use of armored fighting vehicles, aircraft, submarines, and chemical weapons during World War I. The second one first emerged at the end of World War II with use of long-range cruise and ballistic missiles (the V-1 and the V-2) by Germany and nuclear weapons by the United States; it reached full maturity in the 1970s with the fielding of nuclear-armed MIRVed (multiple independent reentry vehicle) submarine-launched ballistic missiles (SLBMs) and intercontinental ballistic missiles (ICBMs), and highly accurate cruise missiles.

By the mid-1970s, with the achievement of rough nuclear parity, both superpower militaries became skeptical about the utility of nuclear warfare and began to focus on the design and use of military forces to conduct non-nuclear operations in a variety of limited conflicts—thereby pushing development of new military technologies that foreshadowed the current prospect of a third military revolution. The main elements of this new transformation were sensors, telecommunications, automatic data processing, advanced conventional munitions, spacecraft, and low-observable unmanned and manned fighting vehicles. Appendix A provides a more detailed description and assessment of some of the key components of this third military revolution. The utility of these new technologies in warfare was strikingly demonstrated in the U.S.-led success in the 1991 Persian Gulf War.
Unfortunately for the United States, many of its Western allies, and the Russians, all of whom have invested and continue to invest heavily in this third revolution, it is not at all clear that the potential future adversaries of these countries will play their game. In fact, quite the contrary: Many such potential adversaries appear to be pursuing—with strong commitment—the weapons of the second revolution, missiles and nuclear weapons, while still showing disturbing interest in the chemical weapons of the first revolution and even looking ahead to what may be a key component of yet a fourth revolution—biological weapons.

In this disquieting situation, the prospect of a regional power acquiring high-performance and survivable long-range bombardment systems of the second revolution (cruise and ballistic missiles) and the prospect of countering such systems (however armed) are worthy of consideration.

The Diffusion of Ballistic Missile Technology

At present, seven countries are capable of producing a transoceanic-range ballistic missile (nominally, a range in excess of 5500 km): the United States, Russia, France, China, Ukraine, Japan, Israel, and India. (The latter three have not produced such missiles but have demonstrated their competence to do so by flying space launch vehicles with ICBM performance characteristics.) While the United States, Russia, and (presumably) Ukraine are restricted by the Intermediate Range Nuclear Forces (INF) Treaty from developing and deploying ballistic missiles in the 500- to 5500-km range, other members of the long-range "rocket club" can and have produced a number of weapons within the INF band. Noteworthy are the ongoing programs in China, India, and Israel to produce solid-propellant ground mobile "theater-range" (500-3000-km) missiles. The technology for shorter-range systems is even more widely spread, with at least eight more states (Iraq, Iran, Egypt, Pakistan, North Korea, Brazil, Argentina, and South Africa) having the capacity to manufacture short- and medium-range (100-500-km) ballistic missiles.

Advances in guidance systems and other refinements suggest that such tactical and theater-range ballistic missiles will soon be very effective in delivering non-nuclear ordnance—a strong motivator for
their development and sale. (This motivation will likely be the case especially for nations that cannot afford to maintain an air force that is any match for that of the United States, Russia, or these nations’ allies.) For example, at ranges of 500 to 1000 km, guidance packages that yield circular error probabilities (CEPs) of 100–200 meters will likely be available in the very near term. Such packages will fully exploit the Global Positioning Satellite (GPS) navigation system (a capability that is rapidly spreading in the global civil aviation industry) and maneuvering reentry vehicles that hold the prospect of upgrades to CEP accuracies as low as 20–50 meters.

The Diffusion of Cruise Missile Technology

Although less well publicized and developed, there is the real prospect that the cruise missile will become a widely used supplement to a ballistic missile arsenal. With access to GPS-class satellites, dozens of countries will be able to build an arsenal of hundreds if not thousands of highly effective, conventionally armed tactical and theater-range cruise missiles. Operating identically to their ballistic-missile analog, mobile cruise missile launchers will be very hard to find and destroy. Unlike ballistic missiles, especially those using large, solid-propellant motors, cruise missiles can be mass-produced with the use of a relatively primitive industrial infrastructure.

There is already proliferation of cruise-missile-type vehicles in the form of short- and medium-range reconnaissance unmanned air vehicles (UAVs), which demonstrated considerable military utility during the Persian Gulf War. A very large number of countries have mastery of such technology. The most prominent include the United States, Russia, France, the United Kingdom, Germany, Italy, Israel, China, Japan, India, and Egypt. Much of the technology of the cruise missile flows from dual-purpose aviation technology, such as efficient jet engines, navigation systems, and nonmetallic structures.

Countering Second-Military-Revolution Delivery Vehicles

Among the most striking lessons of the Persian Gulf War were (1) the inability of the U.S.-led coalition to find and kill Iraqi Scud launchers in spite of complete air superiority in the region and (2) the relative ineffectiveness of the Patriot system as an anti-tactical ballistic mis-
sile (ATBM) defense against the relatively unsophisticated Scud missiles, in spite of the absence of barrage tactics or such potentially daunting tactics as precursor nuclear weapons. Both lessons emphasize just how far those nations that would like to fight subsequent wars employing the weapons of the third military revolution must go in countering second-revolution delivery vehicle technologies—and, inversely, the incentive for their adversaries to continue to pursue improvements in second-revolution technologies (such as more sophisticated deceptive basing techniques and ballistic missile penetration aids).

Clearly, for success to be achieved in countering these ever-improving weapons, a comprehensive systems approach must be taken and operational concepts akin to a campaign must be employed. Such an approach implies far more sophistication and capability in intelligence collection targeted at locating threatening delivery vehicles, real-time coupling between intelligence and the operators of systems that might be able to kill such delivery vehicles once they are located or are in boost phase, and far better performance in mid-course and terminal-phase defenses.

Just how much better a country such as the United States might do when it turns its intelligence-collection assets—and planning for developing new assets—away from Cold War tasks to a greater focus on the threats discussed here remains to be seen. However, it is clear that by any measure the developers and operators of such assets are currently mired in the low end of the learning curve vis-à-vis finding certain relocatable delivery vehicles and chasing a threat that is anything but static, while operating in a tough fiscal environment of declining defense budgets. This is a formidable political situation, demanding that those who would claim significant improvement on the Persian Gulf War experience provide demonstrable and incontrovertible proof of capability.

At the next level of countering delivery vehicles, boost-phase intercept, there is no empirical basis for judging capability. (The boost phase for cruise missiles, e.g., a gas-driven catapult, is so short as to present no real potential vulnerability.) A wide range of ballistic missile boost-phase-intercept concepts is now being put forward to meet the obvious demand to “do something,” but it will be years before any concept can be tested effectively or be measured in
capability against the tactics and countermeasures of a responsive offense.

In terms of mid-course and terminal defenses against ballistic missiles, the United States is conducting an active program within the Strategic Defense Initiative (SDI; now the Ballistic Missile Defense Office [BMDO]), and the Russians continue to pursue terminal-defense concepts. It remains to be seen whether any of the concepts currently under development will meet the extraordinary performance demand—virtually 100-percent effectiveness—that is likely to be imposed in such contexts as theater missile defense. The ability of such defenses to counter a few stragglers from a highly successful counterforce and/or boost-phase attack against an adversary ballistic-missile force could be crucial; however, it will, for example, militarily meaningless if, in the end, a large number of warheads are attacking a key target, such as a national capital or a port, and the first seven are shot down but the eighth gets through.

Both the United States and Russia have a wide range of impressive air-defense sensors and weapons in existence and under development. Although the popular impression is that defending against aerodynamic vehicles is easier than against ballistic vehicles, both present a theater defender with a daunting problem (to say nothing of the problems posed by a simultaneous attack of, say, several hundred cruise missiles and several tens of ballistic missiles). The challenge and potential for a no-leakage defense against cruise missiles is discussed in more detail in Appendix A.

The next chapter looks carefully at the practical implications of the above-described technologies in relation to several possible post-Cold War nuclear eventualities.
The receding of the Cold War has not merely cleared away the political dominance and preoccupation with the problems of that decades-long bipolar confrontation; it has also left exposed in all of its sobering character the actual state of the nuclear proliferation problem.

It would not be an exaggeration to say that a nuclear awakening, a nuclear transformation, is now in progress on planet earth. It is manifest most strongly in the (so-far) mini-nuclear arms race in South Asia, the now-exposed Iraqi and South African nuclear programs, the nuclear progress of North Korea, and the growing evidence of Iranian nuclear weapons ambitions. An acute problem for the human species has been concealed by the so-called nuclear non-proliferation regime and the associated scorecard of nuclear club members: a slow but seemingly inexorable growth in the number of nations that are taking advantage of the increased availability of nuclear weapons technology and choosing to rely (at least in part) on nuclear weapons for their security.

THE PROFOUND IMPACT OF THE ABRUPT END TO THE COLD WAR

From 1989 to 1991, over the course of no more than three short years, the 45-year-long Cold War moved to an abrupt and remarkably non-violent end. In historical terms, the planet was transformed: The heretofore political certainties, if not outright rigid structures, of the ideologically grounded bipolar competition between two superpowers disappeared overnight. The former Soviet Union ceased to exist
altogether; the “victorious” United States celebrated briefly—then turned to face a set of serious social, economic, and fiscal problems, in part the legacy of the protracted national emergency.

In spite of its somewhat weakened domestic base, the Cold War “winner” now faces a central question, a question of no small interest to other nations: What role will this now militarily and politically preeminent nation play in an increasingly dynamic global system of multiple centers of economic, military, and political power? In a sense, the United States faces a historical crisis and—in the classical Chinese definition of crisis—both danger and opportunity. The danger flows from the prospect that the post–Cold War international community will fragment as the United States and Russia, the still militarily powerful and important legatee of the departed Soviet Union, turn inward to deal with domestic needs. The opportunity is the prospect that an enduring period of relative international peace and prosperity can be built through the efforts of a coalition of the great powers—energized in part by continued U.S. international activism and leadership by the United States and other key nations. What has become clearer since the collapse of the Soviet empire is that the Cold War left as part of a legacy the beginning of a period of historic transformation.

THE LEGACY

The U.S. post–World War II strategy had two parts—containment and reconstruction. The collapse of the Soviet Union highlighted the success of the containment component. The success of the reconstruction component, a component that helped propel West Europe and East Asia into an unprecedented period of economic prosperity (and with it greater political independence), is equally well manifest: In simple geostrategic terms, the United States successfully contained the “heartland” of Eurasia, providing a protective cover beneath which the “rimland” of that supercontinent rebuilt its economic power.

Centers of Power

With the twin successes of the U.S. strategy, several major centers of power have appeared in Eurasia. They include the European
Community (with Germany at its core), East Asia (where Japan possesses the world's second-largest economy), China, the oil-wealthy states of the Middle East, and India. Out of the wreckage of the former Soviet Union, a new Russian state is being created alongside a set of new neighbors, which include new states of note, especially Ukraine and Kazakhstan. Eurasia has thus returned again to a constellation of major powers without any one having clear superiority in economic, military, or political assets.

Further enhancing the phenomenon of "multipolarity" is the diffusion of contemporary high-technology industrial capabilities to a number of states, including Brazil, Argentina, Israel, and South Africa—a product of the worldwide industrialization and modernization that was a major feature of the Cold War era. The full impact of this diffusion of capability will now be felt, especially in the realm of military technology, without the constraints imposed by two superpowers locked in a multifaceted global struggle.

**Diffusion of Military-Industrial Technology**

Virtually overnight, the United States, the former Soviet Union, and their Cold War allies have had to face a surplus of military-industrial infrastructure optimized to support a confrontational stance having the characteristics of a "forever war." Denied a smoother transition, arms manufacturers from both sides have turned quickly to the outside world for buyers for the output from plants for which conversion plans (increasingly recognized as a formidable economic and political challenge) are only now being developed. The international community thus faces a difficult transition period in which four major sources of arms (the United States, Russia, the European Community, and the newest major arms exporter, China) compete with smaller but significant producers (e.g., India, Ukraine, Israel, and Brazil) for a shrinking global market. For Russia, the task of conversion is especially daunting since the Russian military-industrial sector remains one of the few advanced elements of an economy in traumatic transition and since much of the former Soviet military infrastructure was purposely centralized in restricted company towns.

As revealed by major arms sales during the summer and fall of 1992, both the United States and Russia are likely to vigorously market ad-
vanced weapon systems, especially to those zones with available hard currency: the Middle East and East Asia. Such domestically driven pressures also operate elsewhere and will make it extremely difficult to craft and sustain a meaningful international restraint regime on the further diffusion of high-technology military hardware and expertise. They will likely accelerate a new round of regional arms competitions within the Middle East and East Asia.

As noted at the outset of this report, in parallel with these trends in the diffusion of military hardware has been the diffusion of nuclear industrial technology and with it some deliberate growth in global nuclear-weapons capability. In addition to the five formally declared nuclear-weapons states, the Perm Five (the United States, Russia, the United Kingdom, France, and China), Israel is judged to have an unacknowledged nuclear arsenal of at least 100 weapons and is treated as a nuclear-armed state by friend and foe alike. India and Pakistan are both now believed to possess very small nuclear arsenals. South Africa acknowledges that it once had assembled six nuclear weapons. Three legatees of the collapsed Soviet Empire, Ukraine, Byelarus, and Kazakhstan (at least at this writing), retain nuclear weapons on their territory. Several other states, including North Korea, Iraq, and Iran, almost certainly aspire to nuclear-armed status (with North Korea’s recent threat to withdraw from the NPT possibly signaling the realization of an operational nuclear arsenal). And several others, such as Sweden, Argentina, and Brazil, are known to have taken various levels of “premobilization” steps to exploit their indigenous nuclear industrial capability.

**Nuclear Weapon Use**

In this context of now-evolving post–Cold War “capabilities” and international politics, it is important not just to count nuclear warheads but also—in fact, more so—to examine the potential role of nuclear weapons in conflict. After all, one of the most positive legacies of the Cold War is no nuclear use since 1945, and what some see as an emerging taboo against use as distinct from possession. What then are the ways in which nuclear weapons might be used in the post–Cold War world?

The following section assesses the character and implications of an emerging global spectrum of nuclear weapon “use” scenarios. Only
through such a process of examination can we hope to see more clearly just what kind of dangers the new world presents, and get on a path to a comprehensive approach to reducing or, as much as possible, even eliminating these dangers.

THE PROSPECT OF NUCLEAR CONFLICT: GENERIC NEXT-USE CASES

With the end of the Cold War, a real prospect is that local or regional conflicts (some unleashed in part by the end of the bipolar standoff) will be the most likely route to nuclear war. Three generic circumstances would appear to capture the spectrum of such nuclear weapon next-use scenarios (and supersede in likelihood the classic superpower nuclear-exchange scenarios of the Cold War):

1. Loss of central control, in which a national command authority fragments during breakup of a heretofore unitary state, raising the prospect of a nuclear civil war.

2. Emergence of a nuclear-armed regional predator, wherein a major power (or a major-power-led alliance) intervenes to thwart some nation’s expansionist or hegemonic efforts.

3. Regional war between two newly nuclear-armed states—the so-called Nth-on-Nth nuclear war problem.

Each of these cases, described in greater detail below, represents a class of events characteristic of the post–Cold War security environment, the dynamic and uncertain international security context that will most likely prevail into the first decade of the twenty-first century, if not well beyond.¹

¹This general approach to framing the post–Cold War nuclear-use problem and much of the perspective in this section are drawn from the results of a RAND project that explored the post–Cold War nuclear-proliferation-related policy landscape through a series of generic policy exercises. See Millot, Marc Dean, Roger Molander, and Peter Wilson, "The Day After...?": Nuclear Proliferation in the Post–Cold War World, Santa Monica, Calif.: RAND, MR-253, forthcoming.
Loss of Central Control

The rapid collapse of the Soviet Union in the aftermath of the failed August 1991 coup dramatically thrust forward the prospect that centralized control of a nuclear arsenal could fragment, laying to rest a debate within the more academic parts of the international security community about whether nuclear civil war scenarios were fiction or a real possibility. In fact, as discussed below, the initial problem of loss of central command and control of the Soviet nuclear arsenal may have evolved into a situation in which political authority of a portion of the arsenal is seriously contested.

In the days and weeks immediately following the 1991 failed coup attempt, who or what institutions controlled the Soviet nuclear arsenal was unclear. Fortunately for the prospect of global peace, the national command authority within the former Soviet Union was not shattered outright in this period. By fall 1991, a central authority dominated by Russia (in effect, the old Soviet Ministry of Defense) maintained clear lines of operational control over the nuclear arsenal, and it was clearly the intent in Moscow to “Russify” the Soviet nuclear arsenal.

Throughout winter 1991–1992, a drama played out, featuring three of the newly independent states—Ukraine, Byelarus, and Kazakhstan—engaged in a debate with Russia on the ultimate status of the long-range “strategic” nuclear weapons on their territory. By the end of this period, and surprisingly to many observers, it appeared that the complete Russification of the former Soviet nuclear arsenal would be accepted by all former non-Russian republics. In particular, all former Soviet nonsstrategic or theater-tactical nuclear weapons were consolidated under Russian physical control by late spring 1992.

But the outcome is now far less certain. As of this writing, Byelarus and Kazakhstan have already accepted Russian control of the nuclear forces on their soil, but the situation between Russia and Ukraine on these systems remains problematic.

Unfortunately, the situation in this post–Cold War drama continues to pose risks (and to emphasize the dynamic and unpredictable character of nuclear loss-of-central-control scenarios). Tensions continue between Russia and Ukraine over a wide range of outstanding economic, security, and territorial issues. While Ukraine initially
appeared prepared to give up the option of what might be called high-speed, or instant, proliferation, i.e., acquiring operational control of the nuclear-armed missiles on its territory, ongoing political processes in that country hint at the development of a more calculated approach to its nuclear status, an approach that could presage outcomes in other future loss-of-central-control scenarios that feature fragmentation of political authority.

Ukraine has substantial military-industrial assets, including a substantial nuclear power infrastructure, and could build a new nuclear arsenal that is unambiguously its own (and that is much more survivable than the strategic forces now on its territory). With this capability, and with an abiding concern about Russian hegemonic instincts that only time could assuage, Ukraine might choose to drag its feet for a long period on giving up existing nuclear forces while it brings its indigenous nuclear-weapons-building capability (its virtual nuclear arsenal) to a more advanced state—perhaps to some holding pattern that conforms to its perception of a likely strategic warning time for Russia “going bad again.” This kind of problem, and possible response by one of the segments of a formerly unified nation, emphasizes the inherent danger in loss-of-central-control scenarios that feature fragmentation of political authority.

As for Byelarus and Kazakhstan, once control over the former Soviet weapons on their territory is lost, neither has the extant infrastructure to reconstitute a nuclear arsenal in the foreseeable future. The combined nuclear infrastructure of all the Central Asian former Soviet republics is substantial, although the prospect of all these states joining in the production of a multilateral nuclear force currently appears highly improbable.

Other nations with nuclear arsenals that are candidates for domestic political trauma and thus the fracture of central control include, in particular, China and South Africa, with Pakistan and India also possibilities. The hint of military civil war during the Tiananmen Square crisis in 1989 gives a strong warning that the post-Deng Xiaoping political era in China may be dangerously turbulent. Unknown still is the final political outcome in South Africa and the ultimate control arrangements over the disposition and maintenance of the South African nuclear weapon infrastructure and weapons-grade material. Finally, both undeclared nuclear-weapons states Pakistan and India
are still relatively new nations and, not surprisingly, are strained by
domestic conflicts with deep roots of diverse ethnicity and religion.
In all these current cases (including within Russia itself), the threat
exists of circumstances (including violent confrontations) emerging
in which at least two factions gain control over what was once a na-
tional arsenal, and nuclear weapon use becomes a distinct prospect.
(If the Russian Federation fragments, war is possible between
European Russia and Siberia.) At a minimum, there could easily be
implicit if not explicit brandishing of nuclear weapons by one or
more of the parties.

Less dramatic but still noteworthy is the prospect that in such in-
choate circumstances one or more of the newly nuclear-armed par-
ties handle irresponsibly the nuclear material and expertise they
come by. In this vein, nuclear weapon technology will likely be an
increasingly attractive export product since a number of regional
powers with a surplus of capital are clearly in the market.

**Emergence of a Nuclear-Armed Regional Predator**

The recent experience with Iraq, and a multitude of examples from
history (including many in the twentieth century), emphasizes the
danger that some state may decide that it has a historical right (based
on conditions that prevailed decades, centuries, or millennia earlier)
or otherwise "deserves" to be much larger or the hegemon over
much greater territory. This challenge to the peace or the status quo
runs counter to the basic principles on which the United Nations was
founded and the prevailing late-twentieth-century effort to dele-
gitimize the changing of borders by force. This latter principle was
fundamental to the successful effort to mount a U.N.-backed inter-
vention against Iraq. But what if Iraq had—or the next would-be re-
gional hegemon has—a completed nuclear weapons program and
the ability to deliver nuclear weapons against a U.N.-backed expedi-
tionary force, and possibly against the redundant territory of the na-
tions making up such a coalition?

Such a threat of potential nuclear weapon use might be further
complicated by the existence of a clear commitment by a major
power or group of nations to guarantee the security of one of the
threatened nations, especially when it is threatened by nuclear
The challenge of designing and maintaining a politically and militarily credible capability to project military power in this overall context is formidable, either for the United Nations or for an individual country, such as the United States, which has a number of extended-deterrent commitments, e.g., to Korea. Ideally, for example, a U.S.-led coalition would like to be able to deploy military forces that rely on high-technology non-nuclear ordnance to rapidly defeat a future predator with minimal casualties, relying on the nuclear arsenal of the United States (and possibly other coalition partners) to deter nuclear weapon use by the predator nation.

However, the predator could decide that the nuclear weapon is a usable “great equalizer.” After all, the United States for more than 40 years consciously and overtly relied on its nuclear arsenal to compensate for its perceived non-nuclear military inferiority in Europe in the face of the Soviet-led Warsaw Pact. It could brandish such weapons or use them in some limited fashion (e.g., a nuclear warning shot) to deter intervention in the first place or to abruptly halt a power projection that was already under way (and thus caught “between the boat and the dock”). Consider, for example, how severely an Iraqi nuclear warning shot might have affected the U.N. Security Council vote in August 1990 or the vote in the U.S. Congress in January 1991. This emphasizes how asymmetry in interests leads to uncertainty about effectiveness of deterrence or coercive threats by either party.

For any military, the prospect of conducting a replay of something like the 1991 Persian Gulf War in a nuclear-stressed environment represents a profound planning challenge. Non-nuclear intervention forces would have to be redesigned both to effectively degrade, if not neutralize, a small nuclear arsenal of a regional adversary and possibly to function under limited nuclear bombardment—placing extraordinary demands on both resources and training. As a consequence, new enthusiasm has been expressed in the United States, and especially within the U.S. military, for policies that would restrict
the evolution of such regional nuclear threats to include fostering far-reaching international restrictions on the flow of advanced military technologies, especially those directly associated with nuclear weapons.

Complicating questions for a country such as the United States are whether and how it will be able to maintain military security commitments to friends and allies that face local nuclear threats. For the United States as the preeminent guarantor of such security, the clearest danger is the threat of a maturing North Korean nuclear weapons program aimed at South Korea.

In the light of the increased appreciation of the downside to the spread of nuclear weapons, there will undoubtedly be a major debate on whether a major nuclear power such as the United States, or a more aggressive U.N. Security Council looking to thwart regional predators, should denuclearize any extended-deterrent commitments. A core dilemma is that relying explicitly on nuclear arsenals to enhance extended-deterrent commitments undermines the argument against such weapons’ utility. Even if (or maybe especially if) extended-deterrent commitments are denuclearized, the question remains whether nations such as the United States, in, for example, leading a U.N.-backed coalition, is prepared to put military forces in “nuclear harm’s way.” The credibility of any such commitment is further challenged if a prospective adversary is able to acquire a transoceanic nuclear-weapons-delivery capacity.

Fundamentally, the United States and other like-minded nations may well be approaching a crossroads of their continued willingness to put their nations at risk to provide reassurance to allied and friendly powers, especially if those nations themselves have the capacity to exercise the nuclear option.

**Regional War Between Two Newly Nuclear-Armed States**

In the past, much of the concern about the danger of nuclear proliferation centered on the prospect that newly nuclear-armed states would go to war with each other. The evolving nuclear-arms competition and continuing military confrontation between India and Pakistan are the most oft-cited examples of such a prospect. From the perspective of the international community, such a prospect
raises a most fundamental question: Is global nuclear peace—the avoidance of nuclear war worldwide—indivisible? Part of what sharpens this question is the relative absence of perceived “vital national interests” on the part of the United States and other major powers in such regions as South Asia.

If, for example, in some future South Asia crisis, diplomatic efforts fail and India and Pakistan go to nuclear war, would the U.N. or a U.S.-led coalition be prepared to intervene militarily in some fashion to quench the “nuclear fires”? If further diplomacy fails to halt the fighting, the likely outcome in such matters could well be a kind of “Yellowstone” option (the “let it burn” option chosen for the Yellowstone National Park fires of 1988), in which a large regional nuclear war would be permitted to simply burn itself out.

Grave doubts about the effectiveness of any military intervention to forcibly disarm combatants engaged in nuclear operations would certainly tend to favor a Yellowstone strategy. So, also, would the prospect that either of the combatants could at the time, or in the future as a payback for butting in, seek nuclear revenge against the interfering nation or nations. Any in-depth involvement of one of the major nuclear weapons states on behalf of one of the combatants would also argue against intervention.

Quite obviously, the outcome of any future regional nuclear war, whether one side gained “victory” or left all in ruins, would have a profound effect on the global perception of the utility of a nuclear arsenal. The prospect that the next use of nuclear weapons in conflict could well lead to victory sharply undercuts the argument of some nuclear proliferation experts that what the world needs to “get itself straight” on nuclear proliferation is just one more nuclear war. If the only two nuclear wars on the global record have both ended in victory by one of the users, there may in fact be a rush to acquire such weapons. Thus, one unanswered question is, Would the U.N. or the United States be motivated to organize a postwar international response that, at a minimum, denied the spoils to a victorious nuclear combatant? The answer to this question will be profoundly affected

2See Millot, Molander, and Wilson, forthcoming.
by perceptions of the national and international interests at stake in the concept of establishing and maintaining a global nuclear peace.

It is apparent that the U.N. and future U.S. governments will be profoundly affected by the character of any next nuclear-weapon user. Whether one is facing a nuclear-armed "elephant" (a great power that has a nuclear arsenal with transoceanic-range weapons) or a nuclear-armed "jackal" (a regional power limited to theater-range delivery systems) will make a major difference in the perception of risks and benefits of intervention before, during, or after a future nuclear conflict. "The Day After . . ." exercise experience strongly suggests that employing concepts of lex talionis or retribution for next nuclear-weapon use will demand near-unanimous support from the great powers, especially the nuclear elephants.³

³See Millot, Molander, and Wilson, forthcoming.
Chapter Five

ALTERNATIVE ASYMPTOTES

This report proceeds from the premise that for the future of conflict between human beings, if not the future of civilization itself, the issue of choosing an asymptote for the nuclear age is a defining one: confronting the inexorable spread of nuclear weapons technology and the accompanying natural tendency toward a highly entropic state, and accepting the challenge of damping or taming that tendency in the direction of a more favorable end state. This premise by its nature calls for careful attention to the articulation and consideration of alternative asymptotes and our ability to effect one or another of these possible futures.

Within the realm of the politically possible, what are the nuclear-weapon-defined (or -confined) end states we might consider at this time and try to navigate toward (or accept and make the best of)? What are the key national and global nuclear metrics—the key quantitative and qualitative characteristics of national and global nuclear arsenals—for describing and comparing such alternative end states or goals to try for even if we never quite get there? Appendix B takes up the question of defining a commonly applicable set of metrics.

This chapter describes four alternative asymptotes to gain a better appreciation of just what might be involved in conceptualizing such nuclear-age end states, and discusses the associated issues of monitoring, verification, and enforcement. Chapter Six identifies the possible strategies or strategic roadmaps that might be followed to achieve the illustrative end states presented here.
Four illustrative alternative asymptotes are set forward for consideration:

- "High Entropy" Deterrence—reliance on, among other things, an expanding web of bipolar or multipolar (or all-azimuth) international deterrence relationships to keep the nuclear peace in a highly proliferated world of few rules of the nuclear road, save possibly a self-perpetuating (if successful) cultural taboo on nuclear use.

- An Ever-Slowly-Expanding Nuclear Club—acceptance of an inexorable slow growth in the number of nuclear-armed states, with new members of the club grudgingly (or sometimes willingly) integrated into the existing nuclear order and carefully educated to a set of nuclear norms of behavior and associated deterrence and/or balances concepts.

- A Two-Tiered Static Have-a-Lot/Have None International System—a handful of “haves” maintain substantial (but limited by treaty) at-the-ready nuclear arsenals and commit themselves individually and/or collectively (most likely through the U.N. Security Council) to maintaining the security of the “have-nots.”

- The Virtual Abolition of Nuclear Arsenals—virtual elimination of existing at-the-ready nuclear arsenals (a handful of states maintain tens to hundreds of nuclear weapons at the ready) underwritten by an unprecedented comprehensive and highly intrusive international regime of inspection and collective enforcement.

As presented, these four alternatives are recognized as not being wholly independent and as having elements that overlap. The intention is to find a handful of good examples and work with them, leaving as an exercise for the reader—or some more formal decisionmaking process—whatever additional interpolation and extrapolation might be judged necessary to produce a set of alternatives for actual decisionmaking.

Each alternative is presented “with its best foot forward,” in a description, then is circled to examine its flaws, in an assessment. Each is arrayed in the above listing on a spectrum from some shaping
down to much designing, or, perhaps better, in a hierarchy from
highest to lowest nuclear entropy.

"HIGH ENTROPY" DETERRENCE

Description

One asymptotic end state that as a bounding condition clearly war-
rants consideration, if only for trying to make a virtue of necessity,
would be to accept a worldwide spread of at-the-ready nuclear arse-
nals and to prepare for such a world as best we can.

There is an iron logic to Charles De Gaulle’s assertion that no
sovereign state can rely for its ultimate survival on anything other
than its capacity for self-defense or, in the nuclear arena, deterrence
(through the capacity to hold an adversary’s vital assets at risk).
Contrary to hopes and expectations, the post–Cold War era may
rapidly degenerate into a period of increased international, political,
economic, and military fragmentation, considering especially that
the great international economic and security institutions were
forged from the victory of World War II and the looming bipolar
competition by the two superpowers. With the collapse of the Soviet
Union, a real prospect is that the United States will turn inward and
away from forceful involvement in international affairs, and accept a
world of considerable turmoil and uncertainty. Without a credible
international security structure backed up by a United States willing
to provide military muscle to an extended-deterrent guarantee,
many states may conclude that possession of a nuclear arsenal is a
reasonable answer to the threat of regional predators.

Thus, many states may attempt to acquire national nuclear arsenals
as a means of deterrence. At some point, this process of rapid or
hyper–nuclear proliferation would compel the major powers to
attempt various regional and global schemes of multilateral nuclear
regulation. In this international security context, there would
presumably be few, if any, globally agreed-on rules of the nuclear
road, although some bilateral or multilateral nuclear-arms-control
agreements might exist that sought to stabilize the size and character
of nuclear arsenals (e.g., a U.S.–Russian agreement, an agreement
among the five—or perhaps six to ten—permanent members of the
U.N. Security Council, or an Indian–Chinese–Pakistani agreement).
Nations possessing nuclear arsenals would go to great lengths to make them survivable against preemptive attack. In turn, there would be a hierarchy of nuclear operational capability, with dozens of nations deploying an array of active aerospace defense systems. In such an environment, smaller national nuclear arsenals might be very vulnerable to a combined counterforce-and-active-defense campaign by an opponent well equipped with a mid–twenty-first-century combination of reconnaissance, surveillance, and target acquisition (RSTA) systems and advanced conventional munitions (ACMs) (see Appendix A). In turn, a number of small arsenals might be controlled by non-state entities, such as international criminal organizations, or political or religious groups (all of which groups benefit from poor security of nuclear weapons and/or material), or might appear out of nowhere in a crisis, such as the loss of central control in some nuclear-armed entity.

Defining international stability would be problematic. The key question is, How did this end state appear and with what velocity? One variant is that the world of many nuclear-armed entities emerges somewhat slowly over the next generation or two, but with no use of nuclear weapons in the transition period; in such a world, there could be growing confidence in the “forever” viability of deterrence. A second variant might be rapid proliferation as a consequence of acute political turmoil in which the decision to go nuclear by one or a few countries has a snowballing effect. A third variant follows from some dramatic demonstration of the military and political utility of nuclear weapons (especially if by a newly nuclear-armed state) during a war (consider the generic scenarios discussed above) that takes place in the next decade or two. If the war left a clear “victor” without a meaningful punitive response from the international community, nuclear weapons would be given a powerful legitimacy, especially if their use had not been catastrophic, e.g., if their use caused minimal civilian collateral deaths, no more than tens to hundreds of combatant deaths, and little fallout. Such an outcome would shatter any nuclear-use taboo and might well trigger a period of hyper-proliferation as many states moved deliberately designed or inherent virtual arsenals much closer to an operational status.

An interesting but unanswerable question is, How would the international community react to the third or fourth use of nuclear
weapons? Would humanity become hardened to city-destroying levels of nuclear violence in the world of global high-definition television coverage? Or, would further nuclear weapon use reenergize the major powers to reestablish some order and hierarchy out of what might have become an increasingly anarchic security environment?

In principle, nuclear weapons might be used during a “police operation” by a number of states against a non-state organization; however, the international community would presumably go to extraordinary lengths to avoid such an occurrence, perhaps absolutely eschewing such use in formal declaratory policy statements.

Certainly, the international community could at some point change its mind about the wisdom of allowing the further proliferation of at-the-ready nuclear arsenals. But halting, much less reversing, the process would require consensus among the major powers and an enormous expenditure of resources and leverage. Organizing that consensus would be critically dependent on the prevailing nature of international conflict. If such conflict is common and destructive, and if nuclear conflict occasionally takes place, the major players may be motivated to impose some form of nuclear law and order. If the propositions of some international relations theorists, that nuclear proliferation will stabilize most regional conflicts, prove correct (which in specific cases may be very dependent on why and how the proliferation occurred in the first place), and if there is some degree of international law and a general commitment to order and peace, an ever-expanding nuclear club may be an acceptable future end state.

Assessment

In essence, high entropy deterrence is the logical outcome of a failure of the international community to build a credible post–Cold War collective security system enforced by the major powers. Stability of the resulting multistate and possible multiorganization nuclear deterrent system is only plausible if all members accept rules of the road. Such acceptance basically views the use of nuclear weapons (from shots across the bow to highly damaging attacks) as the use of “weapons of last resort”—a phrase that would seem to imply that national survival is at stake.
The framework of a presumed large family of bipolar and multipolar deterrence relations will likely collapse if one or more major powers, or a critical coalition of powers, believe that the international nuclear or security status quo, however defined, has become unacceptable. From the contemporary Western perspective, the most plausible sources for such global leverage to challenge “Western” leadership during the early twenty-first century would be a more militant China or Islam, or the appearance of a militant nationalist regime in Russia.

Unless limited by treaty in some bipolar or multipolar stability construct, many of the more wealthy and technologically competent states would likely invest in some array of counter-proliferation measures. These could include defensive (active and passive) measures, as well as some counterforce capability (more likely to be acceptable if of a disabling as opposed to destructive character). They might lead to asymmetric military regional balances, with some countries capable of defeating small nuclear attacks while others remain utterly vulnerable. Given the widespread threat that a bomb might be smuggled into a country, it is quite possible that many states will have far more draconian border and internal security “defensive” measures.

If nuclear entropy grows on a global scale, it is worth speculating about what circumstances would motivate the international community to seek to reverse the process. Certainly, continuing nuclear arsenal use will have a profound effect on the willingness of the international community to tolerate the era of the nuclear “six-gun.” In fact, a drive for international “nuclear law and order” might follow a heinous example, in terms of loss of life or ecological damage, of next nuclear-weapon use. Again, the success of revived support for a broad-based and restrictive counter-proliferation strategy would be highly dependent on the nature of the political, economic, and, possibly, religious divisions of the major global centers of power.

AN EVER-SLOWLY-EXPANDING NUCLEAR CLUB

Description

By definition the asymptote of an ever-slowly-expanding nuclear club is a slow-growth curve along which the major powers of the international community slowly (and presumably grudgingly) accept
newly nuclear-armed states (i.e., states that maintain nuclear weapons at the ready). While this curve, in principle, has the potential over a long period to follow a shape akin to a very horizontally elongated version of the S-shaped learning curve of Figure 1.1 (and reach an international end state with characteristics similar to a global environment of high entropy deterrence), the fact that it is slow makes this asymptote distinctively different from the above high-entropy case. In particular, it seems likely that because the growth in numbers would be slow, this asymptote would in time be overtaken by events (for example, the increasing significance of the virtual nuclear arsenals that could be assembled by many nations in a matter of weeks).

The fundamental assumption of this possible end state is that the process of nuclear proliferation can remain a slow-motion affair, with new entrants achieving acceptance in the club only after a protracted period of nuclear weapon rationalization (and possibly some low-visibility development). In all cases, the security concerns of the new entrant would take on broader legitimacy as the major powers (and, more important, the declared nuclear-weapons states) tolerated and even helped integrate and reassure such new entrants politically and militarily (especially in light of the three-months' notice "supreme national interests" withdrawal clause in the NPT, which was exercised by North Korea in March 1993).

To facilitate a process of gradual expansion, a variety of regional arms-control arrangements might well be negotiated by the new entrants. In essence, the focus of much of the major powers would be to regulate the evolution of nuclear arsenals in the direction of the new regional nuclear balances of deterrence. The success of this strategy would be highly contingent on the new entrants' accepting an internationally defined set of rules of the road. A central concept would be their acceptance of some state of vulnerability to nuclear attack—assured vulnerability—with an emphasis on designing regional nuclear balances giving supremacy to the notion of deterrence. Quite clearly, the concept of assured vulnerability could well erode or collapse as one or more economically and technically more capable nuclear-weapons entrants decide to acquire enhanced counterforce and/or active-defense capability.
A key assumption of the ever-expanding nuclear club asymptote is that a controlled and slow transition to a presumed small constellation of multipolar nuclear deterrence systems is stable over the long run. A further underlying rationale for considering this kind of asymptote is that one may well be in the position of trying to make a virtue of necessity: that the process of nuclear proliferation is inevitable (as borne out by the slow-motion, clandestine appearance of the Israeli, Pakistani, Indian, and South African nuclear arsenals) in situations where the United Nations or a U.S.-led coalition is not prepared to provide such states with credible extended-deterrent guarantees.

Currently, the three likely candidates for entry into a deliberately rationalized ever-expanding nuclear club are Israel, India, and Pakistan.

Assessment

The careful and deliberate processes envisioned in a slowly but ever-expanding nuclear club reflect the assumption that some new would-be nuclear-armed states would be more responsible than others. The major powers, as stewards of such a regime, would discriminate against states it viewed as “rogue” or “predator” states because of their behavior. The international political legitimacy of this “some will sit in judgment on others” strategy is inherently shaky—and subject to constant reassessment. Recall that the United States viewed China’s decision to acquire nuclear weapons as a highly threatening prospect during the 1960s, a view that was all but reversed with the Nixon Administration’s rapprochement with China during the early 1970s. A contemporary example is U.S. skepticism about Iran’s long-term regional intentions: whether it might be a regional revisionist and attempt to establish earlier national borders in the region (witness Serbia on a smaller scale). As a consequence, the United States is currently prepared to expend considerable diplomatic and some economic resources to thwart Iran’s nuclear weapons ambitions.

Taking the obvious first step under this asymptote and accepting Pakistan, India, and Israel as official members of the nuclear club legitimizes their slow-motion, stealthy proliferation strategy. Accepting Israel’s and Pakistan’s nuclear arsenals would give legitimacy to
the proposition that a state without powerful and reliable allies can and should compensate for conventional military inferiority vis-à-vis some threat by deploying a nuclear arsenal. India would presumably find the rationale for its arsenal in classic bilateral nuclear deterrence concepts vis-à-vis Pakistan and/or China.

Overt acceptance of Israel as a nuclear-armed state will undoubtedly stimulate nuclear weapon programs among the Arab states and Iran, so that a predictable "second shoe waiting to drop" would be the eventual demand to grant legitimacy to nuclear arsenals in Iraq and Iran. Crafting a three-party strategic nuclear balance among these three Greater Middle East regional adversaries, which would rationalize the sizes of their at-the-ready arsenals, presents a considerable challenge. With such a rationalized expansion to ten legitimate "haves," other regions of tension could be created beyond the Greater Middle East and South Asia—for example, in East Asia or within the former Soviet Union—that might want to go for a regional nuclear deterrence arrangement. Would-be nuclear weapons states might even conclude that the stewards of this regime, and the international community more broadly, will accept the process of nuclear proliferation as long as it is conducted in a covert and (at least for a time) ambiguous fashion.

In essence, the strategy of the ever-expanding nuclear club is a strategy that buys time without, in the end, resolving the nuclear non-proliferation problem. It is this historical unwillingness to "draw a line in the sand" that is the central critique of tolerating slow-motion proliferation and sustains the argument for the two-tiered have/have not, or contemporary, nuclear proliferation regime.

A TWO-TIERED STATIC HAVE-A-LOT/HAVE NONE INTERNATIONAL SYSTEM

Description

A two-tiered static Have-a-Lot/Have None (hereinafter "Have"/"Have-Not") International System is the implicit goal (and somewhat shakily proclaimed status quo) of the current international non-proliferation regime. Only the five permanent members of the U.N. Security Council (Perm Five) are declared nuclear weapons states under the terms of the NPT. Currently, 160 states have declared
themselves non-nuclear weapons states under the NPT. The only current NPT holdouts of significance are the three nations that have covertly acquired (but as yet not acknowledged) nuclear arsenals: Israel, India, and Pakistan. (Whether any of the still-small number of warheads in the arsenals of India or Pakistan meets the "at the ready in a day or two" criterion is publicly unknown.) In the last few years, entrants to the NPT have included two declared nuclear states, France and China, and a recently declared former owner of a nuclear arsenal, South Africa.

A central aspect of the NPT is the asymmetry of rights and obligations between the nuclear weapons states and non-nuclear weapons states. The former are not subject to the IAEA’s modest inspection regime of their civil nuclear power programs. As a price for continued assistance, all non-nuclear weapons states must open their nuclear power infrastructure to IAEA monitoring. As part of the grand bargain, the NPT commits the nuclear weapons states to assist non-nuclear weapons states in the development of their civilian nuclear power industry. Further, there is a general commitment by the nuclear weapons states to reduce the size of their nuclear arsenals.

With the arrival of the 1995 NPT renewal conference, the fate of the NPT will be called into question. So far, the U.S. government has given no indication that it has any plans for the conference other than to press for a straightforward renewal of the NPT with no fundamental alteration. However, the alteration issue will obviously be examined in depth on more than one occasion in the intervening period, as this report argues it should be. Not surprisingly, the terms of the existing NPT continue to be challenged by the outsiders, such as India, although such nations may find themselves challenged to articulate an alternative acceptable set of "NPT II" constraints (short of the complete nuclear disarmament by all parties that India now claims it needs to have to accede to a global non-proliferation treaty). Conceivably, a twofold set of criteria might be articulated by nations such as India: one for their joining as a "have" and one for their coming in as a "have not."

Assessment

The fundamental problem of the two-tiered system as currently constituted is the fading legitimacy of its basis. It is not by accident
that the Perm Five of the U.N. Security Council are the five declared nuclear-armed states—the “haves” that this end state would presumably try to perpetuate through a “freeze the ‘haves’ in place” criterion. The “haves” are the victors of World War II, shortly after which the United Nations was created. Thus, one key to the viability of the two-tiered system is the viability of the current arrangement of the Security Council. The second key would be the handling of the three significant outliers: India, Israel, and Pakistan.

As for the makeup of the Security Council, Japan and Germany already are showing strong interest in gaining seats as permanent members. Suggestions have been made that such membership might well be part of the price demanded by India (along with the de-nuclear weaponization of Pakistan) if it were to enter a renewed NPT as a non-nuclear weapons state. Not surprisingly, any move to open the membership of the Perm Five raises the question of whether every continent (e.g., South America as represented by Brazil) and every major religion (e.g., Islam as represented by Egypt) should have a permanent member on the Security Council. Any expansion of the Security Council sets forth the question of whether the current veto concept should continue; some type of super-majority vote, e.g., two-thirds or three-fourths of all members or all permanent members, may be viewed as more appropriate to deal fairly and effectively with the most sensitive issue of collective security issues, such as enforcement of a two-tiered non-proliferation regime.

As for the problems posed by India, Israel, and Pakistan, as a variant of the basic approach of this alternative asymptote it might be possible to include these three nations in the NPT in a second tier of “haves” that agree in, for example, an NPT II, to highly restrictive limits on at-the-ready arsenal size, greater transparency in their nuclear programs (to limit their virtual-nuclear-arsenal mobilization potential), and a commitment to become a “have-not” in some long term, assuming successful negotiations of the sources of conflict within the relevant regions. Whether the global community would insist on more explicit and restrictive limits on the size of the arsenals of the Perm Five (or greater transparency in their nuclear weapons programs) in such a context would remain to be seen.
As to the ability of the Perm Five to enforce this kind of regime, the recent experience in dealing with Iraq after its defeat in the Persian Gulf War appears unique and may not hold the strength of a real precedent. The support of France, the UK, and Russia, and the neutrality of China cannot be guaranteed in future regional crises of this character. Saddam Hussein's actions allowed the United States to organize a military coalition which has led, among other things, to the near destruction of Iraq's special-weapons programs and infrastructure. Other potential nuclear weapon proliferators presumably now understand the folly of challenging the United States to a military engagement before they acquire a credible nuclear arsenal (see the discussion on the generic regional predator problem in the preceding section). Iran is likely to be a case in point: It appears that that nation will remain very cautious while it conducts a substantial arms buildup, including the possible construction of an arsenal of weapons of mass destruction.

Without a stake in the non-proliferation status quo as reflected in this two-tiered option, a number of major powers will be driven, in part by economic necessity, to undermine such a non-proliferation regime. The most likely candidate is China, which appears suspicious of the current attempt by the United States to create a "new world order." A coalition of China and several major Islamic states, e.g., Pakistan, Iran, and Syria, might also choose to pull the rug out from under such a regime.

Further, there is the question of whether the U.N., some U.S.–led coalition, or the United States acting alone will be prepared to make extended-deterrent commitments to a number of states to protect their security interests in the face of significant regional threats. A powerful domestic consensus will likely prevail within the United States to limit its overseas security commitments. A post–Cold War commitment might only prove politically plausible for Western Europe, Israel, Saudi Arabia, Japan, and the Western Hemisphere. Unfortunately, there is likely to be a rising demand for some kind of extended-deterrent commitment by states that otherwise will not forgo the nuclear weapons option. This issue has already been raised by Ukraine, prompted by the unstable internal political environment in Russia. Extended-deterrent commitments for any of these nations may or may not have an explicit nuclear dimension.
Another problem with the two-tiered system is the strong role that nuclear weapons right now play in the defense and deterrent strategies of the five nuclear-armed states. Even with the proposed reductions of the second Strategic Arms Reduction Talks (START II) Treaty, both Russia and the United States will maintain nuclear arsenals of several thousand weapons and the other three nuclear-armed Perm Five members currently justify arsenals in the many hundreds. In fact, the five acknowledged nuclear weapons states may not be able to gain unanimous international agreement to a "have/have-not" regime in which they are the only "haves," without forgoing their own heavy dependence on a substantial number of at-the-ready nuclear weapons for security (although it is conceivable that some nations, e.g., Poland, might want the numbers to decrease very slowly). This possibility raises the prospect of negotiating very deep reductions in the Perm Five at-the-ready nuclear arsenals—to levels as low as tens or hundreds—as part of some truly grand bargain that addresses the security concerns of threatened states. This is the strategy of virtual abolition, which is discussed in the next section.

VIRTUAL ABOLITION OF NUCLEAR ARSENALS

Description

In the wake of the end of the Cold War, the view has gradually emerged that the United States and the other four major nuclear-armed nations should seriously examine their current degree of dependence on nuclear weapons in their national security strategies. In the U.S. military, for example, particularly as a consequence of the U.S.-led coalition’s success during the Persian Gulf War, there appears to be a rising belief that the United States may no longer need to rely on a substantial number of at-the-ready nuclear weapons to satisfy its defense and deterrence needs (assuming continued improvement in the U.S.–Russian relationship). At the same time, looking to the future threat environment, there is a rapidly growing appreciation that a small nuclear arsenal in the hands of a potential adversary (for example, a regional predator such as Iraq in 1991) would present the United States, or any U.S.-led and U.N.-sanctioned military force, with a daunting and possibly technically insoluble set of very basic military problems. Emerging from this conjunction of factors is an interest in exploring means—deals; what
it would take—to profoundly de-emphasize the role of at-the-ready nuclear arsenals in international security.

One important issue in such a nuclear de-emphasis is how far existing at-the-ready arsenals need to be reduced to market the concept versus how far such arsenals can or should be reduced while still maintaining stability. For example, Figure 5.1 depicts notionally the possibility that the existing level of stability in the U.S.–Russian relationship as reflected in START II (and associated quantitative metrics of stability) and, by implication, in other nuclear-deterrence relationships, might eventually be sustained at at-the-ready nuclear arsenal levels as low as hundreds of weapons.

One possibility is that the Perm Five make very deep reductions in their nuclear arsenals to an end state that, compared with arsenal sizes today, could be characterized as "virtual abolition" (e.g., hundreds or even tens of weapons) and take on far-reaching and highly intrusive early-warning and enforcement responsibilities as part of a new grand bargain on the nuclear weapons dimension of international security. The larger international bargain to be sought would presumably involve the outright elimination (or very radical reduction to token size) of the at-the-ready nuclear arsenals of the

![Figure 5.1—Notional Concept of Bilateral Stability as a Function of Arsenal Size](image-url)
three currently undeclared nuclear-weapons states and new security guarantees to these and other nuclear-tempted insecure states.

A key element of this approach is the downgrading of nuclear weapons as a long-term national security option or element, i.e., giving nuclear arsenals subordinate rather than flagship status in a country's national security posture. The constellation of very small (and highly survivable) nuclear arsenals would be designed to be "the lid on the jar"—a deterrent and hedge against any nuclear breakout scenario, including by a state with a large virtual nuclear arsenal. At the same time, considerable attention would be given to virtual nuclear arsenals: The United States and other major powers would, if judged necessary, plan to be able to rebuild large nuclear arsenals (e.g., many hundreds or even one or two thousand nuclear weapons) in a relatively short time (e.g., a matter of months). Such capabilities would simultaneously deter and hedge against a breakout from the regime by a rogue nation (which could even be one of the other Perm Five).

An inspection regime of unprecedented intrusiveness and comprehensiveness would be fundamental to the viability of this regime. As depicted notionally in Figure 5.2, the technology and access (and resource commitment) envisioned would be expected to detect a nascent nuclear weapons program far earlier than that revealed in Iraq in the aftermath of the Persian Gulf War. Furthermore, the

![Figure 5.2—the Detection-Versus-Development Curve]
early-detection objective will be well served by the technological advances of the third military revolution discussed above.

Because of technological, materials-access, and other differences, the notional “illegal arsenal” development curve in Figure 5.2 would be very different in character for states such as Iran, Pakistan, Japan, or Russia; it would necessitate widely varying types of intrusive inspections. The intended outcome might be described as the nations of the world displaying their nuclear cards face up.

In large measure, adoption of this kind of asymptotic goal reflects a conclusion that any two-tiered regime that puts a large gulf in at-the-ready nuclear capability between the “haves” and the “have-nots” cannot in the long term be sustained; whereas a framework that deemphasizes nuclear weapons but retains a tier of very small at-the-ready arsenals, a robust virtual-arsenal capability, a highly intrusive inspection regime, and security guarantees backed up by potent non-nuclear forces can be sustained.

Once the conditions that would accompany a virtual-abolition approach have been imposed, the number of “have-nots” hoping and planning to become “haves” would presumably decline, and the remaining “wannabes” could be isolated and dealt with—forcibly, if necessary, and with conventional weapons—by the former major nuclear powers on behalf of the world community. Virtual abolition could then become a global norm, reflected in the institutionalization of a highly intrusive international challenge-inspections regime. Information from such inspections would provide warning of illegal nuclear weapons programs, giving the international community time to build a consensus for diplomatic and economic sanctions, and, if necessary, military actions against the outlawed facilities.

Assessment

This regime assumes that an international consensus of the current nuclear-armed states on the general approach and key characteristics of the asymptotic state to be sought (size of residual at-the-ready arsenals; limits, if any, on virtual nuclear arsenal capability; permitted intrusiveness of inspections; etc.) can be forged in the relatively near term, say, by the end of the century.
The feasibility of this option also crucially rests on the notion that potential proliferators can be convinced that at-the-ready nuclear weapons are, in fact, counterproductive or unnecessary to ensure their national security; that, under a nuclear-abolition regime, threats would diminish and conventional defense and collective security guarantees would prove to be viable means of maintaining security and independence. This means that the U.N. Security Council, some U.S.-led coalition, or perhaps major powers, such as the United States acting alone, would in all cases be prepared to provide potential proliferators with extended-deterrent commitments based on conventional-weapons capability as an element of a new collective security regime. At the same time it should not be surprising to see some of these nations hedge against the failure of such a security regime with well-planned virtual nuclear arsenals (a practice that might readily gain international acceptability).

An important test for this type of regime would be enforcement. In contrast to the virtual turning of a blind eye to nascent nuclear-weapons programs that characterized much of the great-powers approach under the current regime (Israel, Pakistan, and India are the clear examples), suspicious activity would have to be dealt with swiftly and aggressively.

Another problem for this end state is that any country with a large nuclear power program is capable of forming a large virtual nuclear arsenal, and thus of having breakout potential (see Figure 3.3). Such potential will put a premium on maintaining confidence in the information-collection capability of this regime and the ability of the enforcer nations to disable quickly, or otherwise negate, the weapons-production utility of large plutonium stockpiles and handling facilities and large uranium-isotope-enrichment facilities. Alternatively, such facilities might be internationalized as was originally conceived under the Baruch Plan.

Finally, there is potential for a destabilizing circumstance to occur in which the virtual-abolition strategy could become a casualty. For example, the United States or one of the other great powers could be unable to defend some declared vital interest; that is, it could be unable to win a conventional war involving some declared vital interest other than through a great cost in lives, without nuclear weapons. However, such experiences as Vietnam and Afghanistan
have taught a positive lesson: that great powers have at times in the nuclear age already shown an ability to make a distinction between what they want and what they need.

MONITORING AND VERIFICATION

"Trust is earned, not given" was an oft-cited expression of President Gerald Ford on the subject of monitoring and verifying nuclear-arms-control agreements. President Ronald Reagan said much the same thing in admonishing "trust but verify." The concepts of monitoring—carefully watching what is going on—and verification—establishing that the uncertainties in what is going on are within militarily acceptable limits—are fundamental to any pact between parties or nations in which trust has not been established. They will be fundamental to the consideration of alternative nuclear asymptotes, both at the asymptotic or steady-state conditions and, perhaps even more so, in the careful navigation to those conditions.

Save for the high-entropy end state, two characteristics of monitoring seem almost certain to prevail:

1. It will have to be universal.

2. It will, at some stage, have to become comprehensive and intrusive well beyond anything any nation has yet permitted in practice.

The need for universality follows from the imperative of establishing with little or no uncertainty the status of permitted nuclear forces. To the extent that at-the-ready nuclear forces are permitted, it is inconceivable that any globally acceptable nuclear asymptote would allow for significant uncertainty in the size and character of such forces. As noted above, such forces would presumably be sized and negotiated with some agreed concept of stability in mind—which would allow little room for uncertainty in the size of "the other guy's forces."

The appropriate level of comprehensiveness, i.e., the "metrics" that would be monitored, would be to some degree a characteristic of the particular asymptote chosen. As a minimum, it would presumably include such elements as
• Nuclear warheads
• Dedicated and potential nuclear-weapons-delivery vehicles
• Fissile material
• Uranium enrichment
• Plutonium reprocessing
• Uranium mining.

Because change is inherently easier to monitor than an absolute value, a critically important part of the monitoring task is establishing a baseline, especially at the beginning of a transition toward some asymptote. In principle, it can be done with reasonable confidence; in practice, serious questions arise about whether the former Soviet republics, and especially Russia, will (or will be able) to give a persuasively honest accounting of themselves for several years. The same would be true for countries in the Middle East and South Asia, where sustained periods of conflict have left a legacy of extraordinary distrust. A further complicating factor is the shattering of confidence in the ability of the U.S. intelligence community and the IAEA to track emerging nuclear programs (based on the Iraq experience).

These stubborn realities emphasize the importance of “getting on with it,” of charting some future path for the nuclear age—and addressing the tough monitoring and verification issues. In this respect, monitoring will be critical in the early stages of a transition toward some agreed asymptote; trust will be the legacy of a long period of honesty and cooperation.

Technology will play a critical role in the monitoring of the transition to and maintenance of a nuclear asymptote. The technical challenge in this context is to transcend as much as possible the need for human involvement in the day-to-day monitoring task: the acquisition of raw data. Even in the processing of these data, collective efforts by multinational groups will be imperative to ensure confidence—as has been the case in the Resolution 687 U.N. inspections in Iraq.

From the above list of parameters for monitoring, it can be inferred that there may, in the very long term, be a consensus on global effort to establish worldwide technical monitoring stations that would
measure ambient nuclear conditions much like the global network of weather stations. Such stations would look for telltale signs of the initiation of prohibited activity—for example, changes in the ambient levels of particular radioactive isotopes. Such a network would presumably be supplemented by rapidly deployable monitoring stations (possibly deployed covertly by missile or aircraft) that might surround some suspect facility or area to respond to the need for effective challenge inspections with a minimum of intrusiveness.

ENFORCEMENT

Enforcement of treaty provisions will be fundamental to the charting of any nuclear asymptote outside the high-entropy case. The most important questions to be addressed include the following:

1. Who—what international body—will be invested with the power of enforcement?

2. By what means—what kinds of force—will enforcement be carried out?

At present, there is only one obvious serious contender for the responsibility of deciding when enforcement actions are required: the U.N. Security Council. The idea of enforcement by another group of major powers is, in principle, possible; however, the propitious character of the current permanent membership in the Security Council (the Perm Five, the five acknowledged nuclear-weapons states) makes any other multilateral body a poor competitor to the Security Council.

Both in principle and in practice, the actual application of force could be delegated to predesignated military units (most frequently, because of technological advantages, led by the United States). It is increasingly clear that the U.S. military would be most comfortable in situations in which it was (1) acting with Security Council authority and (2) carrying out operations alone or leading a very small coalition of forces.

The question of the force used to effect enforcement of some negotiated asymptote (as opposed to the high-entropy end state) is embedded in a larger question: When politics gives way or turns to
armed conflict to resolve differences, what weapons will it be “fair” to fight with—in this case, to have at the ready for enforcement? There is no a priori reason to assume that the answer to this question would be any different for enforcement of a new non-proliferation regime.

Another important question is whether nations—or the broader international community—will spend the money necessary to equip adequately the enforcer nation or nations to carry out actions of the kind likely to be required with conventional (and not nuclear) weapons.

Alongside the above perspective on alternative asymptotes is the companion issue of just how we might chart a deliberate course toward one of these outcomes—the subject of the next chapter.
Chapter Six

A STRATEGIC ROADMAP TO SOMEWHERE

OVERVIEW

A central thesis of the authors is that a viable, long-term effort to contain the spread of nuclear weapons will require a major, sustained effort by the international community and a strong measure of leadership by such key nations as the United States. Without that effort, that major input of energy, including expending the potential energy of existing political leverage, the "natural" end state of the nuclear asymptote will almost assuredly be high entropy: the wide diffusion of nuclear weapons in the hands of many states and probably some non-state actors in a dynamic "political soup." To contain this natural tendency toward mathematical conditions approaching chaos will require the development of a broad international consensus on an asymptotic goal that reflects—speaks—a concept of containment of entropic forces, and an associated strategy.

This chapter addresses the strategy question. How should the strategic roadmaps from here to there be formulated? "Here" is the intersection or intellectual crashing together of the existing non-proliferation regime and the residual forces and concepts from the so-called strategic nuclear competition of the Cold War. "There" is the four sample asymptotic states of Chapter Five.

FROM HERE TO HIGH ENTROPY

Two separable and still credible paths appear to be leading to a state of nuclear high entropy and are worthy of examination; one is very
rapid, the other is in slow motion. Both pathways into a nuclear well-armed future for the planet would be cleared by a conscious national and international decision to step aside and not invest the energy and political leverage necessary to rein in the prevailing trends in the nuclear arsenal realm—a posture that an inward-turning United States might credibly adopt by default.

The domino that will likely decide whether the path that a world of relatively unfettered access to nuclear weapons will take is rapid or slow is the ongoing struggle in Eurasia between the twin forces of integration and fragmentation. If the outcome on that supercontinent is a return to fragmentation, to extreme nationalism, we can expect that a logical path will take many nations very quickly to a re-consideration of nuclear weapons. It is then not far from a "the best defense is self-defense" perspective to a "the best (and cheapest) means of self-defense is nuclear weapons" perspective. The grounds (probably correct) would be that nobody is likely to attack a nation that has nuclear weapons that are survivably based, at least to some degree, and reliably deliverable. The latter qualifying conditions underscore the kind of decisions that will have to be made for a strategic roadmap along this "go with the flow," or default, choice of end state. The following paragraphs provide examples of some of those decisions and possible situations to bring about at-the-ready status.

Once a nation has stepped over the line (or is about to step over the line) from nuclear weapons potential to nuclear weapons at the ready, one decision is whether, or when, it is in the global interest to make that newly nuclear-armed state a more competent club member. Should that nation get the latest safety equipment for saing, fuzing, and firing mechanisms? Should it be educated in how best to hide its arsenal? And, as the principal means of ensuring its survivability against attack, should it be given the (almost?) latest in tactical warning systems?

If, as a possible worst legacy of the rapid end of the Cold War, nuclear proliferation is already happening fast, we might be much more inclined to ensure that those nations who choose to become nuclear-armed do so safely, a policy that itself might further accelerate an already rapid process. In any event, the resulting world would either be in a highly turbulent state worthy of the label nuclear anarchy or a quiescent state, with the widespread deployment of nuclear weapons
creating an interstitial nuclear "force field" that kept adversary nations "separated."

Even if the forces for global integration gain dominance in Eurasia (for example, from a further broadening and deepening of the European Community), a world with a more laissez-faire attitude toward nuclear arsenals would still move unambiguously toward a state of high entropy, but it would do so presumably at a more deliberate pace, stimulated not by a continental trend but by region-specific security problems. In the Greater Middle East, failure to resolve the security problems of the region (and especially the Arab–Israeli dispute) in the next few years would likely see the growing Iranian nuclear potential move to a nuclear arsenal at the ready and similar steps by an Iraq once freed from the U.N. inspection and monitoring regime. Similarly, in South Asia, an unfettered India and Pakistan would likely move to unambiguous deployment of small arsenals and debate over an appropriate nuclear asymptote for South Asia.

In East Asia, failure to achieve Korean reunification in the near term will likely lead to an unambiguously nuclear-armed North Korea, with South Korea likely to be hard on its heels. Whether Japan, in this situation (or one where a reunified Korea drags its feet in dismantling North Korea's nuclear-weapons-production capability akin to the situation as of this writing with Ukraine), would feel compelled to take steps to move its substantial virtual nuclear arsenal closer to an at-the-ready state would remain to be seen; such a step would not be surprising, although it may not be revealed, much less rationalized. Thus, just by describing the above credible examples, there could be 11 nuclear-armed nations in 10 to 15 years, and more would almost certainly follow. Each such nation would pose the policy questions regarding nuclear force safety and survivability discussed above.

**HERE IS THERE: AN EVER-SLOWLY-EXPANDING NUCLEAR CLUB**

 Unlike the above inward-turning-U.S. case, the United States and other key major powers could adopt an activist role in international affairs. Consequently, a strong coalition could emerge that seeks to rein in, but not necessarily halt, the proliferation of at-the-ready nu-
clear arsenals. Such a coalition could conceivably include the United States, the major powers of Europe, and Russia, Ukraine, Japan, and China.

A key early issue along this path would be how the undeclared nuclear-armed states, Israel, Pakistan, and India, are to be brought into this slow-growing nuclear club. Resolving it would be the testing ground for concrete cases on the policy questions regarding nuclear force safety and survivability cited in the preceding section. This step of formally acknowledging these nations' existing (or imminent) status as nuclear weapons states might even be taken in the context of a 1995 NPT renewal conference that explicitly takes up the problems these nations pose.

FROM HERE TO A TIGHT “FIVE HAVES” TWO-TIERED INTERNATIONAL SYSTEM

The primary requirement to effect a future nuclear proliferation regime based on the logic of maintaining a small but finite number of nuclear-armed special nations, presumably the U.N. Security Council Perm Five, is convincing Israel, Pakistan, and India to give up their nuclear arsenals. It would, in turn, presumably require both new and credible security commitments and guarantees for all three parties and substantial progress on diminishing the sources of the conflicts that stimulated acquisition of these arsenals in the first place. In theory, this commitment could be made through the vehicle of a modified and reinforced U.N. Security Council framework supplemented by regional collective security guarantees.

If no such international commitment proves satisfactory, one or more of these states could, in principle, be brought into the NPT on a one-time-only basis as temporary overt nuclear-weapons states. Such temporary membership might be conditional on, for example, agreement to limits or a freeze on arsenal size and nuclear infrastructure inspection procedures akin to the “full-cope safeguards” of the IAEA.

The maintenance of such a basically two-tiered system will require that all the significant actors accept the international political status quo. Not surprisingly, a major war in which nuclear weapons came
into play, either through brandishing or outright use, could rapidly collapse such a two-tiered system.

FROM HERE TO VIRTUAL ABOLITION

Of those end states presented, the one that requires the greatest engagement and input of energy on the part of the major world nations is virtual abolition, which follows from two imperatives: (1) Five major (and several other) nations must go through the wrenching experience of rethinking their own security needs absent at-the-ready nuclear arsenals as a flagship element. (2) New and far-reaching elements in a U.N. Security Council–based multifaceted security system must be formulated and marketed.

A strategy of virtual abolition is grounded on the concept that the threat to global peace posed by nuclear weapons proliferation is so great that the major powers will take heroic steps to make nuclear weapons “illegitimate”: The goal will be to take nuclear weapons off the list of weapons with which nations plan to fight; fundamental new elements will be added to the existing international security system, including a highly intrusive global inspection regime and new and unambiguous security commitments to some nations as they need it. For the international community to head down this path, especially during this critical and difficult early phase of the post–Cold War era, the United States in particular would have to become active in promoting such a security structure to the major economic and military powers, especially in Eurasia, possibly in a trial case as early as the lead-up to the 1995 NPT renewal conference.

In further testing of the viability of such a concept, the United States and other like-minded nuclear-armed nations, by their own weapons procurement and posturing actions, might demonstrate their willingness (1) to move away from large at-the-ready nuclear arsenals as a flagship element of a security posture and (2) to expend the resources to develop whatever conventional forces are necessary to play a lead role in “extending deterrence” to insecure nations and to enforce a virtual abolition regime.
FROM HERE TO THE 1995 NPT RENEWAL CONFERENCE

In all four of the above roadmaps, the 1995 NPT renewal conference looms large as a forum that could reveal the direction that many leading nations, most notably the United States, will take on the nuclear proliferation problem. We consider here which of the possible four paths the conference will be taking according to the actions that may lead up to it.

If the 1995 conference is a repeat of 1990, 1985, and previous conferences, in which the United States and other key nations basically paid homage to NPT as is, we can infer that a decision to acquiesce to the force of entropy has essentially been made.

If the lead-up to the conference is characterized by a strong effort to bring Israel, India, and Pakistan into the NPT, even as nuclear weapons states, or no serious effort is made whatever to lobby these countries on NPT membership, we can infer that the choice is an ever-expanding nuclear club, with the first expansion beyond the core Perm Five possibly tolerable as a separate category.

We can infer an effort to hold the line on the Perm Five as the only nations with at-the-ready nuclear weapons if the lead-up to the conference is characterized by the following two actions: (1) a strong international effort to persuade India and Pakistan to rein in their nuclear-arsenal-building programs “before it’s too late to turn back” (assuming that state has not already been reached) and to join the NPT as non-nuclear weapons states in return for some new international security guarantees (e.g., for India with respect to its concerns over China), and (2) a strong effort to forge a peace settlement in the Middle East within which Israel makes a commitment eventually to forgo at-the-ready nuclear weapons (although it may retain a significant, acknowledged, and well-planned virtual nuclear arsenal).

Finally, we can infer that serious steps toward setting an asymptotic goal of virtual abolition will probably have been taken if the lead-up to the conference is marked by seriously debated proposals within the Perm Five for radical reductions in nuclear arsenals and the extending of new or reinforced security guarantees by that body; agreement to open themselves to the kind of intrusive inspection that would characterize a virtual nuclear arsenal regime; and presentation to the conference itself of a new Perm Five “interim”
nuclear forces reduction package (say, to 1,500 warheads apiece for the United States and Russia and 300 apiece for the other three nations).
ISSUES

As this report goes to press, thousand-year-old maps and memories are governing the breakup of two former nation-states, the Soviet Union and Yugoslavia. A multitude of questions are being raised in reaction: Can others be far behind? Will nuclear weapons play a role in this new political redistricting of planet earth? As Ukraine still holds to "its" nuclear weapons (a check on perceived Russian inclinations toward "correcting" the former Soviet borders?), would the Bosnians be in a different political position if they had not just weapons but nuclear weapons available to them? Might the Bosnians be seeking such weapons now? If the Serbs are successful and the Russians are forced to do no more than grind their teeth over Ukrainian intransigence, will the next breakup of a nuclear-armed or near-nuclear-armed nation-state see more than just a scramble and then a long argument over nuclear weapons and assets?

One might even ask whether, viewed in the long term, the integrity of the United States is itself at risk, especially in an environment of unconstrained nuclear capability. In the extreme, might there someday be a demand for restitution for U.S.–Native American treaties long violated, as a result of some twenty-second-century brandishing by Native American militants of an "Apache–Iroquois–Oneida" bomb assembled—or not yet assembled—in a deep underground bunker on a reservation in upstate Minnesota, or is it in Wyoming? Fanciful? Or is this simply a Western Hemisphere version of what could happen with the disintegration of the Russian Federation?
The issue in the end for preventing nuclear war, however small, however, is not possession but use.

In Nagasaki on August 9, 1995, its citizens plan to mark the fiftieth anniversary of the last nuclear weapon used in anger on planet earth and proclaim to the world the hope that the over 100,000 citizens who died in their hometown as a result of the August 1945 atomic bomb will go down in history as the last people to die by nuclear weapons.

Fifty years thereafter, on August 9, 2045, when the planet will assuredly have navigated to one of the asymptotes described in this work, the citizens of Nagasaki will mark the one hundredth anniversary of the atom-bombing of that city. They will (a hope and a bit of a prediction) proclaim that those who died as a result of the bombing on August 9, 1945, did not die in vain. They were the last to die by nuclear weapons. And if for a hundred years, why not forever?

That is a worthy goal by which to judge the efforts of the next decade—and the decades thereafter in perpetuity. It is the nature of people to follow natural processes, and only through the constant expenditure of substantial energy can nature’s tendency toward the high-entropy state of nuclear chaos or anarchy be adequately restrained.

THE CHALLENGE

Powerful forces—political, military, and economic—are afoot for greater integration in the world, and for the United States to adopt a leadership position in their exercise. But powerful forces also are afoot for fragmentation and disaggregation, the more natural state of things. This situation poses a special challenge for the United States as a new president and government come to power with a focus on domestic issues. A heavy burden of proof will fall on those who argue for investing the substantial time and energy (of the president, his administration, and the Congress) that will be needed to build a strong and active U.S. leadership posture in, and politically sustainable consensus on, such crucial international matters. Containing nuclear entropy in the long term may, however, require nothing less.
Appendix A

THE "THIRD MILITARY REVOLUTION"

BACKGROUND

Similar to the Russo-Japanese War of 1904, the Persian Gulf War of 1991 may have foreshadowed a broad revolution in the conduct of future warfare. A central thesis of many commentators on contemporary military "technique" (doctrine, organization, training, and technology) is that this realm has undergone three distinct "revolutionary" transformations during the twentieth century, and that the third revolution is now well under way and diffusing rapidly.

The first "revolution" was the use of armored fighting vehicles, aircraft, submarines, and chemical weapons during World War I. Much of the doctrinal debates during the inter-war period, prior to World War II, focused on designing military forces that would adapt to the new military technology. During World War II, many of the more radical advocates of armored and/or mechanized warfare were vindicated, and the submarine proved devastatingly effective; the more extreme views of strategic aerial warfare proved deficient, although the use of combat aircraft was a central feature of that war. Noteworthy was the absence of chemical weapons in the conflict, although all major combatants maintained large chemical-weapon stockpiles that acted as an effective deterrent against use.

The precursors of the second revolution occurred at the end of World War II with development and use of the nuclear weapon by the United States and the long-range ballistic missile, the V-2, by Germany. The former revealed the prospect of efficient, long-range
bombardment of cities; the latter matured as a high-performance delivery system during the 1950s.

During the mid- to late 1950s, the political and military leadership of the former Soviet Union became entranced by the combination of thermonuclear weapons delivered by the transoceanic-range ballistic missile. The acme of this technological combination was the development of the nuclear-powered submarine armed with transoceanic-range ballistic missiles. Throughout much of the 1960s, the Soviet military remained convinced that future warfare between the major powers would involve the mass and sustained use of nuclear weapons in support of combined-arms operations over continental distances. Preceding the shift in Soviet military views, U.S. political-military leadership became increasingly disillusioned about the prospect that nuclear weapons could be widely used in a U.S.-Soviet war in a politically and militarily useful way, leading to an ultimately positive outcome. Not unlike the experience with chemical weapons, it became increasingly apparent, as expressed in a wide body of military opinion, that the principal role of nuclear arsenals was to deter nuclear weapon use against one’s homeland, forces, and friends. This opinion was reinforced by the strongly held belief by civilian theoreticians of nuclear warfare that use of nuclear weapons in large numbers by the great powers would lead to society-destroying outcomes. In essence, nuclear weapons were perceived to violate the ultimate ends-and-means test by which warfare could be rationalized as a viable societal activity.

By the 1970s, militaries of both superpowers had shifted focus on the design and use of military forces to conduct nonnuclear operations in a variety of limited conflicts. Although the United States and the Soviet Union have had similar frustrating experiences with limited conflict (Vietnam and Afghanistan), both pushed the development of new technologies that had lead to the current prospect of a “third military revolution.” The main technological elements of this discontinuous change are sensors, telecommunications, automatic data processing, advanced conventional munitions, spacecraft, and low observable unmanned and manned fighting vehicles. More problematic but of potentially great significance is the maturation of directed-energy weapons. Even without the appearance of the latter, there is a broad consensus that the era of warfare based on weapons
made of iron and aluminum is being replaced by one based on weapons made of silicon.

THIRD-REVOLUTION TECHNOLOGIES

Unlike the technologies of the second revolution — most specifically, nuclear weapons — the technologies of the third revolution appear useful as a means of combat. Several combinations of these new technologies directly challenge the supremacy of the combat-fighting vehicles that matured during World War II — the weapons of the third revolution described in this section.

The RSTA–ACM Combination

The central feature of the development of military technology over the last 30 years has been the maturation of reconnaissance, surveillance, and target acquisition (RSTA) systems to provide “information supremacy” over the battlefield. Manned fighting vehicles, specifically those operating above the ground and oceans and in the air, have become very vulnerable to a lethal combination of RSTA and advanced conventional munitions (ACMs). Within the domain of ACMs, the most noteworthy has been the development of increasingly “intelligent” guided munitions, or what are widely known as precision guided munitions (PGMs). The results of the Persian Gulf War showed that a combatant lavishly equipped with the modern versions of first-revolution weapons could be annihilated by an opponent using the RSTA–ACM combination. A one-sided result flowed from Iraq’s inability to use countermeasures to significantly degrade the effectiveness of the RSTA–ACM combination deployed by the U.S. military coalition.

Certainly, the RSTA–ACM combination is vulnerable to countermeasures. After all, its early version appeared in the form of radar-directed air defenses used during the Vietnam War against U.S. combat aviation. During that conflict, the much-touted first-generation surface-to-air missile, the SA-2, was rendered ineffective by changes in flight tactics and electronic countermeasures. That war signaled clearly the beginning of a dynamic race between those designing the RSTA–ACM combination and those designing combat vehicles.
To ensure the fighting viability of the contemporary manned combat vehicles, their designers have resorted to engineering a number of major mutations. For air-combat vehicles, the focus has been on the development of low observable, or "stealth," vehicles to be used in combination with sensor-blinding electronic countermeasures. As for the design of the main battle tank, the focus has been on creating a more battleworthy vehicle through enhanced passive (armor) protection. Finally, the designer of the surface warship has relied less on stealth or armor than on active defenses to destroy the attacking carriers of ACMs. For the United States, this focus has meant the investment in elaborate air defenses for its surface navy—most specifically, the aircraft carrier, an icon of the first military revolution. Noteworthy is that the inherently stealthy weapon of the first revolution, the submarine, has remained relatively immune to the RSTA-ACM threat.

In this struggle of measure and countermeasure, a historic trend has become apparent: the rapid rise in the cost of each succeeding generation of combat vehicle.

**Structural Disarmament**

To accommodate the rising costs of technology, the size or structure of the force that employs that technology is often reduced. This so-called structural disarmament is a problem that has plagued the military planners of the Cold War era. To build fighting vehicles capable of surviving in a battlefield filled with sensors and ACMs, the unit cost of the modern combat vehicle has been rising far faster than the global inflation rate. Within defense budgets constrained by powerful downward economic pressures, the militaries of the East and West have had to confront the trade-off between maintaining force structure and sustaining modernization. The armed forces of the West, most notably those of the United States, were prepared to sacrifice force structure to sustain modernization. For example, U.S. forces did not increase in size during the procurement surge of the 1980s. Rather, the U.S. military was able to carry out a modernization program that led to a near-complete generation turnover of combat vehicles. Other smaller states of the Western military alliance, such as the United Kingdom and France, followed a similar pattern with far fewer resources. As for the "East," only the dominant
member, the Soviet Union, was able to sustain a vigorous military modernization program. Contrary to the U.S. approach, the more conservative Soviet military establishment was able to maintain a much larger force structure—at an economic price that proved ultimately fatal to the Soviet empire.

With the end of the Cold War and the collapse of the Soviet empire, the above approach to modern combat-vehicle design appears doomed to obsolescence. It is not by accident that the very expensive combat-vehicle programs, such as the B-2 stealth bomber, have been prematurely terminated with short production runs. The fate of the programs to design and build the next-generation heavy armored fighting vehicles and large surface warships remains very much in doubt. Clearly, the focus of the next generation of manned combat vehicles will be on designs that have low observable attributes and can be produced at affordable unit costs. In many instances the solution may be to take the person out of the combat vehicle and substitute robotic warriors.

Robotic Warriors

In essence, the modern guided munition is a primitive robotic weapon. The rapid advance of microprocessor and sensor technologies has opened the prospect of a menu of robot weapons that will expand rapidly during the next 20 years and will accommodate the powerful economic incentive to design weapons that can be massed-produced at reasonable costs. In their early form, unmanned or remotely piloted air vehicles have been used for tactical and theater reconnaissance missions. Other unmanned air vehicles (UAVs) have been used as communications relays and electronic decoys.

Blurring the distinction between UAVs and ACMs is the class of long-range standoff weapons that have matured over the last decade. These include long-range cruise missiles, such as the sea-launched Tomahawk and the currently deployed air-launched cruise missile (ALCM-B). To allow non-stealthy aircraft the option of attacking heavily defended targets, a variety of standoff guided munitions has been developed and deployed. Several types were used during the Persian Gulf War on a wide scale to give combat aviation unprecedented target-killing capacity. One of the important and unresolved
debates is over the mix for future air forces between manned aircraft that penetrate a defended battle space and aircraft that act as aerial "trucks" to bring standoff weapons within range of a target.

Overall, the trend is likely to be the increased use of robot weapons in high-threat areas of the battle space. For the next several decades, pure robot warfare may remain in the realm of science fiction, but the military and economic incentives to move warfare in that direction will remain powerful. A key question remains: Can the move to intelligent self-guiding weapons be countered by a variety of countermeasures that are both active and passive?

Gaining Information Supremacy

A key to the U.S.-led military success over Iraq in 1991 was gaining battlefield and other "information supremacy" in the theater. Whereas the U.S. offensive used an RSTA-ACM combination to deliver devastating aerial blows to Iraq's military forces and war-supporting infrastructure, supremacy was not complete without defensive measures to blind Iraq's capacity to monitor the battle space. Such measures included the extensive use of electronic warfare and the use of ACMs to directly attack Iraqi sensors. Thus, the United States and its allies carried out what the former Soviet military would call an integrated radio-electronic combat (REC) operation.

To survive this threat, future opponents of the U.S. military must either rely on similar technology to directly counter the U.S. capacity to gain information supremacy or operate in a fashion that nullifies the RSTA-PGM combination. For many future opponents, attempting to replicate the RSTA-PGM combination will be economically and technically hopeless. Adaptation strategies include fighting the United States in a low observable form of warfare. This form will range from terrorist- and guerrilla-type low-visibility operations to the exploitation of mobile and more readily hidden long-range weapons, such as the ground mobile missile launcher. For this reason alone, many regional navies will find the submarine attractive as an inherently "stealthy" weapon.

Not surprisingly, the United States will likely focus its smaller military R&D and procurement budgets on those technologies that allow it to gain information supremacy on a future battlefield. Such a bat-
tlefield will include the continued and expanded exploitation of spacecraft—a product of the second military revolution—to provide global coverage against a wide range of diverse, potential military opponents, making space the “fourth dimension” of warfare.

**Space as the Fourth Dimension of Warfare**

The use of space vehicles has become a standard feature of modern military operations. Many believe that the Persian Gulf War was the first “space” war, a war in which vehicles in orbit played a critical support role for military operations. Spacecraft are now used regularly as sensing platforms, communication relays, and navigation aids. The first use led to the strategic reconnaissance revolution during the height of the Cold War.

Contrary to the expectation of many, space has remained a sanctuary for combat operations, in large measure the product of the protracted arms-control negotiations between the former superpowers. Once the exclusive domain of the United States and the former Soviet Union, remote sensing from space for military reconnaissance, weather surveillance, and environmental and resource sensing has become a multilateral enterprise. As for satellite communications, various systems have become a global utility available to almost all nation-states and private users. In a similar fashion, a navigation “revolution” is under way with the deployment of the U.S. Navigation Satellite System (NAVSTAR). Several other systems, such as Russia’s GLONASS, will be fully deployed by the late 1990s. These navigation systems will rapidly become a global utility for government and private users to provide very low-cost and very precise navigation information. Already, the use of the partially deployed NAVSTAR constellation during the Persian Gulf War demonstrated its utility. It provided U.S. military forces with precise navigation information to conduct a massive encircling movement over trackless desert; guided rotary and fixed-wing aircraft to their targets; and furnished navigation updates to long-range standoff missiles.

As noted, it is the last use that may well prove most worrisome for the United States military planner. By exploiting this new global utility, a number of regional powers should be able to radically increase the military effectiveness of their long-range ballistic and cruise missile arsenals by providing accurate guidance information.
Given the increased military utility of spacecraft, the question is, Will the fourth dimension become an arena for combat? Prior to the termination of the Cold War, powerful military and technological trends suggested that both the United States and the Soviet Union would develop and deploy space-combat capabilities. At a minimum, both nations appeared ready to deploy a variety of anti-satellite (ASAT) weapons to provide a counter-reconnaissance capability. With the collapse of the Soviet empire, the military incentive for the United States to deploy either a terrestrial or space-based ASAT has faded but has not disappeared. For the rest of the 1990s, the U.S. space-exploitation capability will clearly be second to none as the Russian Federation struggles to preserve the former Soviet space-exploitation infrastructure. Several other space-faring powers have appeared on the scene and include the European Space Agency, China, and Japan. Other major regional powers, such as India, Israel, and Brazil, aspire to becoming space-faring countries. An interesting question is, Will space become a combat arena by accident or design?

Independent of Cold War pressures between the former superpowers, spacecraft may be placed at risk by a variety of nations by the early twenty-first century, as a consequence of the desire by many to deploy true aerospace defenses to provide active protection against ground mobile ballistic missiles.

Enhanced Aerospace Defenses

Given the difficulty of destroying mobile and hidden ground-launched tactical and theater ballistic missiles, anti-tactical missile (ATM) defense will likely be developed and deployed by the turn of the century. One of the major challenges for the U.S. military is whether it can exploit the elements of the third revolution to provide a credible damage-limiting capability against a major regional power armed with an arsenal of mobile missiles. If a variety of regional powers with interests hostile to the United States are able to deploy nearly invulnerable and effective long-range bombardment arsenals, then the U.S. military power-projection option will be severely constrained, if not totally compromised.

Given the uncertainty about deploying an airtight counterforce capability, the United States and a number of its friends and allies will
want to deploy increasingly robust theater missile defenses. In essence, the RSTA–ACM combination to deal with long-range unmanned bombardment systems will have both an offensive and defensive component. As a side effect of the worldwide deployment of ATM systems of increasing performance, a number of states will acquire a capacity to put satellites operating at low earth orbit at risk. As for satellites operating at medium earth orbit, e.g., NAVSTAR, or geostationary earth orbit, such as most SATCOMS, only a handful of countries will be able to put them at risk. High-altitude satellite destruction will require a significant space-vehicle-launch infrastructure.

For the next ten years, only the United States might conceivably pursue the option of permanently deploying weapons in space as an anti-missile system, through the Brilliant Pebbles program. The concept remains costly and controversial, and with many domestic and foreign opponents has ended in cancellation.

In this regard, the military in Russia will likely oppose any treaty-sanctioned U.S. space weapon deployment, fearing that the U.S. military will leap out ahead too far in the third revolution. And the U.S. military will likely show restraint, if only from fear of the budgetary consequences of a large space weapon deployment program. On the other hand, the U.S. military would prefer that the current technological advantage demonstrated against Iraq be sustained into the early twenty-first century. Maintaining that comparative military advantage will not be easy.

THE DIFFUSION OF THE THIRD REVOLUTION

In the face of declining defense budgets, the U.S. military will attempt to maintain some of the comparative advantages demonstrated during the Persian Gulf War. In the face of dynamic and reactive potential threats, this will not be an easy task. As with the first and second military revolutions, the third revolution is a reflection of technological change within the civilian economy. For example, much has been written about the “information revolution,” which played no small role in the rapid and peaceful collapse of the Soviet empire. With the end of the economic barriers of the Cold War, Russia, Ukraine, and China will benefit from a massive infusion of information and telecommunications technologies.
In a similar fashion, advanced engine and avionics technology is rapidly diffusing into the Russian and Ukrainian commercial aircraft industries. This suggests that by the turn of the century, the United States will face a number of high-technology competitors capable of exploiting many elements of the new industrial revolution. Aside from former "enemies," the United States faces competition from the major states of Europe, i.e., Germany, France, the UK, and Italy; Japan; the "little tigers" of East Asia; and, possibly, Brazil and India. This suggests that a broad equalizing process will be under way by the turn of the century, in which the U.S. military will find its comparative technological advantage fading away in the face of potential opponents who exploit a dynamic high-technology marketplace.

Even in the face of this economic and technological challenge, the U.S. military will likely prefer that global military competition be focused on the nonnuclear weapon domain: the essence of U.S. post-Cold War planning and experience. Not surprisingly, a number of potential opponents of the United States may have other ideas, including the exploitation of the technology of the second military revolution: nuclear weapons and the long-range ballistic missile—and probably cruise missiles, as well.
If serious consideration is to be given to the charting of some nuclear asymptote, a common framework for evaluation must be developed and "negotiated" in whatever global "deal" defines the asymptotic goal. This appendix examines the metrics that might be employed for comparing alternative asymptotes, i.e., the parameters, quantitative or qualitative, or even formulas that could be used in a side-by-side comparison and/or evaluation.

FLAGSHIP METRICS

Whatever the framework chosen for making comparisons, it must permit rigorous monitoring of flagship metrics, those metrics that would characterize the goal that had been set and the progress toward it. In this particular context, a set of key metrics for consideration include the following:

1. The number and names of nations that maintain nuclear arsenals at the ready.
2. The size of these permitted at-the-ready nuclear arsenals.
3. The restrictions, if any, that might be imposed on virtual nuclear arsenals.
4. In cases where there is a treaty or other "deal," the rationalization for permitted at-the-ready arsenals—for example, as a deterrent against adversary use or treaty breakout or as a means of "extending" nuclear deterrence to identified friends and/or allies.
5. The size and character of defenses against nuclear attack.

These metrics are explored in more detail in the material below.

**At-the-Ready Nuclear-Armed States**

The number of nations that maintain nuclear weapons at the ready and the number of weapons in those arsenals are clearly important metrics of any nuclear end state. Table B.1 lists the nations currently possessing nuclear arsenals, an estimate of the current size of those arsenals, and a *very* crude estimate of the arsenal sizes that might exist in the year 2003 (when the reductions in U.S. and Russian "strategic" nuclear forces under the so-called START II Treaty [second Strategic Arms Reduction Talks] deal are scheduled to be completed but little else in the way of nuclear arsenals has any strong basis for predictability). It is assumed—guessed—that in 2003 the United States and Russia might still maintain up to 1,000 tactical nuclear warheads in their arsenals.

One set of nations—the permanent members of the U.N. Security Council (currently the United States, Russia, the UK, France, and China)—presents itself as a potentially logical and/or defensible

<table>
<thead>
<tr>
<th>Country</th>
<th>Arsenal Size Today</th>
<th>Estimated Arsenal Size in 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>20,000</td>
<td>3,500-4,500</td>
</tr>
<tr>
<td>Russia</td>
<td>20,000</td>
<td>3,000-4,000</td>
</tr>
<tr>
<td>Ukraine</td>
<td>1,500</td>
<td>0?</td>
</tr>
<tr>
<td>UK</td>
<td>700</td>
<td>500-700</td>
</tr>
<tr>
<td>France</td>
<td>600</td>
<td>500-700</td>
</tr>
<tr>
<td>China</td>
<td>500</td>
<td>600-1,500</td>
</tr>
<tr>
<td>Israel</td>
<td>100-200</td>
<td>200-300</td>
</tr>
<tr>
<td>India</td>
<td>10-20</td>
<td>40-60</td>
</tr>
<tr>
<td>Pakistan</td>
<td>5-10</td>
<td>30-50</td>
</tr>
<tr>
<td>South Africa</td>
<td>6?</td>
<td>0?</td>
</tr>
<tr>
<td>Iran</td>
<td>0</td>
<td>10-30</td>
</tr>
<tr>
<td>North Korea</td>
<td>0?</td>
<td>10-30</td>
</tr>
</tbody>
</table>
limited number of "haves" for which global consensus might be achieved in a have/have-not framework.

Beyond the concept of a permanent finite limit on the number of nuclear-armed states in the 5–10 range (whether from U.N. Security Council membership or some other rationale), the only other static end states would appear to be the extremes of (1) no nations maintaining nuclear weapons at the ready and (2) a dozen or scores of nations maintaining such arsenals (in which case, after some point, the number will not matter). As discussed later in this appendix, the first extreme may not offer nearly as much inherent stability as a small number of states with very modest arsenals; the second extreme, a world of a multitude of nuclear-armed adversaries, poses a separate and profound multibody stability problem.

Finally, the concept of "slowly changing" has been proposed as an asymptotic state (mathematically, a small but relatively stable first derivative) and should be considered in looking ahead for the next generation or two, as set forth under the "Ever-Slowly-Expanding Nuclear Club" alternative in Chapter Five of the main text.

The Size of Asymptotic Nuclear arsenals

"How much is enough?" is a classical question that has dogged nuclear-force-posture assessments since the early years of the nuclear age. The answer to this question is, to be sure, a matter of strategy, context, and the function that nuclear weapons are intended to serve.

The most important function of nuclear weapons would appear to be deterrence, the "Don't hit me or you'll be sorry" of the schoolyard. Nuclear weapons clearly do go a long way to deter one nation from attacking another, and may, in fact, be sufficient for this purpose. To date in the nuclear age there is only one modest example of a nuclear-armed nation being attacked by another nation—the Arab attack on Israel in the 1973 Middle East Yom Kippur war—and in that instance it may very well have been that the Arab allies did not believe that Israel had (or, in the light of their own concepts of limited aims, would use) nuclear weapons.
It would not be an exaggeration to say that the first nuclear weapon that a nation acquires is the most important, and that at least the first dozen or two are all "strategic." As testimony to this perspective, in the early weeks of the Carter Administration, when the president's immediate staff was being briefed on the U.S.-Soviet nuclear balance and the elements of nuclear deterrence, Carter's Chief of Staff Hamilton Jordan offered the view that he was sure he knew what would deter the United States from attacking some other nation: "the ability to retaliate with one nuclear weapon on Washington, D.C., during working hours." The story of President Kennedy's 1962 Cuban Missile Crisis query to then-Strategic Air Command (SAC) chief Gen. Thomas Powers as to whether a U.S. attack on the missile sites would assuredly get all of the Soviet nuclear weapons also emphasizes the significance of a small nuclear arsenal. Powers answered honestly that he could not give such an assurance.

Four representative approaches can be taken to fixing the size of permitted global at-the-ready nuclear arsenals:

1. Seek to limit permitted arsenals to the reduced START II levels for U.S. and Russian arsenals (roughly 3,000 warheads) and at or near-current levels for other nations.

2. Reduce permitted at-the-ready force levels to roughly one-third of the projected 2003 START II levels for the United States and Russia (say, 1,000 warheads apiece), with other nuclear-armed nations proportionately lower.

3. Further reduce permitted force levels another factor of 3 to 10 (to U.S. and Russian ceilings on the order of 100–300 warheads) and remove nuclear warheads from almost all military roles except deterrence of use and breakout.

4. Further reduce permitted force levels another factor of 3 (to U.S. and Russian ceilings on the order of 30–100 warheads) and remove nuclear warheads from almost all military roles except deterrence of use and breakout.

The absolute and relative sizes of permitted at-the-ready nuclear arsenals in a context in which arsenal sizes are explicitly limited would presumably be determined largely on the basis of stability arguments. Even in a bilateral context, the issue of stability was highly
controversial. Thus multiparty-arrangement nuclear stability assessments pose a daunting problem.

Figure B.1 presents the stability problem in a notional fashion as a function of the number of at-the-ready nuclear warheads permitted the United States in the nuclear end state. Note that two types of stability assessments are illustrated:

1. A traditional bipolar assessment (A and A'), for which the stability curve is generally assumed to increase, albeit slowly, at the very high levels.

2. Notional stability curves (B and C), two examples that peak at different arsenal levels for the multipolar calculations that would support reductions to virtual-nuclear-arsenal levels.

It remains to be seen just what kind of numerical (as opposed to political) stability calculations can be made in situations where the "balancing act" involves more than two parties. At the global level, for example, at very low nuclear force levels, a triparty stability assessment involving U.S. (with or without British and French forces), Russian, and Chinese nuclear forces needs to be pursued. A similar challenge presents itself in the Greater Middle East if, for example, a

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**Figure B.1—Notional Stability Curves for a Range of Nuclear Force Levels**

- A — 1989 bipolar
- A' — 2003 bipolar
- B, C — Multipolar (alternative virtual-abolition asymptotes)
"stable" arrangement were to be negotiated involving modest levels of nuclear forces in the hands of Iran, Iraq, and Israel.

**Strategic Warning Time and Virtual Nuclear Arsenals**

One of the most important characteristics of any nuclear asymptote will be the absolute and relative size of the nuclear arsenal that a nation can bring from a virtual state to a real and usable—at-the-ready—state inside some notional "strategic warning time." Figure B.2 portrays those forces that can be brought to an at-the-ready status inside a matter of hours or a day or two.

It is important to assess just what the circumstances and requirements might be for adding to these at-the-ready forces. The following questions may be part of such an assessment: Is it important to maintain forces that can be brought to an at-the-ready state in a matter of weeks instead of just days, keeping in mind that this would also legitimize comparable forces in other nations? Or is it adequate, or better, to effect a more significant time separation, say, months, before additional forces can be brought to readiness by any of the parties in some volatile international situation? Or is it best to think about a two-stage process, with, say, a tripling of forces in a matter of months and another tripling or more in a matter of years? Figure B.2 depicts these choices.

![Figure B.2—Sizing and Timelines for a Virtual Nuclear Arsenal](image-url)
Rationalizing Permitted Arsenals

To ensure that the size of permitted nuclear arsenals goes hand in hand with the rationalization of the roles that the permitted weapons will have, the following are the roles that nuclear weapons might be proclaimed to serve and representative warhead requirements (in the absence of warhead-based defense penetration requirements, e.g., for precursor bursts or defense exhaustion):

- Deterrence of attack achieved by holding at risk the political and military leadership and virtually the entire economic and conventional military infrastructure of a large adversary (the deterrence requirements underlying current U.S. and Russian force levels)—requiring thousands of deliverable warheads.

- Deterrence of attack achieved by holding at risk the major cities and many other vital targets (e.g., the key ports and air bases) of an adversary—requiring tens to hundreds of deliverable warheads.

- Deterrence of attack achieved by holding at risk only the political and military leadership of an adversary—requiring tens to hundreds of deliverable warheads, possibly including those with special characteristics, such as earth-penetrating weapons to destroy deep underground command centers.

- Extended deterrence to deter attack on allies—requiring tens to thousands of deliverable warheads, depending on the size of adversary forces.

- Counterforce capability against modest-sized nuclear arsenals in the hands of adversaries or rogue nations—requiring, if it is possible at all, tens to hundreds of weapons, depending on the size and deployment mode of adversary nuclear forces.

Defenses

In looking to the future, we can see that the challenge presented by incorporation of competent defenses in a multipolar environment in some conceptualized (and politically sustainable) end state is substantial. This challenge has already proven formidable in assessing stability with other than negligible defenses in a bilateral context.
The task of marshaling persuasive stability arguments in a multibody context, most likely with different defense capabilities for different nations, is even more daunting.

In the multibody context, stability and equilibrium arguments for many nations may simply be reduced to whether a nation has nuclear forces that can absorb a preemptive strike and retaliate with modest numbers of surviving weapons against an adversary's vital targets—a slightly enhanced version of the "one nuclear weapon on Washington, D.C., during working hours" criterion cited above.

In terms of air defenses, while the penetration of certain heavily defended areas by cruise missiles and aircraft would not be easy, there is no reason at this time to believe that air-defense penetration will be an insurmountable problem either for the few nations (such as the United States) that are likely to depend on aircraft-delivered nuclear weapons or those (such as some regional powers) who might deploy modern nuclear-armed cruise missiles.

In terms of ballistic-missile defenses, current concepts for achieving high levels of defense capability are so far just concepts; they suffer from a lack of demonstrated "prowess." In this situation the casting forth of ballistic-missile defense concepts as a component of alternative end states will be inherently limited. Especially at low levels of nuclear arsenals, where arsenal size would be carefully rationalized on the basis of being able to carry out a precise mission, there will presumably be real "mission viability" impediments to including ballistic-missile defenses in the depiction of a preferred asymptotic end state.