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The Costs, Risks, and Benefits of Arms Control

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and Arms Control

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Introduction

It is no exaggeration to say that arms control has undergone a revolution in the past decade. In the forty years since the bombings of Hiroshima and Nagasaki ended World War II and began the nuclear age, governments, organizations, and individuals have worked to reduce the threat of wars between great powers employing weapons of mass destruction—nuclear, chemical, and biological. Some progress was made during this period; the Limited Test Ban Treaty (LTBT) of 1963, the nuclear Non-Proliferation Treaty (NPT) of 1970, and the Anti-Ballistic Missile (ABM) Treaty and Biological Weapons Convention (BWC) of 1972 were the more notable achievements. But progress was always slow, frustrating, and tentative, with no assurance that the whole fabric might not be undone by an increase in superpower tension or by domestic forces in either the United States or USSR hostile to the very concept of arms control.

All of this changed dramatically with the advent of Mikhail Gorbachev's domestic and foreign policy reforms in the Soviet Union. Suddenly, everything seemed possible in arms control. In 1986 Gorbachev approved the Stockholm Confidence and Security Building Measures (CSBM) document, which introduced on-site inspections into the European security regime established at Helsinki eleven years earlier. One year later, Reagan and Gorbachev signed the Intermediate Nuclear Forces (INF) Treaty eliminating totally all of the two states' medium and shorter range ballistic and cruise missiles and creating a far more elaborate on-site inspection regime to monitor the agreement. These agreements were followed by a rush of major new treaties eliminating, limiting, or controlling a wide range of weapons categories, including nuclear, chemical, biological, and conventional (see Table 1).

Table 1: Major Arms Control Agreements Since December 1986

Weapon Type	Treaty/ Agreement	Date Signed	Signatories	EIF
Nuclear	INF	8 DEC 87	US-USSR	1 JUN 88
	TTBT	3 JUL 74	US-USSR	1 DEC 90
	PNET	28 MAY 76	US-USSR	11 DEC 90
	START I	31 JUL 91	US-USSR (4 FSU parties)	5 DEC 94
	START II	3 JAN 93	US–Russia	–
Conventional	CFE CFE 1A	19 NOV 90	30 states (ATTU)	17 JUL 92
	Stockholm-Vienna CSBM	19 DEC 86 24 MAR 92 28 NOV 94	52 states (OSCE)	1 JAN 87 1 MAY 92 6 DEC 94
	Open Skies	24 MAR 92	27 states	–
Chemical	Wyoming MOU	23 SEP 89	US-USSR (Russia)	23 SEP 89
	Bilateral CW	1 JUN 90	US-USSR (Russia)	–
	CWC	13 JAN 93	158 states	–
Biological	Trilateral BW	11 SEP 92	US-UK-Russia	11 SEP 92

- Nuclear delivery systems were drastically reduced by the Strategic Arms Reduction Treaties START I (1991) and START II (1993), as well as by mutual unilateral retirements of most tactical nuclear weapons by both superpowers. The NPT was extended indefinitely and unconditionally by a surprisingly strong majority in 1995, and the five recognized nuclear weapon states have committed themselves to achieving a comprehensive nuclear test ban (CTB) in 1996.
- The Conventional Forces in Europe (CFE and CFE 1A) treaties mandated the removal of hundreds of thousands of pieces of military equipment and troops from the European continent, and the Vienna CSBM documents of 1992 and 1994 extended the military transparency regime begun by the Helsinki and Stockholm documents. The Open Skies Treaty (1992) promises to add substantially to this regime when it enters into force.
- The Wyoming Memorandum of Understanding (MOU) of 1989 and the Bilateral Destruction Agreement (BDA) of 1990 marked the beginnings of the long-term effort to eliminate the massive and dangerously unstable chemical weapon arsenals of the United States and Russia. The Chemical Weapons Convention (CWC) of 1993 will extend the

prohibition of chemical weapons, and has created the most elaborate monitoring and inspection regime in history to ensure compliance.

- Progress on biological weapons control has been slower than the other areas, but the United States, United Kingdom, and Russia have created a trilateral agreement to attempt to increase the transparency of their biological weapons programs, and the states parties to the BWC have mandated the study of a possible verification regime for the Convention.

Many questions surround this revolution, and the author has attempted to address a number of them in a larger study from which this paper has been adapted.[1] This paper will focus on one relatively narrow set of questions relating to the costs to the United States of implementing and verifying all of these agreements and the ones that may follow. The United States has been a leader in the negotiation of all of the recent agreements, and it is clear that if the agreements are to survive the United States will have to maintain this leadership role for the indefinite future. Leadership never comes without cost, and the fact that arms control and disarmament cost real money has only recently begun to sink into the consciousness of the international community. Of course, it is not only the United States that must bear the costs of arms control. Russia's weapon stockpiles are larger than those of the United States and therefore it will likely cost at least as much to reduce or eliminate them. In addition, Russia, along with the other successor states to the former Soviet Union and its Warsaw Pact clients, finds itself in severe economic distress as a result of the collapse of the Soviet Union. Therefore, the United States, which has a major interest in assuring the compliance of these countries with the agreements they have signed, has been called upon to provide financial aid for the implementation of nuclear and chemical weapons elimination and to exercise patience as economically strapped states like Belarus and Ukraine struggle to eliminate the vast stocks of weapons left on their territories by departing Russian forces.

Arms control and disarmament are expensive for everyone, but it is clear that the costs to the United States will be the greatest, especially if it continues to provide aid to former Soviet republics and to make its traditional contributions to international institutions like the United Nations, the International Atomic Energy Agency, the Organization for the Prevention of Chemical Weapons (OPCW), and whatever agency is created to administer the Comprehensive Test Ban. Therefore, it is essential to have a reasonably good idea of what all of this will cost, of whether the benefits derived from individual treaties and arms control as a whole justify those costs, and of how costs might be kept under control as existing agreements are implemented and future ones are negotiated.

At the height of the Cold War it would have seemed odd to ask about the cost of implementing or verifying arms control agreements between the superpowers. Each side was spending hundreds of billions of dollars on military preparations, and while the satellites, seismographs, and antennas used to monitor the Soviets were certainly expensive, their primary purposes were threat assessment, order of battle surveillance, and strategic warning, all attributable to the military competition. As far as arms control monitoring was concerned they were considered a "free good,"[2] and it would not have occurred to anyone that the costs of using them in this way were comparable with the benefits of reducing nuclear weapon and anti-ballistic missile deployments and enhancing crisis stability.

The world has changed, however, and so have the questions being asked about arms control. As perceptions of imminent threat have decreased, awareness of cost has increased, and this paper is being written at a moment when the two curves appear to be crossing. A

few examples will illustrate this point. A comprehensive nuclear test ban has been under discussion for many years in the Geneva Conference on Disarmament, and is now mandated for achievement in 1996 as a result of the NPT Review and Extension Conference. One analysis notes that "CTB negotiators are increasingly sensitive to the cost of implementation... While most negotiators would agree that multilateral verification, non-discriminatory decision making, and prompt, non-confrontational inspections are desirable, there is a limit to what they are willing to pay for what might come to be seen as too much of a good thing."[3,4]

A second example of cost consciousness can be found in the instructions to the group of experts (VEREX) evaluating possible verification measures for the Biological Weapons Convention. One of the explicit criteria against which possible BW verification measures must be measured is their "financial implications."[5] Without doubt this concern for costs derives from a growing realization that the Chemical Weapons Convention will impose significant financial burdens both on governments and private industry, burdens that were not given much weight when the primary goal was ridding the world of chemical weapons. Few question the value of the goal, but many more are beginning to realize just how expensive it will be to achieve. Future financial problems of the Organization for the Prevention of Chemical Weapons may be foreshadowed by those currently experienced by the International Atomic Energy Agency (IAEA). IAEA Safeguards funding has been essentially level since 1984, even though the number of facilities and the amount of fissile material requiring safeguards have steadily increased.[6]

Within the U.S. government, the costs of implementation and verification have begun to emerge as a serious issue. A study of the CFE Treaty by the General Accounting Office (GAO) suggested that the Pentagon had been a bit overzealous in destroying equipment and participating in inspections, and a bit extravagant in using military instead of commercial aircraft to deliver inspection teams to their points of entry. According to GAO, the latter practice alone added about $3 million to the cost of implementing CFE.[7] It is not necessary to argue the merits of this criticism here, only to point out that no one would have quibbled over 3 million dollars in 1988 when Europe was armed to the teeth with vast arsenals of conventional and nuclear weapons and when on-site inspection was seen as a dramatic and highly reassuring breakthrough in arms control monitoring. Another example involves an important innovation of the Intermediate Nuclear Forces (INF) Treaty: continuous perimeter portal monitoring. It has fallen from favor in subsequent agreements as its relatively high cost-to-benefit ratio has become more apparent.[8]

These examples will suffice to make the point that an awareness of the financial costs of arms control is beginning to assert itself in both domestic and international politics. The traditional criteria of "adequacy" or "effectiveness" for monitoring were difficult enough to define precisely based on an assessment of the "military significance" of violations. Now the criterion of military significance is being replaced by the even more subtle concept of "cost-effectiveness." This is most emphatically presented in an August 1995 report on an Inspector General's investigation of the Arms Control and Disarmament Agency. The first finding and recommendation of the study stated in no uncertain terms that

> The United States will not be able to meet the funding obligations implicit in all arms control agreements currently contemplated. It will be difficult to fully fund U.S. participation in even those agreements to which the United States is already a party. All such agreements should be subjected to a rigorous cost-benefit analysis of the contribution each makes to vital U.S. interests. It is no longer sufficient to argue that

> international commitments require these budget outlays. Increasingly—as Congressional limitations on funding for UN assessments underscore—trade-offs will have to be made within budget categories. Budgetary constraints, including the political momentum to achieve a balanced budget early in the next century, require persuasive evidence that expenditures to implement current and proposed international understandings serve priority U.S. interests.[9]

It is worth noting that the United States is a rich country compared with many of its arms control partners. The financial costs of arms control are felt much more strongly by developing countries and by the financially strapped newly independent states of the former Soviet Union.[10]

It is difficult to argue with the principle underlying the Inspector General's warning. Cost-effectiveness is as necessary and legitimate a criterion to apply to arms control as to any other activity. At the same time, it will become clear as this analysis unfolds that the amounts being spent on arms control are dwarfed by the funds appropriated for sophisticated weapon systems for which little or no national security justification can be found. Just one example will illustrate this point. The Congress seems more than willing to abandon the ABM Treaty, which is quite inexpensive to implement and verify, in order to urge deployment of a nationwide ballistic missile defense, which would not only cost many tens of billions in its own right, but which would also in all likelihood sacrifice the substantial savings anticipated under the START I and II treaties and their possible successors. Common sense would suggest that the Congress apply the same rigorous standards of cost-effectiveness to military expenditures as it wants applied to arms control implementation.

Not all of the costs of arms control, and in some cases not even the most important ones, are financial. There are also risks of undetected cheating, risks of loss of military or commercial secrets, and risks of complacency or false assumptions of security. These must be added to the financial costs to produce a fair assessment of the value of any agreement. For example, the United States benefits from on-site inspections because of the opportunity to examine the military activities and equipment of potential adversaries. Those potential adversaries also benefit from their inspections of U.S. bases and facilities, which poses some risk to U.S. security. But comparison of these benefits and risks defies quantitative analysis. The Office of Technology Assessment (OTA) has found it "difficult to get net assessments of the gains and losses of sensitive information that come with on-site inspections."[11] OTA speculated that "Somewhere in the government, there may be rigorous, all-source analysis comparing the values of the potential gains and losses." But, "OTA was not privy to such analyses...." It is unlikely that such comparisons exist, since the risks and benefits they would compare are both unquantifiable and incommensurate.

Therefore, the present analysis cannot offer a clear and quantitative comparison of benefits with costs and risks. Some costs can be estimated to within ten or twenty percent, others only to an order of magnitude. Benefits and risks are inevitably qualitative and depend on the analyst's values and basic assumptions. All that can be done here is to summarize the best available information on costs and define the essential categories that determine risks and benefits. Some judgments are relatively easy to make, but others are far more difficult and must ultimately be made by the political process. Examples of both will be present in the following analysis.

Generic Costs

Figure 1 illustrates the evolution of costs for a generic arms control agreement.[12] Most of the money is spent during the period between signature and a few years after entry into force (EIF), precisely the period we are interested in here. The curves for costs and manpower requirements are qualitatively correct for the nuclear and conventional treaties, but a bit misleading for the bilateral and international chemical weapons agreements, for which high implementation costs will persist much longer after EIF. Another variation on the generic picture may be introduced by U.S.-Russian negotiations to clarify the distinction between theater and strategic ballistic missile defenses. If this distinction is made more precise it could increase the costs of verification, and this could cause the curve to begin to rise again in the long-term compliance phase of the ABM Treaty.

Figure 1 shows several treaties in the medium- to long-term compliance phase: ABM, INF, CFE, and CSBM. START I is in its early implementation phase, while BDA, CWC, Open Skies, and START II remain in limbo between signature and EIF. However, a significant fraction of the total costs of a treaty is spent in this period, so there should be enough data on all of these agreements to make reasonably reliable cost estimates. Several such estimates have already been made, and this paper will rely heavily on them. No independent estimates will be attempted, since they are beyond both the scope of the study and the competence of the author.[13] One important conclusion emerges from a comparison of the earlier cost estimates and the actual experience: on-site inspection has consistently proved to be cheaper than predicted. The reasons for this will be explored below, along with the question of what this may imply for future treaties.

National Technical Means

National technical means (NTM) of verification include a wide variety of satellite and aircraft imaging systems; extensive networks of satellites, seismographs, radiation monitors, and other sensors for detection and measurement of nuclear weapon tests; space-, land-, and sea-based antennas and sophisticated decryption and traffic analysis methods for communications monitoring; radars for tracking aircraft, ballistic missiles, and satellites; ground-based imaging systems for observing and identifying orbiting spacecraft; underwater sonar devices that can track submarines and surface ships and detect hydroacoustic waves at great distances; and many more. They have cost many billions of dollars to develop, deploy, and operate, and have provided the United States a detailed and remarkably accurate picture of the military capabilities of its actual and potential adversaries. NTM have been used primarily for gathering military intelligence, but they have also been crucial for the progress of arms control, permitting the verification of both quantitative and qualitative restrictions on a variety of strategic and tactical systems.

It has never been possible to obtain reliable estimates of NTM costs attributable to arms control. The Intelligence Community (IC) has been steadfast in its unwillingness to make such estimates, or, if they have been made, to share them with other agencies, even in classified form.[14] The ostensible rationale is the protection of sources and methods, and while there is some basis for this argument, it is unclear why aggregate estimates cannot be released without compromising sensitive information. During the Cold War the “free good”

Figure 1: Generic treaty cost profile

assumption for the contribution of NTM to arms control was probably an acceptable first approximation. But U.S. arms control and nonproliferation commitments have increased substantially in the past several years, suggesting that monitoring for these purposes now accounts for a significantly larger portion of the activities of U.S. NTM. Testifying in February 1995 in support of START II ratification, the CIA's Deputy Director for Intelligence pointed out that "The Intelligence Community has reduced its resources devoted to Russian military developments across the board... But, in reality, there are now no fewer questions being put to us by the Executive Branch and Congress on strategic military-related issues—from the location and status of Russian nuclear warheads, to the production and potential proliferation of all kinds of weapons and missiles, to command and control of the strategic forces, to monitoring strategic arms control agreements."[15]

The National Reconnaissance Office (NRO) accounts for a sizable fraction of the approximately $28 billion U.S. intelligence budget.[16] The Reagan administration launched a major effort to modernize and expand U.S. satellite capabilities, and NRO's budget has remained at an estimated $7 billion per year.[17] A large imaging or signals satellite costs at least a billion dollars,[18] and the U.S. aerospace industry has been producing them at a steady rate since the mid-1980s. The imagery and signals intelligence obtained by NRO's satellites are processed and distributed by the Central Imagery Office (CIO) and National Security Agency (NSA). CIO's budget request for FY 1995 was $123 million, but the Defense Department is anticipating a substantial increase in this appropriation over the next few years. Planning for the 1996-2001 period shows an average yearly budget for CIO of $300 million.[19] NSA's budget is estimated to be about $3.5 billion.[20]

Even if we assume that arms control monitoring accounts for at most ten percent of the total budgets of NRO, CIO, and NSA, this comes out to about $1 billion per year. As we will see shortly, this is roughly comparable to the total annual cost of cooperative measures. If more treaties enter into force with more extensive cooperative monitoring regimes, the relative contribution of NTM may decrease. There are insufficient data to allow an estimate of the trade-offs at the margin between NTM and cooperative measures, even if we assume that they can be substituted for each other for some monitoring tasks. They have always been seen as complementary rather than substitutable, and this still appears to be the appropriate way to think about them.

There is a danger in emphasizing the role of NTM, especially satellites, in arms control verification and nonproliferation surveillance. The rapid expansion of verification demands that followed the INF Treaty was used by some members of Congress to argue for even more deployments. CBO noted in its 1990 study that "Legislators who might not support 'spy satellites' or 'targeting satellites' could find the idea of 'verification satellites' more palatable, even though the distinctions are somewhat artificial."[21] However, subsequent events do not appear to have borne out these concerns. Imaging and signals satellite constellations have not been expanded; in fact, they and their associated ground stations are being reduced by almost half because of cuts in the IC budget.[22] However, data acquisition rates will remain at least as large as they have been.[23] Improvements in sensors, computers, and communications equipment allow nearly ten times the amount of data to be gathered, processed, and transmitted, with no increase in the number of satellites. It is highly unlikely, therefore, that new satellite sensors (beyond normal replacement requirements for existing assets) will be required for arms control monitoring in the foreseeable future.[24]

Research and Development Costs

A major portion of the expenditures in the pre-ratification phase of any agreement goes to research and development, which are usually necessary for both implementation and verification. For example, in preparation for START the Defense Department planned to spend $62 million over a three-year period learning how to destroy solid fuel rocket motors in an environmentally safe way.[25] As it turned out, the United States was not required to destroy any missiles under START, but the study was still necessary in view of Congress' order to the Air Force to make sure that the environment was not harmed by the destruction of obsolete missiles. Other examples of pre-ratification R&D can be found in the development and testing of Open Skies sensors, in the practice on-site inspections carried out in preparation for START and CWC, and in the vastly expensive program to develop a safe and environmentally sound method of disposing of old chemical munitions and agents.

The money spent on verification R&D is significant, and the large fraction of it devoted to developing NTM and other intelligence techniques is secret. It is reasonable to assume that a substantial fraction of the budgets of CIA, NSA, and NRO, probably totaling several billion dollars per year, must be spent for R&D. It is used to develop new satellites, aircraft, sensors, communications, cryptology, and information systems. A relatively new area, measurement and signatures intelligence (MASINT), which develops new methods of detecting and identifying substances, devices, facilities, or activities related to weapons proliferation or ballistic missile defenses, has also grown in recent years.[26] Most of this money is paid to private contractors, but a significant amount is spent in the national laboratories, which do secret R&D on both NTM and cooperative measures. National lab resources devoted to R&D for the Intelligence Community are still at least an order of magnitude greater than those spent on cooperative verification projects.[27]

Spending on cooperative verification is more open and therefore more accessible to analysis and oversight. There are four main agencies involved in this activity: the Defense Nuclear Agency (DNA), the Advanced Research Projects Agency (ARPA), the Department of Energy's Office of Arms Control, and the Arms Control and Disarmament Agency (ACDA). Figure 2 shows funding histories for these agencies during the FY 1986-1994 period. Total R&D spending rose from $83 million in FY 1986 to a peak of $260 million in FY 1991. It then declined to about $220 million in FY 1994, where it has leveled off. The rapid rise in DNA's funding was associated with its responsibility to support the new On-Site Inspection Agency, which began operation with the INF Treaty in mid-1988 and grew rapidly as it acquired more responsibilities under subsequent agreements. DOE's verification budget requests for the three years from FY 1989 to FY 1991 were all increased ten percent or more by Congress, which felt that verification R&D was inadequately funded.[28] In FY 1992 DOE expanded its program and budget request, and both have remained at historically high levels since then.

Implementation and Inspection Costs

We can now examine the costs, risks, and benefits of individual agreements, first those that have a solid record of implementation and then those either just ratified or still awaiting entry into force. We will start with the INF Treaty, and not examine earlier ones such as the

Figure 2: Funding history for arms control verification research

Source: *Arms Control: Improved Coordination of Arms Control Research Needed.* U.S. General Accounting Office, GAO/NSIAD-92-149, April 1992, p. 16.

Limited Test Ban Treaty, the Strategic Arms Limitation Treaties (SALT I and II), or the ABM Treaty. None of these involved any actual implementation, and all have been monitored entirely with NTM, for which, as we have just seen, costs are notoriously difficult to estimate. The SALT agreements have been superseded by START, but the LTBT and ABM agreements are still in force and still being closely monitored. Indeed, many of the systems used to monitor the LTBT will be adapted to help monitor the Comprehensive Test Ban, if and when it is achieved. We will come back to this prospect at the conclusion of the paper.

INF Treaty

The INF Treaty provided the first hard data on the costs of implementation and verification, and the results were encouraging. In the three years from June 1, 1988 to May 31, 1991, the U.S. Army and Air Force destroyed a total of 403 Pershing IRBMs and 443 ground-launched cruise missiles (GLCM) at a total cost of $128 million.[29] The great majority of this amount (84 percent) was spent on destroying the Pershings, and much of the cost was incurred because all of the missile stages were flown back to the United States from their West German bases for destruction. Only the Pershing launchers were eliminated on West German territory.[30] As has been the case in every treaty so far, the USSR had far more missiles to eliminate (1,846 vs. 846) and far more infrastructure and supporting equipment to destroy as well. Nevertheless, the Soviets were able to meet these requirements on time and with no external aid.

Monitoring the INF Treaty has proven to be less expensive than anticipated, although there are hidden costs that make the savings less impressive than they appear at first glance. The Congressional Budget Office, in a study dated September 1990, estimated that quota inspections at Warsaw Pact bases would cost $1-2 million per year, giving an estimate of $10-20 million for the 1991-2001 period.[31] The GAO, in a study published just one year later, estimates $7.5 million for the same inspections over the same period, which works out to an average cost of $60,000 per inspection.[32] These are the "active" inspections, and experience has shown that it is generally more expensive to host an inspection than to conduct one.[33] It requires considerable effort and expense to prepare a base or facility for an on-site inspection so that legitimate secrets are protected from foreign inspectors, most of whom are assumed to be well-trained intelligence personnel.

An even bigger difference can be found in the estimates of continuous perimeter-portal monitoring (CPPM) costs at Magna, Utah, and Votkinsk, Russia. Where the CBO estimated a total annual cost to the United States of $30-50 million at the two sites, GAO estimated an average cost of only $12.4 million per year in constant 1989 dollars. Still, $12.4 million per year is about ten times what it costs to conduct the full quota of on-site inspections in that year, and it is not obvious that the added benefits justify the much greater cost.[34] CBO estimated the total cost of monitoring the treaty for its thirteen-year lifetime to be in the range $641-$1,216 million.[35] But in a 1992 analysis, based on two more years of experience and the full implementation period, the Institute for Defense Analysis (IDA) obtained a figure of only $490 million for the total monitoring costs.[36] Clearly, the early estimates were too high by a considerable margin.

The costs considered in these estimates are only those directly attributable to the Army, Air Force, and OSIA. They do not include a variety of other costs which for various reasons are difficult to estimate or to obtain. NTM costs cannot be estimated accurately, because the Intelligence Community has always refused to attempt to estimate the fraction of the overall

intelligence effort that is devoted to arms control monitoring. Most of the personnel costs of the OSIA are not included in its budget figures, because military personnel serving with OSIA are treated as if they were cost-free.[37] The GAO identifies a number of other hidden costs that include FBI counterintelligence activities, some preparation costs for Soviet inspections at overseas bases, temporary duty personnel from other agencies that accompany on-site inspections, personnel costs for the interagency committees and consultative bodies that analyze compliance and engage in negotiations, State Department support for OSIA in foreign countries, and others. The lack of detailed accounting for many of these costs is not surprising; they are often difficult to apportion accurately to different agreements, and in some cases it would not be worth the extra effort and cost to keep track of them. Such hidden costs are an unavoidable aspect of the implementation of any arms control agreement. They constitute a kind of "overhead" that will typically add a few percent to estimates of explicit costs.

NTM are also neglected in the GAO estimates, but their contribution to INF costs is probably quite small. Because the treaty eliminates all the missiles of each class and all testing and production of them, the monitoring job is much easier than keeping track of limited numbers or restricted deployments. U.S. satellites could photograph IRBM bases at less frequent intervals to ensure that no forbidden missiles or activities are reintroduced after the close-out inspections. Satellites are used to examine Russian SS-25 operating bases six times a year under the "enhanced NTM" provision of Article XII, but this would not add much to the overall monitoring cost nor interfere appreciably with the many other jobs done by those satellites.

Are these costs reasonable compared with the benefits of the INF Treaty? The answer seems clearly to be yes, with the possible exception of the continuous monitoring at Magna and Votkinsk. Not only has the precedent of intrusive on-site inspection been established, but several classes of nuclear-armed missiles have been completely eliminated, including two of the most modern and threatening IRBMs, the Soviet SS-20 and the U.S. Pershing II. Even in strictly financial terms the costs of destroying these missiles and verifying the treaty were less than the lifetime operational costs of the weapons had they remained deployed. This was the conclusion reached by the Congressional Budget Office, which advised the Senate Foreign Relations Committee in 1988 that "Savings totaling as much as $1.1 billion would accrue each year from lower force levels including fewer military and civilian personnel and other lower operating costs."[38] CBO's estimate was challenged by Senator Jesse Helms, who asked the General Accounting Office for a second opinion. GAO estimated that $219 million and $240 million would be saved in FY 1988 and 1989, respectively, and that savings on the Pershing II program between April 1988 and September 1995 would total about $1.2 billion. Another study by GAO done in 1989 identified 16,701 personnel, including 15,559 military and 1,142 civilians, who could be reassigned or retired as a result of the treaty.[39] The GAO's estimate of savings is significantly lower than the CBO's, but both conclude that the treaty represents a net financial savings when costs avoided are balanced against the costs of implementation and verification.

Intangible political benefits from the INF Treaty are much more important than the relatively small financial benefits. The on-site inspections in the treaty represented a historic increase in transparency and have served as models for inspections under all subsequent treaties. The contacts they have established between Russian and American military and civilian personnel and organizations have been a major factor in removing long-held Cold War assumptions and fears. While these political benefits are unquestionable, the contribu-

tion of on-site inspections to reducing the risk of clandestine cheating is harder to estimate. By targeting the most likely facilities and bases where clandestine production, testing, or deployment might be carried out, inspections make cheating more difficult, risky, and expensive. This clearly reduces the risk of cheating below what it would be without inspections. At the same time, it was evident in the context of U.S.-Soviet relations in the late 1980s that neither side had a military incentive to cheat on its INF commitments, and both sides had strong political incentives to make the treaty work. On-site inspections reduce the probability of successful cheating; if that probability is already low, OSI has relatively less benefit.

In the new Europe that Gorbachev's reforms helped to create, the INF missiles were militarily worthless, so there could be no point to hiding some of them or trying to manufacture new ones clandestinely. NTM and other national intelligence activities remained in operation and continued to create an incalculable but significant risk of discovery even without inspections. Indeed, in the opinion of many analysts the inspections added only marginally to the effectiveness of verification. From the beginning it was clear that "inspections are likely to be most useful precisely when they are least needed—when parties to an agreement have a strong desire to cooperate."[40,41] Their greatest benefit derived not from their ability to detect or deter cheating, but from the political message they conveyed that the Soviet regime did in fact have a "strong desire to cooperate." Willingness to agree to intrusive inspections has continued to carry this message to the present day, just as an unwillingness to accept inspections conveys the opposite message. South Africa, by renouncing nuclear weapons and opening all of its former weapons plants to IAEA inspections, provides an excellent recent example of the former. Iraq and North Korea are good examples of the latter category because of their many efforts to delay, evade, or mislead on-site inspectors from the United Nations Special Commission on Iraq (UNSCOM) or IAEA.

CFE Treaty and CSBM Agreements

The CFE Treaty entered into force in the summer of 1992. Unlike the INF Treaty, which emerged quite suddenly with no attempts to estimate the costs of its implementation in advance, CFE was anticipated well before its EIF. It is therefore possible to compare a priori cost estimates with actual expenditures and draw some lessons from the experience.

Nearly two years before EIF the CBO estimated that one-time costs associated with CFE implementation would be between $105 and $780 million, and that annual costs would be $25-$100 million.[42] Amortizing the one-time costs over the first ten years of the treaty gives an average annual cost of $35-$178 million for U.S. implementation. The extremely large range of these estimates reflected uncertainty at the time about how much would have to be spent to close or reconfigure U.S. bases in Europe and how much of those costs should be attributed to the CFE Treaty. Other major uncertainties included whether there would be an aerial reconnaissance arrangement added to the treaty and how much it would cost to prepare U.S. bases for inspections. CBO's estimates were updated in March 1991 for the use of the Senate Foreign Relations Committee in its ratification hearings, and on the basis of these estimates (which were slightly higher than the earlier ones but spanned at least as wide a range of uncertainty) the Committee estimated an average annual cost of $50 million, close to the lower end of the CBO range.[43]

In 1993 the General Accounting Office evaluated implementation through the end of the first one-year reduction period and found actual expenditures of $60.2 million in FY 1992

and $38.5 million in FY 1993.[44] GAO projected costs of $36.2 million for FY 1994. These numbers included all the money spent on destruction of U.S. equipment, which was completed by November 1993. For the inspections and escort duties alone (essentially the task of the On-Site Inspection Agency), GAO estimated $10.4 million in FY 1994. For comparison, an OSIA briefing chart prepared in January 1995 gives a figure of $8.6 million for OSIA's CFE expenses in FY 1994.[45] Since OSIA has some responsibility for data management and equipment, preparation and training, and program management (other categories used by GAO in addition to inspection and escort missions), OSIA's overall attribution of only $8.6 million to CFE suggests that actual costs for FY 1994 were well under the GAO projection, which means that the overall cost of the CFE Treaty will be even lower than the lowest pre-EIF estimate.

CFE inspections have proven to be "surprisingly inexpensive" for the United States, although not necessarily for other parties.[46] There are several reasons for this. One is the limited geographical area of the treaty (Atlantic to Urals), which means that only U.S. bases in Europe are inspected, and no inspections are conducted on U.S. territory. Second, the treaty limits annual inspection quotas to only a small fraction of objects of verification; and, third, the U.S. quota is only a fraction of the full NATO quota. The United States has saved even more money by joining with NATO allies to form joint inspection teams. Further savings have resulted from the way in which elimination inspections have been conducted. The treaty permits continuous monitoring of eliminations, but the United States and other parties have found it sufficient to inspect only at the beginning and end of the elimination process. A party planning to eliminate some tanks, for example, will notify the other parties of the number and types to be eliminated and the date and location of the eliminations. Inspectors will verify the numbers and record the factory serial numbers of the tanks, or use some other marker to identify them.[47] After the elimination is completed, the pieces of the dismantled tanks will be displayed for a second inspection that verifies the serial numbers and confirms the destruction. This eliminates the necessity for inspectors to be stationed at the destruction site for extended periods. Finally, CFE inspections are "low-tech" operations that do not require highly skilled or specialized inspectors. All U.S. inspectors are military personnel, and their salaries are not counted as inspection costs. The rationale for this is that if they were not doing CFE inspections they would be doing something else for the military. It would be more consistent, however, to count their salaries as a hidden or overhead cost of implementing the treaty.

The GAO has suggested some ways in which OSIA could save money on CFE inspections. These include not carrying out the full quota of allowed inspections and using commercial flights instead of military aircraft for transportation to ports of entry and inspection sites.[48] So far, U.S. policy has been to adhere rigorously to the letter of the treaty in carrying out inspection activities, so these savings opportunities have not been exploited. Even if they were the savings would be small, at most a few million dollars per year.

NTM have the same status in CFE as they do in INF, and each party or group of parties has the right to use them without interference for the purpose of verifying the treaty. However, it is unlikely that U.S. NTM spend much time monitoring the CFE Treaty. The threat of Russian aggression against Western Europe has declined virtually to zero, and the evidence for this is openly available. U.S. satellites certainly monitor Russian military deployments, movements, and other activities, but these have been greatly curtailed in the past several years. Nevertheless, the invasion of Chechnya and other deployments associated with pressures or reassurances for countries in Russia's "near abroad" are of great interest to

the United States, its NATO allies, and the newly independent states of Central and Eastern Europe. U.S. NTM will continue to play an important role in verifying Russian declarations and notifications concerning these activities.

Cost estimates for the Stockholm-Vienna CSBMs do not seem to exist, but they are probably much smaller than those for CFE. There are many fewer CSBM inspections, and most of the monitoring activity involves observation of military activities, attendance at conferences and seminars, and other relatively low-cost activities. No expensive equipment or specially trained personnel are required, and there is far less traveling involved than under CFE.

As in the case of INF, the benefit-cost ratio for CFE and CSBMs is clearly favorable, especially for the United States. One measure of the benefits is financial, a savings of $10-14 *billion* per year resulting from the reduction of U.S. troop deployments in Europe by 100,000-150,000.[49] It would be an exaggeration to attribute all of this to the CFE Treaty, since the relaxation of tensions in Europe and the removal of the Soviet invasion threat would have allowed the United States to reduce its deployments whether or not a formal treaty was signed. Still, even if only a fraction of these billions are attributed to the treaty, when they are added to the benefits of increased transparency and reduced threat of invasion, the benefits greatly exceed the relatively modest price of $134 million estimated by the GAO for the entire first three years of CFE.[50] The verification regime appears to be working well, and most members have been able to demonstrate their compliance to the satisfaction of all other parties.

Nuclear Testing Treaties

The Threshold Test Ban Treaty (TTBT) entered into force in December of 1990, so it also has a record, however brief, of implementation and verification. The TTBT was ratified by the United States more than 16 years after it was signed, and only after an on-site yield measuring technique called CORRTEX[51] had been added to the verification protocol. In this technique a satellite hole is drilled next to the emplacement hole for the nuclear device, and electrical signals are transmitted through a coaxial cable run down the satellite shaft. The energy released by the explosion is measured by recording the rate of expansion of the shock front as it crushes the cable. CORRTEX is claimed by its promoters to be more accurate than remote seismic methods for yields over 50 kilotons: 30 percent uncertainty for CORRTEX versus 50 percent for remote seismic measurements.[52]

Most professional seismologists argued that the improvement in accuracy was marginal at best, however, and no one ever came up with a plausible scenario for how the Soviets could exploit the extra 20 percent imprecision (assuming it existed) to gain a militarily significant advantage over the United States.[53] Indeed, seismic monitoring of Soviet testing over a period of 20 years had produced solid evidence of Soviet compliance with the TTBT as negotiated in 1974.[54] But the Reagan administration insisted that CORRTEX was necessary to make the TTBT "effectively" verifiable, and, for reasons of its own, Gorbachev's government went along. A Joint Verification Experiment was conducted at the Nevada and Semipalatinsk test sites in 1988 in which CORRTEX and seismic measurements of two explosions of known yield were compared. The results were never released by the U.S. government, but leaks to the media suggested that the comparison was inconclusive, with both seismic and CORRTEX measurements falling within expected margins of error. Because the measurement errors for both techniques are statistical, it would not be possible

to make a meaningful comparison with a single experiment anyway. Nevertheless, CORRTEX was incorporated into the TTBT, and plans were made to use it to monitor all U.S. and Soviet underground tests with yields greater than 50 kilotons.

Surprisingly, no one thought to ask at the TTBT ratification hearings how much this would cost. Nor does the Foreign Relations Committee's report on the TTBT mention implementation costs, as it has done in all its reports on other treaties since that time.[55] The only estimate available for the cost of monitoring Russian testing under the TTBT as ratified was done by the CBO in 1990.[56] CBO estimated one-time costs of $85-200 million and annual costs of $50-100 million depending on how many tests Russia conducted at yields of 50 kt or greater. The cost range quoted assumed a range of from 2 to 6 such tests per year. We have seen that the CBO estimates were too high for both INF and CFE, so some discount might be appropriate for these estimates. But it would not be a large discount. According to one evaluation of CORRTEX, its application would require the continuous presence at the test site of personnel from the monitoring country for "perhaps 10 weeks or so before as well as during each test."[57] If Russia conducted 5 or 6 high-yield tests per year, the presence of U.S. personnel would have to be essentially continuous. These would be primarily civilian personnel from the U.S. national laboratories with high levels of expertise in nuclear test measurements, and commensurably high salaries. They would need equipment for drilling the satellite hole and operating the electronics and diagnostic instruments. A large shipment of such equipment was flown to the Soviet test site in C-5A transports for the Joint Verification Experiment, and more would have been required to sustain an ongoing CORRTEX monitoring capability. Given these requirements the CBO estimates do not seem inordinately high, if indeed they were high at all.

What would have been the benefits of such an operation? If we take the claims for CORRTEX accuracy at face value, the United States would have improved its estimates of Soviet test yields by 20 percent. For a 150 kt test this means that CORRTEX would have a 90 percent probability of measuring a yield in the interval 115-195 kt, whereas the equivalent range for seismic measurements would have been 100-225 kt. Unless one wants to place a value on scientific precision for its own sake, it is very difficult to understand what would have been gained by this narrowing of the range of possible yields. Most importantly, there is nothing in the improved accuracy which would have reduced in any significant way the ability of the Soviets to cheat on the treaty. The very same range of uncertainty that plagued U.S. measurements of Soviet test yields would have made it impossible for a Soviet planner to predict how his larger than allowed test would register on American seismographs.[58] Soviet risks of discovery would therefore be far greater than American benefits from increased precision.

The CORRTEX exercise might still have been worthwhile if it had contributed to progress toward a comprehensive nuclear test ban. But the method is useless for a comprehensive ban. CORRTEX works only if the test is announced in advance and has a relatively large yield. Verification of a CTB requires the ability to detect and identify small clandestine explosions with no advance warning. For this the United States has an excellent seismic network, supplemented by a worldwide network of foreign and private seismic stations as well as other kinds of sensors. The U.S. nuclear explosion monitoring network costs between $10 and $100 million per year and provides a reliable means of detecting, and in many cases identifying, nuclear explosions down to yields of 1 kiloton or lower.[59]

The addition of CORRTEX to the TTBT is a textbook example of verification overkill, an arrangement in which the costs clearly outweighed the benefits, however the latter are

defined. It was, in the words of one critic, "a monument to the incredible lengths to which the United States is prepared to go to achieve technical solutions to unimportant or even non-existent problems."[60] There were also significant risks associated with using CORRTEX. U.S. military and nuclear weapons agencies worried about the long-term or continuous presence of Soviet inspectors at the Nevada Test Site (NTS) and the necessity for Soviet access to areas close to the actual emplacement hole of the device.[61] An effective counterintelligence effort at NTS would have added significantly to the cost of implementing the TTBT. Fortunately, none of this has been necessary because of the nuclear testing moratoria being observed by both sides. Nevertheless, OSIA remains on standby status to resume its work in support of on-site monitoring should testing resume. Maintaining this status requires about $4 million per year, approximately 8 percent of OSIA's FY 1995 budget.[62]

Nuclear Non-Proliferation Treaty

The nuclear Non-Proliferation Treaty has had twenty-five years of experience with on-site inspections under the IAEA Safeguards system, a record unapproached by any other agreement. At the beginning of the Review and Extension Conference in April 1995 there were 172 signatories to the NPT, and 102 of them had signed safeguards agreements with the IAEA.[63] At the end of 1994 the Agency was safeguarding 170 nuclear power reactors, 158 research reactors, 196 other facilities (including conversion, fabrication, enrichment, reprocessing, and storage facilities), and 334 locations outside of safeguarded facilities. The number of facilities under safeguards has increased steadily at a rate of approximately 10 per year, with South Africa, Brazil, and Argentina providing much of the increase during the early 1990s.[64] Ukraine's decision to join the NPT in December 1994 promises to add another 16 power reactors to IAEA's burden, some of them the Chernobyl-type RBMK that require more intensive inspections because of their more proliferation-prone design.[65]

The total amount of plutonium under safeguards has also continued to grow. Nearly 500 metric tons of plutonium (both in spent fuel and reprocessed) was under IAEA safeguards at the end of 1994, and the amount has been increasing at a rate of at least 50 tonnes per year in recent years.[66] IAEA does all of this on an annual safeguards budget of about $70 million, of which the United States contributes about 25 percent, or $18 million.[67] Despite the continuing increase in safeguards requirements, this budget has remained virtually constant (adjusted for inflation) since 1984.[68] As a result the annual number of person-days of inspection has fallen nearly 14 percent, from a high of 11,000 in 1990 to about 9,500 in 1994. Also down is the percent of facilities at which IAEA has been able to achieve its full safeguarding objectives. This had dropped from 83 percent in 1990 to 68 percent in 1994. This is clear evidence of a "deepening financial crisis" faced by the IAEA, a crisis which appears to have no resolution in sight.[69] IAEA points to economies of scale which allow it to supervise larger facilities and greater quantities of material for the same total cost.[70] But the declines in inspector-days and achieved goals suggest that the quality of safeguards protection is deteriorating despite what may well be significant improvements in efficiency.

On the whole, the NPT experience has been positive, and in the vast majority of cases the IAEA has been able credibly to certify that states have not diverted safeguarded nuclear materials from peaceful to military uses. The IAEA Safeguards regime has contributed significantly to making it more difficult, expensive, and politically risky for states to acquire nuclear weapons. In addition, export controls mandated by the Nuclear Suppliers Group and Zangger Committee, which require the application of safeguards to nuclear facilities

transferred even to non-parties of the NPT, have forced proliferators to rely more heavily on indigenous development than they might have without them. The result seems clearly to have been worth the effort and expense of the Safeguards program. Certainly from the point of view of the United States the benefits have amply justified an expenditure of less than $20 million per year.[71]

Despite their generally positive record, however, some disturbing developments in the past several years have begun to raise questions about the adequacy and cost-effectiveness of IAEA Safeguards as they are presently constituted. Iraq was a party to the NPT and had a safeguards agreement with the IAEA. Its nuclear facilities were routinely visited by inspectors, and it was routinely given a clean bill of health. Yet for more than ten years Iraq was constructing and operating a massive clandestine nuclear weapons program that completely escaped detection by the IAEA. Suspicions certainly existed, and intelligence efforts were expended by the United States to try to learn more about what Iraq was doing. But everyone was surprised at both the nature and extent of the Iraqi program when it was exposed in the wake of the Gulf War.[72]

North Korea provides another uncomfortable example. It signed the NPT in 1985 but took seven more years to reach a safeguards agreement with the IAEA and allow inspections to begin.[73] When IAEA analysis of plutonium samples taken in the first inspections suggested discrepancies in North Korea's declarations, North Korea refused to allow further inspections that might have resolved the discrepancies, and threatened to withdraw from the NPT. An agreement reached with the intervention of the United States has smoothed over some of the difficulties, but the crucial on-site inspections of two waste sites demanded by the IAEA have been delayed for at least five years.[74] These inspections would not incur great costs, but the benefits in clarifying the nuclear status of North Korea would be substantial.

Meanwhile, the IAEA spends the great majority of its time and budget inspecting states about which virtually no one harbors suspicions of cheating. Because safeguards monitoring is politically neutral and focused on fissile materials, most of IAEA's inspections and surveillance are concentrated where the largest amounts of plutonium and enriched uranium are produced and used.[75] This means that 60 percent of IAEA's safeguards budget is spent in Germany and Japan alone. Another 10 percent is spent in Canada, 8 to 10 percent in the nuclear-weapon states, and a "sizable share" in Belgium, Sweden, Spain, the Czech Republic, and Slovakia.[76] All together, at least 85 percent of all safeguards funds are spent watching countries that pose virtually no proliferation threat.

Most people would happily trade ten years of routine monitoring of Canada's nuclear fuel inventories for just one day at the two North Korean waste sites, but the prospects for shifting resources to states of more serious proliferation concern do not seem promising.[77] As an international organization the IAEA cannot overtly discriminate between states in the application of safeguards.[78] As far as the IAEA is concerned, the threat of diversion associated with any state is proportional to the amount of nuclear material in that state. Any formula that included political factors in weighing diversion risks would almost certainly be unacceptable to non-nuclear weapon states parties. The only hope for improving the system is the use of special inspections based on evidence supplied to the IAEA by member states. IAEA Director Hans Blix proposed such an arrangement in 1991, but little progress has been made in implementing it since then.[79]

All of this adds up to an ambiguous cost-benefit analysis for NPT safeguards. So far they have not been overly expensive, but they are now unquestionably underfunded and will require both structural changes and substantial increases in national contributions to avoid

further degradation of their effectiveness and credibility.[80] They have succeeded in monitoring the vast majority of nuclear activities and fissile materials in the world, but the things they have missed have been enough to damage their credibility with political leaders and opinion makers in many countries. Nevertheless, a substantial majority of states endorsed an indefinite extension of the NPT in April 1995, and this would appear to express an overall sense of confidence in the treaty and by implication in the safeguards regime that supports it.[81]

A Look at the Record

This concludes the list of agreements for which there is an objective record of costs and benefits. The overall evaluation is mixed. INF and CFE seem clearly worth the costs of their implementation and verification, but the TTBT clearly is not. IAEA safeguards are a much tougher call. This is not to suggest that the NPT itself is of dubious value; it obviously is not. The treaty continues to serve the interests of the vast majority of its signatories, and it creates a desirable international norm that complicates and stigmatizes attempts to evade it. Still, it is legitimate to ask whether the safeguards system that has grown up under the NPT is the most cost-effective way to achieve the treaty's objectives. Similar questions arise in the international treaties controlling chemical and biological weapons. The requirement that international treaties be politically neutral inevitably requires that large sums be spent monitoring large and industrially advanced parties. The benefits of this arrangement derive less from the deterrence or detection of violations than from the political legitimacy given to surveillance of states more likely to be tempted to acquire prohibited weapons.

There are three general observations that can be made on the basis of the experience so far. The first is that the cost of implementation is a strong function of the nature of the weapons controlled by the treaty. Solid fuel rocket engines, like those in Pershing II or SS-20 ballistic missiles, are a lot more expensive to eliminate (assuming reasonable attention to environmental protection and health and safety of workers) than tanks or artillery pieces. It is also much more expensive to prepare a strategic missile base or production facility for inspection than a tank regiment or helicopter base. The second is that on-site inspection has consistently proven to be cheaper than anticipated. A typical INF inspection costs at most a few tens of thousands of dollars, and a CFE inspection considerably less. The cost of inspection, like the cost of implementation, depends on the complexity of the target and the technical sophistication required of inspectors. A nuclear weapon or ballistic missile engineer costs more than an artillery or tank officer, so personnel costs can vary widely for different kinds of inspections. Finally, continuous monitoring is more expensive than periodic inspections, as demonstrated by the experience with INF continuous portal monitoring or IAEA surveillance safeguards. Whether the enhanced confidence produced by continuous monitoring is worth the extra cost will of course depend on the individual situation. Still, the greatly reduced emphasis on CPPM in START relative to INF (see below) suggests that the benefit-cost ratio is smaller than many people thought it would be in the 1980s.

All the other treaties to be considered here either have not yet been ratified or have entered into force too recently to permit quantitative analysis of their costs and benefits. Estimates will therefore be more tentative, but experience with the treaties that have been

implemented at least helps us to ask the right questions and to make more realistic projections of implementation and verification costs.

New and Pending Agreements

Strategic Arms Reduction Treaties

START I and II build directly on many of the precedents set by INF, but extend them over a wider scope as well as into qualitatively new areas. There are more kinds of missiles and aircraft to be monitored, more bases and facilities to be inspected, and more detailed technical information to be collected and analyzed. The result is a treaty that will be considerably more expensive to implement and verify than INF, but which also accomplishes a great deal more in the way of nuclear arms reductions and transparency. START entered into force in December 1994 and did not begin its baseline inspections until March 1995, so there were still no data on costs as this was written. However, both the United States and Russia had begun their implementation activities well in advance, and by the time of EIF the United States had already dismantled 41 ICBM silos, 15 ballistic missile submarines, and 230 strategic bombers.[82] Unfortunately, no cost figures are available for this activity.

The CBO estimated START implementation costs in 1990, and just as with INF the estimates appear to have been too high. At that time the prospects were for considerably more equipment to be eliminated, continuous portal monitoring to be conducted at four or five sites in each country instead of the one finally agreed on, and a considerably larger list of prospects for what the START treaty calls "special access visits."[83] CBO estimates for full implementation included one-time costs of $410-1,830 million and annual costs of $100-390 million.[84] Of the one-time costs, $260-1,090 million were for elimination of U.S. equipment and the rest for one-time monitoring procedures, such as baseline inspections and setting up portal monitoring stations. Two years later, when the treaty was submitted to the Senate for ratification, the Foreign Relations Committee estimated $200-1,000 million for one-time expenses and total inspection costs over the 15-year life of the treaty of $1,250-$2,050 million.[85] One other study, made at about the same time as the Foreign Relations Committee estimates, looked only at verification costs and projected a total of $760 million over the life of the treaty, significantly less than the Senate Foreign Relations Committee's estimate.[86] Comparing the three studies' amortized annual cost of implementing START I, we find: CBO (1990) $127-$512 M; SFRC (1992) $100-$200 M; and IDA (1992) $51 M (verification only). Since the treaty has been in force for less than a year as this is written, it is still too early to compare these projections with experience. Allowing for the cost saving modifications made in the treaty between 1990 and 1992, and allowing a small adjustment for the tendency to overestimate verification costs, we will use values of $200-$1000 M for one-time costs and $50-$100 M per year for recurring costs.[87]

These will be the costs to the United States of carrying out its own obligations under START. But the United States is also providing considerable aid to four former Soviet republics through the Nunn-Lugar Cooperative Threat Reduction (CTR) program. In the first three years of its existence the program received annual appropriations of $400 million, and a sizable fraction of this has been directed toward START implementation. The Defense

Department divides CTR expenditures into three categories: destruction and dismantlement, chain of custody, and demilitarization. Through December 12, 1994, the amounts obligated to the three categories were $472 million, $261 million, and $150 million, respectively.[88,89] If we take the first figure (less $55 million obligated to chemical weapons elimination) as an estimate of costs directly attributable to START, we get an average of $140 million per year contributed by the United States to START implementation in the former Soviet Union. This is about the same as the CBO estimate of the United States' own yearly implementation costs. So, if Nunn-Lugar support continues at the same level throughout the life of the treaty it would roughly double the cost to the United States of START implementation. This is probably an overestimate, since it is likely that the major CTR investments will be needed in the early stages of implementation, making the 15-year average considerably less than $140 million per year.

For this money, the United States will achieve a reduction of close to 75 percent in the former Soviet strategic nuclear weapon arsenal, from nearly 12,000 to about 3,500.[90] The United States also saves a lot of money that in the absence of a treaty would have to be spent to maintain, operate, and modernize U.S. strategic nuclear forces, although it is difficult to separate treaty-related savings from those which would have happened even without a treaty. The CBO estimates an overall saving of $46 billion in the first 5 years of the treaty and as much as $130 billion through 2010. This averages out to savings of $9 billion a year for 15 years, which is at least 20 times the cost of implementing the treaty for the same period, depending on what is assumed for the amount of Nunn-Lugar aid required.[91]

The risks associated with START are that the Russians will cheat or that Russian intelligence will benefit in unforeseen ways from on-site inspections at U.S. bases and facilities. The risks of cheating were evaluated by the Senate Intelligence Committee at the time of ratification. There were some worries about covert production of launchers and undeclared mobile missiles, and there were others about counting warheads and monitoring bombers and cruise missiles. But in each case the Joint Chiefs of Staff assessment was that the likelihood of a militarily significant violation was acceptably small.[92] Special preparations would be necessary for special access visits (see above) at U.S. facilities, but the Committee was satisfied that the Administration shared its concern for this problem and would fund appropriate security and counterintelligence measures. Presumably, these costs, which can be substantial, are already included in the CBO and SFRC estimates.

In summary, while the costs of implementing and verifying START are far from trivial, the risks of Russian cheating and espionage are manageable, and the benefits in the form of reduced Russian nuclear capability, reduced U.S. expenditures on strategic weapon modernization, and greatly increased transparency are substantial. START appears to be an excellent bargain for the United States from both the security and economic points of view.

Open Skies Treaty

The Open Skies Treaty had still not entered into force at the end of 1995. Of the 27 signatories, five—Russia, Belarus, Ukraine, Georgia, and Kyrgyzstan—had not ratified it, and there was no information available about when they intended to do so.[93] The treaty cannot enter into force until Russia and Ukraine ratify it, but the United States went ahead and spent substantial sums preparing for EIF. Enough preparation has been done to be able to make reasonably accurate projections of the future costs of implementation. Since Open Skies is not arms control, there are no weapons or bases to be eliminated or converted. The

entire cost will be for monitoring, and the unique feature of this treaty is that the monitoring need not be connected with the verification of any specific agreements. It is a pure confidence building measure intended to provide all parties with opportunities to observe anything about their neighbors that can be seen from an aircraft equipped with modern imaging sensors, albeit with some relatively tight restrictions on their capabilities. There are even mechanisms in the treaty for recovering some of the costs, since the data from any Open Skies flight can be purchased by any other state party.

The treaty was signed in Helsinki in March 1992, and even before ratification the Defense Department began allocating funds in preparation for EIF. A total of $93.7 million was appropriated in FY 1992 and 1993, mostly to be spent on modifying the three WC-135 aircraft that will be used in U.S. observation flights or to "taxi" other states' inspectors who request this service.[94] The first modified aircraft, now redesignated OC-135B, was delivered to the On-Site Inspection Agency at the end of June 1993.[95] It is equipped with four optical cameras but no infrared or radar equipment. The treaty requires these sensors to be phased in three years after EIF. Two other WC-135s are being modified to include the full suite of permitted sensors and are scheduled to be delivered to OSIA by the time they are needed. It is possible that the parties will agree to permit other sensors to be added to the aircraft, such as radiation detectors or environmental chemical sensors. Any new kinds of sensors must be agreed to by all states parties in the Open Skies Consultative Commission.

Long-term costs of Open Skies will depend on how many flights are conducted. The initial U.S. quotas allow for 31 active and 31 passive flights in the first year after EIF.[96] The limit will rise to 42 per year once the treaty achieves its steady state, but it is unlikely that the full quota will be used. From the beginning of on-site inspection it had consistently been U.S. policy to exploit all monitoring opportunities to the fullest extent of the letter of the treaty.[97] However, in the case of Open Skies the benefits of this are not obviously greater than the costs. The Senate Intelligence Committee pointed out that under present plans all resources needed to analyze Open Skies imagery will come from existing budgets and personnel and will therefore compete with other Defense Department priorities. The committee noted that "Executive branch managers recognize the distinct possibility that the costs of Open Skies exploitation will exceed the expected value of the data."[98] It seems unlikely, therefore, that the United States will conduct or receive its full quota of overflights. One Defense Department projection assumes that the United States will conduct and receive just 15 flights per year for the first three years and 22 per year thereafter, only about half of what is permitted.[99]

The cost of an Open Skies flight has been estimated to be $100-$150 thousand for operation of the aircraft alone. If Russia decides to require that American observing teams use Russian aircraft to overfly Russian territory (the "taxi option"), the cost to the United States would be roughly the same.[100] However, the quantity and quality of data obtained from Russian aircraft may be inferior, lowering the benefit-cost ratio even further. For flights by other states over the United States, most of the costs are to be borne by the inspecting party. Still, there will be an estimated $25,000 per flight in non-reimbursable costs to the United States. These include ground support and security for the foreign aircraft, support of an OSIA escort team, and monitoring the processing of the data obtained by the flight.[101,102]

If the United States were to use its full quota of passive and active flights (31 per year for the first three years and 42 per year thereafter), and average costs are $125,000 per active flight and $25,000 per passive flight, the total cost of operating the aircraft would be $4.65 million per year in the first three years, rising to $6.3 million per year thereafter. If the

projections of the Under Secretary of Defense for Acquisition and Technology are used, the corresponding numbers are $2.25 million and $3.3 million. The latter figure is about 40 percent of OSIA's projected annual budget for Open Skies in 2001 ($8.5 million).[103] Other expenses besides those directly attributable to overflights include management, data processing, maintenance, counterintelligence, assistance to foreign countries, and participation in the Open Skies Consultative Commission. Early expectations were that the Department of Defense would spend $20-40 million per year in the period FY 1994-97 to implement the treaty, but these figures probably included money spent on modifying the two remaining WC-135s.[104] A reasonable estimate of the annual implementation costs would be $10-$15 million over the long term, depending on how many flights the United States chooses to conduct.

The benefits of Open Skies for the United States go well beyond the intelligence value of the imagery itself and involve both diplomatic and national security benefits. Open Skies imagery will add only marginally to what the United States can already obtain from satellite sensors, but for states without such assets it represents an unprecedented opportunity to observe their neighbors and possible adversaries. According to Secretary of State Warren Christopher, the treaty "will contribute to mutual understanding and confidence building by giving all States Parties, regardless of size, a direct role in gathering information about military forces and activities of concern to them."[105] The benefits to the United States from this added transparency cannot be quantified, but would appear as increased stability and security in Europe and increased acceptance of the legitimacy of transparency by states which can trade greater transparency in their own military activities for access to high quality imagery on the activities of their neighbors. If Open Skies could be extended to unstable areas like the Middle East or South Asia, the benefits would be even greater. Unfortunately, the prospects for such extensions appear dim as this is written. Still, the existence of an Open Skies regime and the experience gained from it could provide added incentives for new states to join.

From the point of view of U.S. national security, the Senate Armed Services Committee was able to see a wide range of benefits. The treaty will open all areas of states parties, including areas formerly restricted for national security reasons,[106] to aerial observation, but it will establish a new framework for contacts, cooperation, and consultation among participating states and aid in the implementation of START and CFE.[107] Open Skies flights can be used to orient START and CFE inspectors at inspection sites and to help in selecting sites to be inspected. With or without additional radiation or chemical sensors they could be useful in monitoring a nuclear test ban and the Chemical and Biological Weapons Conventions. Open Skies flights could also be used to protect intelligence sources and methods in compliance disputes by providing a credible public cover for evidence first obtained by national technical means or human intelligence.

There are some risks associated with Open Skies. Allowing foreign aircraft to overfly military or industrial facilities will require precautions to ensure that sensitive information is not revealed. These precautions will add an unpredictable increment to the cost of implementation. There is also a risk that data from overflights will fall into the hands of nonparticipating states or even terrorist groups. The treaty requires that the data from all flights, while available to all states parties, "shall be used exclusively for the attainment of the purposes of this Treaty."[108] But there remains a small risk that data will be stolen by or leaked to unauthorized groups and be used for hostile or criminal purposes. Finally, there are safety concerns associated with the use of aircraft in a foreign country. An accident in which

foreign inspectors are killed or injured during an inspection could create an awkward diplomatic incident. The coordination of Open Skies flights with normal commercial and military traffic will be an important part of implementing the treaty successfully.

In summary, the Open Skies Treaty appears to be well worth its costs and risks. Its cost will be less than that of INF, START, and CFE, and much less than CWC. Its risks are manageable, and its benefits to the United States, while largely indirect, could be substantial in improving transparency and military stability in conflict-prone regions of the world. In their decisions on how many active overflights to conduct, U.S. policymakers should take more into account than the simple comparison of cost with intelligence benefit. The value of establishing the precedent of full use of active quotas and the wide distribution of the data they generate could turn out to be well worth the few million dollars per year in added costs.

Chemical Weapons Agreements

There are two major chemical weapons treaties to which the United States is party: the Bilateral Destruction and Non-production Agreement (BDA) and the international Chemical Weapons Convention. The costs to be incurred under the BDA include the destruction of national stockpiles of CW agents and weapons and the elimination or conversion to peaceful activities of the facilities and bases at which they are manufactured, stored, and deployed. They also include bilateral monitoring of the destruction and non-production of these agents in Russia and the United States for the indefinite future. Expenses under the CWC will be associated almost entirely with monitoring the chemical industries of all states parties, which will be done by an international agency, the OPCW, supported by contributions from the states parties in roughly the same proportion as their contributions to United Nations operations. The United States will therefore contribute about 25 percent of the OPCW's operating budget.

All analysts agree that both the implementation and verification of these agreements will be expensive. The initial estimate of the cost of destroying the full U.S. stockpile of chemical weapons and agents was $1.7 billion in 1985.[109] By 1994 it had passed $10 billion and was continuing to rise as technical problems and environmental, health, and safety concerns forced costly delays and modifications in the destruction process (see Figure 3).[110,111] However, it is unclear how much of these costs should be attributed to the BDA and CWC. The vast majority of U.S. chemical weapons were obsolete and in some cases dangerously unstable. They had already lost most of their military effectiveness when Congress ordered the destruction of most of the U.S. stockpile, long before either agreement was signed.[112] It would therefore be misleading to consider the full cost of eliminating them as a cost of chemical disarmament.

The avoidance of future investments in binary weapons could legitimately be counted as a benefit of the CWC, since the United States' promise not to use chemical weapons in warfare and to eliminate its entire stockpile is contingent on the Convention entering into force.[113] Just how large this saving will be is impossible to estimate, especially since U.S. spending on *defensive* CW preparations will continue at a relatively high level even after the Convention is ratified. According to Joint Chiefs Chairman General John Shalikashvili, "The Defense Department...is committed to maintaining a robust Chemical Biological Defense program...to protect U.S. forces under all possible conditions of deployment."[114]

The costs of verification are not much easier to predict than the costs of implementation. There have been trial inspections under the Wyoming MOU and in preparation for the

Figure 3: Projected cost of destroying the U.S. chemical weapons stockpile.

Source of data for 1985–1994 is *SIPRI Yearbook 1995* (Oxford: Oxford University Press, 1995), Table 10.1.
The 1995 projection was reported in the *Washington Post*, 23 January 1996.

CWC. The former have focused on weapons facilities and their results remain classified, but the latter, called National Trial Inspections, have focused on chemical industrial sites, have been carried out in many signatory states, and have been used by the Conference on Disarmament and the OPCW Preparatory Commission to design the CWC inspection regime. By mid-1993 there had been more than 200 trial inspections in many countries, and a U.S. contractor had developed a computerized database to organize the information generated by them. [115] Estimates of the cost of inspections of commercial facilities are derived from this experience, but substantial uncertainties will remain until implementation begins. The cost of an inspection will depend on its type (baseline, routine, or challenge), the size and nature of the facility being inspected, and the degree to which the inspection requires major preparations or interferes with normal production activities. OTA estimates range over a factor of 50, from a low of $10,000 to a high of $500,000 per inspection. Such a range of uncertainty makes reliable estimates of overall costs difficult, but an order of magnitude estimate suggests that the cost to U.S. chemical facilities of CWC inspections might be about $5 million per year.[116]

There will also be costs of data collection and reporting for which each facility will be responsible under the Convention. OTA does not provide quantitative estimates of these costs, but does note that efforts are being made to reduce paperwork to a minimum by having all reports done on simplified standard forms. Companies would "simply check off boxes and fill in blanks."[117] If this effort is successful, reporting costs should decrease relatively quickly as the Convention matures. Given the already substantial reporting costs that U.S. chemical facilities incur under environmental, health, safety, and export control regulations, the marginal costs of CWC reporting do not appear to be unreasonable.[118] There has been some discussion of government subsidies for industries that may be particularly hard hit by these requirements, especially smaller firms on whom the reporting responsibilities are relatively more burdensome. Help could also be provided by the industry itself, possibly in the form of a fund to equalize the burden of compliance costs. On-site inspections will also be relatively more costly for small companies. An on-site inspection insurance fund might be created to equalize this burden.

The U.S. taxpayer will also contribute to implementing the BDA and CWC. To administer the CWC, the OPCW is expected to need $150-$250 million per year, which means that the U.S. contribution will be in the range of $40 to $60 million.[119] For the BDA, the Nunn-Lugar program has already committed $55 million to help Russia design a CW destruction facility, but this is only a drop in the bucket. The Russian stockpile is at least 33 percent larger than the U.S. stockpile and will cost a comparable amount to eliminate, especially under the scrutiny of the emerging Russian environmental movement. There was a time when Soviet authorities simply could have ordered the destruction of CW agents wherever and however they chose. But those days are long gone in Russia, and from now on, "human factors—including health concerns, environmental impact, workers' compensation, insurance programs and guarantees, safety and public opinion in the local communities—will play a key role in shaping Russia's chemical demilitarization efforts."[120] These are precisely the factors that continue to drive up the cost of U.S. disposal efforts. Inspections under the BDA will also be expensive. The On-Site Inspection Agency anticipates that CW inspections will account for more than half of its projected $150 million budget in 2001.[121] If this happens, BDA inspections in Russia and the United States will cost more than inspections for all other treaties combined.

There are two available estimates of the full cost of implementing the BDA (exclusive of weapons destruction), one by the CBO in 1990 just after the agreement was signed,[122] and the other by the GAO in March 1994, when the Wyoming MOU still had not been completed.[123] CBO estimated one-time costs of $45-$220 million and average annual costs of $15-$70 million. These numbers give a range from $195 million to $920 million for the total costs over the first 10 years of the agreement, an average annual cost of $19.5-$92 million. GAO used actual expenditures between FY 1989 and FY 1993 to make its estimate. A total of $165 million was spent during this period, about 60 percent of it for research and development and 35 percent for compliance and verification activities. Projected expenditures for the next six fiscal years (1994-99) total $716 million ($120 million per year average), which includes some money for the OPCW PrepCom and Nunn-Lugar aid already committed by FY 1994. However, GAO's estimate of $20 million for the U.S. contribution to the OPCW appears too low by a factor of two or three. Implementing and verifying the BDA and CWC will therefore cost the United States at least $100 million per year, and possibly as much as $150 million per year.[124] This adds ten to fifteen percent to the $1 billion per year required to eliminate the U.S. stockpile by 2005, and still does not include any future aid to Russia's CW destruction program.

By any measure, then, eliminating chemical weapons under a verified international convention will be very expensive. Will the benefits justify the costs? There can be no definitive, much less quantitative, answer to this question. Kathleen Bailey, who opposes ratification of the CWC, explains her position succinctly: "Although these moneys would not be too much to pay for effective verification, they are excessive for marginal verification."[125] However, the Chairman of the Joint Chiefs of Staff, testifying in support of ratification, did not feel that CWC verification was "marginal." He stated that while verification is "less than perfect, the verification regime allows for intrusive inspection while protecting national security concerns...[and] reduces the probability of U.S. forces encountering chemical warfare in regional conflicts."[126] He concluded that "The Convention's advantages outweigh its shortcomings."

Jessica Eve Stern, another supporter of ratification, acknowledges the high cost of implementation, but concludes that "few opponents of the CWC are likely to consider [the elimination of Russia's stockpile] a bad bargain."[127] She recommends that verification costs be kept down by reducing the number of routine inspections and emphasizing challenge inspections.[128] This would avoid the IAEA's practice of spending most of its safeguards budget on countries of little or no proliferation concern, but it could conflict with the principle of non-discrimination fundamental to an international disarmament convention. Another approach, which also promises to be difficult to achieve, would allow individual states to nominate facilities in other states for routine inspections. The OPCW cannot inspect all chemical facilities routinely, so each year it must choose a sample using a weighted lottery system designed to distribute such inspections randomly without regard to the suspicions of other parties.[129] Stern urges reconsideration of a "national nominations" approach in which individual parties could anonymously suggest facilities in other states for "routine" inspections. Such an approach, however, was explicitly rejected by non-aligned and developing states in the CWC negotiations, and it is not clear why they would change their minds now.

Stern concludes that "despite its imperfections, the CWC is a better deterrent to chemical warfare than the status quo."[130] This conclusion avoids the more difficult question raised by Bailey: whether it is a sufficiently better deterrent to warrant the high costs. According to Stern,

> The CWC is an historic achievement in that it bans outright a particularly abhorrent class of weapons. It contains unprecedentedly intrusive verification measures. And it is the first disarmament treaty to contain provisions that explicitly call for a collective response to violations.[131]

While Bailey would probably agree that the verification measures are "unprecedentedly intrusive,"[132] she nevertheless concludes that the CWC is "only minimally verifiable" and "not...worth the cost."[133]

It would be foolish to think that a quantitative cost-benefit calculation could settle this argument. The CWC is expensive, but the costs are small compared with those required to modernize, maintain, or even eliminate existing U.S. and Russian stockpiles. So, if the major powers have indeed decided that chemical disarmament is in their interests, an international regime of verification adds only marginally to expenses they would have to incur even without such a regime. Meanwhile it adds significantly, if not absolutely, to their confidence that disarmament is really taking place, while complicating, but not necessarily preventing, clandestine violations. It also creates a regime that establishes and to some degree enforces an international norm against the manufacture and use of these weapons. It is not inconceivable that such a norm could evolve and be enforced even without a formal convention, but in the current state of international politics the institutionalization of such norms appears to have positive value.[134] States that do not join the convention or try to cheat on it risk ostracism and sanctions that would be harder to impose in the absence of a formal convention. The inefficiency of subjecting the most highly industrialized states to most of the routine inspections appears to be an unavoidable consequence of this kind of treaty. However, it does contribute to the legitimacy of the regime and adds both to the pressures and the incentives for smaller states to join it.

There are some risks associated with a CWC. Some states may simply refuse to join and will have to be deterred or prevented from acquiring chemical weapons by traditional diplomatic, economic, or military measures, or simply be allowed to have them. Experience with the nuclear NPT should allow no illusions about this risk. The Convention may create a false sense of security, causing some states to reduce traditional intelligence activities and to ignore defensive preparations that hedge against violations. Finally, the inspection regime may lead to an increase in industrial espionage and even to a higher risk of proliferation as more inspectors get to see the insides of advanced chemical plants and take this knowledge back to their home countries.

All of these risks are real, and the drafters of the Convention were clearly aware of them. The Convention forbids discriminatory export controls against states parties, but by implication permits them against non-parties (Article XI). This will allow restrictions on the export of sensitive chemicals to states that do not join the Convention and, along with Article I, will allow sanctions against a State Party that exports prohibited chemicals or technologies to non-State Parties. However, the Convention explicitly allows the development of CW defenses, and even permits the retention of small stocks of CW agents to be used in defensive R&D. It also requires that defensive measures be fully accessible to all states parties (Article X), which suggests that exports of some materials and technologies would be legitimate between states parties. Such exports pose a risk of enhancing the very activities the Convention is supposed to inhibit. This tension between the need to prevent proliferation and the desire of less developed states for aid in developing their high technology industrial base is a persistent problem in nonproliferation or disarmament regimes.

The risk of loss of proprietary information has been reduced by the use of "managed access" restrictions for challenge inspections.[135] The tension in this situation is quite obvious: to do their jobs well inspectors should be highly skilled, knowledgeable, observant, and persistent. At the same time it is precisely these qualities that could enable them to discover information that would compromise vital industrial secrets. The chemical industry is worried about this aspect of the Convention, and programs have been instituted by ACDA, OSIA, and the Department of Commerce to teach operators of U.S. chemical plants how to prepare for inspections and guard against loss of proprietary information.

One interesting example of the cost of risk reduction is the requirement to design a small, portable gas chromatograph mass spectrometer (GCMS) that can detect prohibited agents but *cannot* detect most legitimate agents. Another measure under study by the Provisional Technical Secretariat that is likely to find its way into the CWC inspection protocols is a requirement that no GCMS data acquired during a facility inspection be permitted to leave the site. All analysis must be done on-site and all evidence and data destroyed or left behind before the instrument is taken away. Most of the research effort now being devoted to GCMS development is focused on these risk-reducing features, which will add substantially to its cost.[136]

In conclusion, the CWC is a tough call. In order to support its ratification one must believe that the benefits of establishing an international regime banning chemical weapons are worth an annual cost to the United States of $100-$150 million, as well as both political and commercial risks. The CWC will improve transparency and reduce some military risks, but it will not make the world safe from chemical weapons. One need go no further than the sarin attack on the Tokyo subway in March 1995 to find evidence for this unhappy reality. There is nothing in an international convention that can prevent such incidents, although a regime that rigorously monitored the production and transfer of key precursor chemicals might make these somewhat more difficult.

Despite the acknowledged imperfections of the CWC, there are clear positive benefits associated with increased transparency and widely accepted norms of behavior, enforced by systematic inspections and continued national vigilance. There would also be major political costs associated with a U.S. decision to back away from a convention it has done so much for so long to try to achieve.

Biological Weapons Agreements

There are currently no implementation or verification costs associated with the BWC, aside from the minor costs of reporting U.S. activities under the 1986 and 1991 confidence building measures. One could try to attach a cost to the UNSCOM efforts to find and destroy Iraq's BW capabilities, but this is a small and in many ways unique operation that would provide little insight into the costs of an international BW verification regime. Reciprocal inspections ("visits" in official U.S. jargon) have taken place between the United States, United Kingdom, and Russia, but data on them are inaccessible because of secrecy. One positive aspect of biological weapons is that they are a lot easier and cheaper to destroy than chemical weapons or nuclear materials. The quantities involved are typically several orders of magnitude smaller than for chemical weapons, and since most BW agents are living organisms they die out relatively quickly unless sophisticated measures are taken to preserve them. Even then they can only survive for several months.[137] One exception is anthrax, which forms spores that can live in a dormant state for decades. Anthrax stockpiles would have to

be destroyed by incineration or by some kind of chemical treatment, but the cost would still be much lower than for CW disposal.

If international verification were added to the BWC, costs could increase dramatically. Even such common commercial facilities as breweries or yogurt plants could be used to produce BW agents. A verification regime that could subject all such facilities to even a small risk of on-site inspection would be even more expensive than the CWC, and would still not be particularly reassuring to people concerned about BW proliferation. An Ad Hoc Group of Experts has been at work since January 1995 on a possible verification regime for the BWC.[138] Its instructions explicitly require that the "financial implications" of proposed verification measures be considered along with their technical effectiveness.[139] The financial criterion will be one of the most important in the evaluation by the United States of whatever proposals are made by the Expert Group. In view of its already heavy financial commitment to arms control implementation and its often-articulated skepticism of the possibility of meaningful verification of the BWC, the United States will be a hard sell on an international BW verification regime.

Non-Proliferation Export Controls

The United States fulfills its obligations to its partners in the Nuclear Suppliers Group, Zangger Commission, Australia Group, and Missile Technology Control Regime by maintaining control over the export of materials, devices, and technologies to states of proliferation concern. Unfortunately, the process is diffuse and difficult to monitor, and it is almost impossible even to make order of magnitude estimates—that is, to come within a factor of ten of the right answer. Even more fundamentally, the "right answer" is highly dependent on starting assumptions about the scope, effectiveness, and monetary value of export controls. These assumptions vary greatly from one study to another, and there appears to be no consensus in the analytical community on the costs to government, industry, and the U.S. economy as a whole of export controls, not to mention the even less quantifiable benefits and risks. The best we can do in a short assessment, therefore, is to point out some of the essential dimensions of the problem and try to get a qualitative sense of the relationship between costs and risks on one side and benefits on the other.

Costs can be broken down into those paid by government and those incurred by private firms.[140] The primary cost to government comes from supporting the labyrinthine bureaucracy devoted to evaluating applications for export licenses. License applications fall into two major categories: munitions and dual-use. The former begin their journey in the Office of Defense Trade Controls in the State Department's Bureau of Political-Military Affairs. The latter start out at the Bureau of Export Administration in the Department of Commerce.[141] The number of munitions list applications has remain relatively constant at about 50,000 per year, but the number of dual-use applications decreased substantially when the end of the Cold War permitted relaxation of many restrictions on computers, which have traditionally dominated the lists of controlled technologies. Dual-use license applications fell from almost 100,000 in 1988 to just under 25,000 in 1992.[142] The curve seems to have leveled off in 1993, when the Department of Commerce processed 23,830 applications,[143] but the further relaxation of controls on high-performance computers and the prospective

revision of former CoCom controls under the so-called "New Forum" promise to reduce the number even further.[144]

One way to estimate the cost of this process is to assume an average cost per license application and multiply by the number of such applications. However, there are many problems with this approach. License applications differ widely in their complexity and in the number of agencies that must review them. Some applications cover multiples of a single item, others cover several types of article, each with a different export control classification, and some include items that do not even require a license if shipped separately from controlled items.[145] Some licenses can be approved directly by the Department of Commerce, but others must circulate to Energy, State, Defense, Defense Intelligence Agency (DIA), CIA, or all of the above. Some that cause serious conflicts among different agencies must be kicked upstairs to interagency groups with the authority to resolve the differences. Taking all of this into account, one might guess that the average cost to the government to process a license application is between $100 and $1,000, including person-hours, paperwork, overhead, and other costs.[146] With 75,000 applications in a year, this comes to $7.5–$75 million per year to administer the program. Only a fraction of these applications are related to nuclear, chemical, or biological weapons, but there are no reliable estimates of what this fraction might be.[147] Therefore, our best estimate would be that U.S. export controls probably cost the taxpayer a few tens of millions of dollars per year.

A few hundred dollars per application does not seem excessive, but the calculation looks very different if one calculates the cost per *denied* application. The system's purpose is, after all, not to put a stamp of approval on 90 out of every hundred applications, but to identify and intercept the one out of a hundred that poses a genuine threat to U.S. security.[148] Using this measure of effectiveness we would estimate that each denied application costs the government between $10,000 and $100,000. To the extent that the process is successful in catching and stopping exports that would pose genuine security threats or foreign policy setbacks if allowed to proceed, these numbers still do not appear unreasonable. However, at least two major studies have questioned the effectiveness of the process, and one of the major criticisms is that responsible agencies do not have the personnel or resources to devote enough attention to the problem.[149] This suggests that however much the government is spending on export control administration, it may need to spend more to do the job properly.[150]

The magnitude of costs to industry is generally believed to be much higher than the costs to government. The costs come primarily from lost sales, but also from having to devote personnel and resources to fulfilling licensing and compliance requirements. One survey of 42 large exporting firms found that they averaged 24 employees and spent an average of $1.3 million per year on licensing and compliance in 1992.[151] That is nearly $30 million for just those 42 companies. Estimates of lost sales are notoriously unreliable, but they range from the low billions per year to the several tens of billions. The losses are often expressed in terms of lost jobs for American workers. The Council on Competitiveness assumed that 19,100 domestic jobs were lost for every billion dollars of exports foregone. In eight case studies of the effect of export controls on items ranging from tractors to supercomputers, the Council concluded that "Over $6 billion in annual U.S. exports and 120,000 domestic jobs were affected to some extent by these decisions."[152,153] Another study, by J. David Richardson of the Institute for International Economics, estimated that "National security export controls on dual-use goods almost surely cost $20 billion of U.S. exports annually prior to recently proposed liberalization, and may have cost as much as $30 billion."[154] According to

Richardson, "losses fell disproportionately on small firms," and "over half of the losses fell on exporters of machinery, instruments, electronics, transportation equipment, and other high technology goods." Five states—California, Texas, Washington, Michigan, and New York—accounted for more than half of the losses.

Such estimates are highly uncertain, and there is probably a tendency for groups interested in high-technology exports to exaggerate the impact of controls. It should also be kept in mind that only a fraction of export licenses are related to nonproliferation objectives. For example, one survey of 344 denied applications attributed 118 to nonproliferation reasons, suggesting a fraction of about one-third.[155] But more than two-thirds of those applications involved computers, on which controls were relaxed the following year. Even including the computers the total financial impact of the 344 denied licenses was only $0.2 billion, less than 1 percent of the total dollar value of all applications. Another study, by the Office of Technology Assessment, found that in 1992 the total dollar volume of advanced technology exports was $107 billion, and that only 22.3 percent of these required license applications. Of these, 16.6 percent were approved, 4.9 percent were returned without action, and only 0.8 percent were denied.[156] Assuming a direct proportion between numbers of licenses and economic value, the lost sales amounted to $0.85 billion. These estimates ignore the licenses returned without action. They probably represent some lost revenue, but it is difficult to know how to estimate it. One more case study by OTA of machine tool exports found "no concrete evidence...that export controls in general, let alone the small fraction represented by nonproliferation controls, have in fact significantly harmed the industry."[157]

The difference between the Richardson and OTA estimates is more than an order of magnitude. We will make no attempt to decide which is correct, but will conclude simply that the economic loss to U.S. industry as a result of nonproliferation-related export controls is probably in the range of $1–$10 billion per year. The only other treaty we have examined with significant costs to the private sector is the Chemical Weapons Convention. Even our low-end estimate suggests that export controls cost industry many times what the CWC will cost. But export control costs are spread over a larger number of firms and plants, and they are likely to continue to decrease as controls are further relaxed in coming years.

Whatever the costs of controls, they are at least in principle calculable. The same cannot be said for the benefits. Export controls have many purposes, but the one we are interested in here is the prevention, or at least significant inhibition, of proliferation of weapons of mass destruction. The true measure of benefits, therefore, is how well the existing controls fulfill that objective. The most favorable situation for export controls occurs when the sensitive material or technology is scarce and/or highly sophisticated, difficult for the proliferant to produce indigenously, and obtainable from only a small number of suppliers. In addition, the more specialized the item is to a particular weapon-related task, the easier it is to identify as a proliferation threat, and the more effective controls on it are likely to be.

These conditions are best satisfied for major nuclear and ballistic missile technologies, and much less applicable to chemical and biological weapon technologies. The key to nuclear weapons is fissile materials, and the technologies to produce these, i.e., uranium enrichment and plutonium reprocessing plants, are expensive, technically sophisticated, and produced by a relatively small number of potential suppliers. Key elements of ballistic missiles, such as precision guidance systems, solid fuel rocket motors, and advanced reentry vehicles, also require many years of research and development to perfect, and are produced by relatively few technically advanced countries. On the other hand, chemical warfare agents

like mustard or chlorine gas or nerve agents like sarin are relatively easy for most countries to produce for themselves. Easiest of all are biological agents like anthrax, or toxins like botulinum or ricin. The raw materials and equipment needed to make these agents are used in virtually all countries for food processing or pharmaceutical production.[158] Another technology that has become relatively immune to effective export controls is unmanned air vehicles or cruise missiles. The growing availability of small, efficient turbofan engines, and simple inertial guidance systems that can use Global Positioning System (GPS) satellite signals to correct drift, seriously weakens attempts to inhibit cruise missile proliferation with export controls.[159]

This spectrum suggests that export controls on nuclear and ballistic missile systems are likely to produce maximum benefits, while those on CW, BW, or cruise missile technologies may not be worth the cost. However, even this distinction is unclear. At the nuclear end of the spectrum are some prominent examples of the failure of export controls to prevent proliferation. South Africa developed its uranium enrichment technique indigenously, with only moderate foreign assistance,[160] and Iraq and North Korea were able to use "bronze medal" technologies, long considered obsolete and inefficient in the industrialized countries, to produce fissile materials for their nuclear weapon programs.[161] Still, it is clear that the nuclear weapon programs of all three states would have made faster progress and achieved greater success if they had been able to obtain key components or materials from foreign sources. At the biological end of the spectrum there are some sophisticated technologies, such as microencapsulation and specialized growth media, that would add greatly to the military effectiveness of a proliferant BW program and on which export controls might still be relatively effective.[162] Close controls on "stealth" technologies are also worth maintaining to prevent widespread development of radar-evading cruise missile or pilotless aircraft.

Unfortunately, it is not possible to go much further toward a genuine cost-benefit analysis than these qualitative remarks. The data on export license applications do not permit identification of those related to weapons of mass destruction, and even if they did there would still be far too many unknowns to permit an assessment of the effectiveness of particular controls. For example, many export licenses are granted contingent on certain conditions being met by the exporter. An example might be restrictions on resale of the item to a third country. There are supposed to be both pre-license and post-shipment checks to verify that the conditions are met, but resources for conducting such checks are limited and only a small number are actually conducted, mostly on a random basis.[163] Even the relatively sophisticated Nuclear Materials Management and Safeguards System operated by the Department of Energy to track nuclear materials exported to foreign countries has been found to have serious inadequacies. According to the General Accounting Office, "The system does not track exported U.S. nuclear materials that are moved from facility to facility within countries, nor does it show the current status of the nuclear materials (e.g., irradiated, unirradiated, fabricated, burned up, or reprocessed)."[164]

In conclusion, there are obvious benefits from enforcing export controls on sensitive technologies. But as the OTA points out, "the benefits, while potentially great, are essentially intangible and long-term, and accrue to the nation as a whole." The costs, on the other hand, "are more palpable and immediate, and are unevenly imposed across a few firms and industries."[165] The cost-benefit calculation is therefore not only economic, but political. Those who pay the costs are not those who benefit. This is certainly not a new phenomenon; it is a common feature of any situation in which private interests conflict with the public

welfare. Unfortunately, that observation does not make the problem any easier to solve. It does suggest, however, that the problem is likely to be around for a long time to come.

Summary

The cost estimates made in this paper are summarized in Table 2. It must be emphasized one more time how tentative and approximate many of these estimates are, especially those in the lower portion of the table. Still, while the results for individual treaties have uncertainties of perhaps 50 percent, the overall totals probably give a reasonable picture of the costs of implementing and verifying agreements already in force or on the verge of ratification. Comparison with the original Congressional Budget Office study shows that our numbers tend to be either slightly below CBO's or at the low end of CBO's range of uncertainty.[166] This reflects the observation made at the beginning of the paper that there was a tendency to overestimate costs in the years before much experience with implementation had accumulated. Another study, by Michael Renner of the Worldwatch Institute, has attempted to analyze the costs of arms control and disarmament to the United States.[167] Renner uses different categories and includes other activities besides formal arms control agreements, such as base closings and economic conversion. But where comparisons can be made his estimates appear to be more or less compatible with ours.

A few general comments can be made on the basis of Table 2. First, it is striking how high the costs of chemical disarmament are compared to all other treaties. If CW destruction were included in the total it would completely dominate all other estimates combined. Similarly, in the annual costs column the loss of sales by U.S. high technology industry would dominate all other costs if the high-end estimate were used. Both of these costs are real, although both are highly uncertain. Either or both might be reduced by new technology or administrative reform, but neither can be avoided. Old chemical weapons must be eliminated, if only because they pose a continuing danger of gradual or catastrophic release of hazardous agents to the environment. Export controls may be reformed, but because they fall most heavily on industries that sell sophisticated and expensive technologies, they will always represent a disproportionately high cost. Not even their most severe critics have suggested that they can be completely eliminated as long as the threat of nuclear and ballistic missile proliferation exists.[168]

Secondly, it is remarkable that Nunn-Lugar aid to the former Soviet republics accounts for nearly half of the entire annual expenditure on arms control implementation. In effect, the United States is spending just about as much to disarm the former Soviet Union as it is to disarm itself. But while the costs are approximately the same, the benefits are very different. Nunn-Lugar funds provide benefits in the form of enhanced U.S. security and increased Russian transparency. This represents a recognition by the Congress and the Clinton and Bush administrations that the Cooperative Threat Reduction program is probably the most cost-effective investment the United States can make in its national security at this point in history. The real question about CTR is not whether the United States can afford it, but rather whether the Russians will continue to cooperate with it and whether the Republican Congress and a possible Republican president will continue to support it.

One final observation must be made. The overall cost of implementing all of the agreements considered in this study is just about one billion dollars per year, even including

Table 2: Summary of U.S. Arms Control and Nonproliferation Costs (millions of dollars)

Treaty	One-time costs	Annual costs
R&D	–	220[1]
INF	128	20
CFE	27	35
CSBM	small	small
TTBT[2]	(85-200)	(50-100)
NPT/IAEA	–	20
Subtotal[3]	250	75
START	200-1,000	50-100
Nunn-Lugar	–	400
Open Skies	100	3-5
BDA/CWC	(10,000)[4]	100-150
BWC	small	small
Export controls	–	(50-5,000)[5]
Subtotal	300-1,100[6]	650-750[7]
Total[8]	550-1,350	945-1,045

[1] Does not include R&D on NTM or other secret intelligence technologies.

[2] Russian and U.S. nuclear testing is currently suspended, so there are no implementation costs for the TTBT except for a small standby appropriation for the OSIA.

[3] TTBT costs not included in subtotal.

[4] The $10 billion estimate for chemical weapons elimination is tentative, and no attempt has been made to estimate the fraction of it to be attributed to the agreements.

[5] The smaller figure is a rough estimate of governmental administrative costs, and the larger figure is based on highly uncertain estimates of lost sales to U.S. industry attributable to nonproliferation export controls.

[6] Chemical weapons elimination costs not included in subtotal.

[7] Subtotal includes only U.S. administrative costs for export controls.

[8] Totals do not include costs of NTM or HUMINT.

a generous subsidy for implementation in the former Soviet Union.[169] This means that total arms control implementation costs would have to nearly triple before they would equal just one percent of the U.S. military budget of $260 billion. The international norms and military transparency created by the interaction of these regimes show promise of creating a fundamentally different environment for international relations. But, even if one believes that arms control contributes only marginally and temporarily to national security, it is difficult to argue that the treaties negotiated so far are not worth the expense of implementing them. So far, at least, arms control taken as a whole appears to be an excellent bargain.

Impacts on Future Agreements

This analysis has focused on agreements already signed or in force. These are treaties whose essential provisions are known and for which reasonably accurate estimates of costs can be made. But there are more agreements in the pipeline: a comprehensive test ban treaty (CTBT), a fissile material cutoff treaty (FMCT), and a possible verification regime to be added to the Biological and Toxin Weapons Convention (BWC). No attempt will be made here to make detailed estimates of the costs of implementing and verifying these agreements. All three are in too early a stage of evolution, at least as far as publicly available information is concerned, to permit such estimates.

One thing can be said, however. All three have the potential to be expensive, and costs are certain to be a major factor in determining their final forms. The days of "cost-is-no-object" arms control are over. As negotiations proceed on the CTB and FMC in the Conference on Disarmament and on BWC verification in the Ad Hoc Group of Experts, the cost of each monitoring, reporting, or inspection requirement is going to have to be justified on the basis of its positive contribution to the security of all parties.

From the point of view of the United States, all three of these treaties could incur significant costs. Preliminary estimates of CTB monitoring costs are $100 million for startup and $60-80 million per year for the indefinite future.[170] The United States will most likely contribute its usual 25 percent, although it may get some credit for contributing components of its national monitoring system to the international system. This money will create and operate a worldwide network of four kinds of monitoring sensors: seismic, infrasound, hydroacoustic, and radionuclide; all connected by electronic communication links to one or more international data centers where the data from hundreds of sensors will be collected and processed for distribution to the states parties. There are also likely to be on-site inspection provisions, although the costs of such inspections will have a major impact on their frequency and intrusiveness. Finally, there will be provisions for data exchanges, notifications, and possibly invitations for observers at large chemical explosions connected with mining or construction activity.

If all of this were to cost the United States just $25 million up front and $15-20 million per year, it would not add greatly to the sum of other arms control obligations the United States has already accepted. And the benefits would be substantial. The development of new weapon designs by the nuclear weapon states would be made far more difficult if not impossible, and the development of sophisticated thermonuclear weapons by threshold and non-nuclear weapon states effectively prevented. A CTBT would also fulfill the political commitment made by the nuclear weapon states at the 1995 NPT Review and Extension

Conference and realize a hope that can be traced all the way back to 1949, when U.S. scientists proposed that a test ban be negotiated with the Soviet Union to head off development of the hydrogen bomb.[171] The realization of this hope by putting an end to all nuclear explosions, something the non-nuclear states have been demanding almost as long as nuclear weapons have existed, would be well worth several times the projected costs of the international monitoring effort.

However, this is only a small fraction of the full cost of a test ban to the United States, which has determined that it must make provisions to maintain the safety and reliability of its stockpile of nuclear weapons for the indefinite future in the absence of nuclear testing. The Department of Energy has proposed, and President Clinton has approved, a Stockpile Stewardship and Management Program designed to "ensur(e) the safety, security, and reliability of the U.S. nuclear weapon stockpile...for the foreseeable future."[172] The costs of this program dwarf the cost of monitoring a test ban. It includes the construction of several expensive new facilities for simulating various aspects of fission and fusion explosions, for producing tritium (an isotope of hydrogen used to enhance the efficiency of H-bomb triggers), and for maintaining a cadre of weapon scientists capable of dealing with problems of aging or deterioration that may appear in the stockpile. The program is also mandated to preserve the capability to resume testing at any time in the future when the President may order it.

DOE estimates that the Stewardship Program will cost $3.6-4.0 billion per year to operate, at least 50 times the cost of monitoring a CTBT.[173,174] It is not clear what fraction of this amount to attribute to the CTBT, since many of the stewardship and maintenance activities would continue even if testing were to continue. But some facilities, such as the National Ignition Facility (NIF), are justified almost entirely on the basis of their ability to compensate for the absence of an active testing program.[175,176] The NIF alone will cost at least $1.1 billion to build and approximately $115 million per year to operate.[177] This facility by itself will therefore cost more than any savings the United States might make by not conducting the five or so tests per year it claims it would need to maintain the stockpile in the absence of a test ban.

One is forced to the conclusion that in purely economic terms a test ban is no bargain. The benefits must be counted in the less tangible realm of a CTB's contribution to nuclear nonproliferation, especially its political role in maintaining the legitimacy of the NPT in the eyes of the non-nuclear weapon states (NNWS). Unfortunately, even this contribution is somewhat diluted by perceptions among many NNWS that the U.S. Stockpile Stewardship Program, along with similar programs now being created by France and other nuclear weapon states (NWS), are really nuclear testing by other means. References by DOE and others to the "enduring nuclear stockpile," which must be maintained for the "foreseeable future,"[178] do not inspire confidence that the NWS are serious about another important commitment they made at the NPT conference—the commitment to eventual nuclear disarmament. If the credibility of this commitment is undermined, the benefits of a CTBT may be considerably less than hoped for, and the costs may begin to appear disproportionately large.

A fissile material cutoff is even further from realization than a CTBT, and it is still much too early to estimate costs. Under an FMC, all states would declare their stocks of highly enriched uranium and civil and excess military plutonium. Fissile materials in weapons and kept in military reserve by the NWS (and possibly by the so-called "Threshold States"—India, Pakistan, and Israel) would be exempt from such declarations, although excess

materials created by reductions in nuclear stockpiles under future agreements could be added to the international safeguards system as they became redundant.[179] If an FMCT can be negotiated it will most likely be administered by the International Atomic Energy Agency, and the inspection and surveillance techniques would be modeled as closely as possible on existing IAEA Safeguards. These are already in operation at more than 500 facilities around the world (see above), and have a long history of successful application. They may be supplemented by some of the measures under study in the IAEA's "Programme 93+2," including, inter alia, increased transparency measures, environmental sampling, and "analysis of additional sources of information," which is generally assumed to mean reliance on the national intelligence sources of individual states parties.[180]

One rough estimate of the cost of an FMCT suggests that current IAEA Safeguards operations would have to be doubled or tripled to provide comprehensive coverage, including civil plutonium. Costs could be reduced by safeguarding only enrichment and reprocessing plants, but this would leave the vast majority of plutonium outside the treaty's jurisdiction. The FMCT poses a problem similar to that of the NPT and CWC: the most important targets of a cutoff are the three Threshold States, and probably a handful of potential proliferants. In order to obtain safeguards coverage of the small number of sensitive facilities in these states, the rest of the major producers of fissile materials would have to accept it on their much larger and more numerous facilities. This would create another situation in which the vast majority of the monitoring effort would be expended on states that pose no meaningful proliferation threat. We have already noted the increasing sensitivity to this problem in existing treaties, and it seems likely that the industrialized countries will think long and hard before they permit the creation of another regime with this feature.

The only thing to be said about verification of a BWC here is to reiterate the conclusion made earlier that worldwide monitoring of possible BW facilities would be extremely expensive, highly intrusive, and inevitably imperfect. An Ad Hoc Group of Experts is preparing a report to be delivered to the 1996 meeting of the BWC Conference of States Parties. Until that report is presented, there is no way to make even an approximate estimate of the cost of verifying the BWC. One hopes that the Group will be able to create a transparency and inspection regime that will strike a reasonable balance among costs, risks, and benefits. But one also knows how difficult this will be to accomplish and what a long road it will have to travel before it can be realized.

Conclusion

In ACDA's 1994 Report to Congress, Director John Holum begins his overview with the observation,

> Arms control is threat control. It is national defense by cheaper means. If viewed as a 'weapon' for removing threats, arms control is staggeringly cost effective.[181]

The director illustrates his point with the START Treaty, and most would agree that this example comes closest to deserving the hyperbolic adverb "staggeringly." The director does not mention the Threshold Test Ban Treaty, which could just as well be labeled "staggeringly cost-*ineffective*," or the Chemical Weapons Convention, which, while probably a positive achievement on balance, falls well short of deserving any hyperbole at all. In short, it is not

particularly illuminating, and could even be misleading, to make generic judgments about the overall costs and benefits of arms control agreements.

There can be no question that cost-effectiveness has become a key criterion in arms control, but as this study has demonstrated, this criterion is going to be difficult to apply in practice. Not only are financial costs difficult to estimate in advance, but issues of benefit and risk will never be quantifiable in any meaningful or useful way. The criterion continues to beg the question of what "effective" actually means in each new context. This question was difficult enough to answer when military and political risk were the major factors in assessing it. When cost is added to the equation, the proper balance becomes even more difficult to find.

Judgments of cost-effectiveness will inevitably be political and subjective and will have to be made in the negotiating process. This suggests that an integral part of the backstopping of any U.S. delegation should be a capability to estimate the costs of verification and implementation proposals as they arise in negotiations. Just as military and intelligence representatives have traditionally advised delegations on the security risks and benefits of particular provisions, economic and technical advisors should be available to do rapid estimates of costs. The more timely and credible these estimates are, the more useful they will be in negotiations—not only in informing U.S. positions, but in providing solid arguments to challenge those made by states that use exaggerated cost projections to oppose provisions they do not like for other reasons. Credible cost projections will also be crucial in gaining support for ratification of treaties in the Senate, where traditional opponents of arms control are beginning to discover the opportunities for delay and obstruction inherent in raising questions about costs.

In conclusion it is worth repeating the ACDA Inspector General's warning quoted in the introduction to this study. "Budgetary constraints... require persuasive evidence that expenditures to implement current and proposed international understandings serve priority U.S. interests." It is clear that the Clinton administration finds the evidence persuasive, as have all previous administrations, both Democrat and Republican, dating back to Eisenhower. It is also clear from the estimates summarized in this study that the total cost of implementing and verifying all of the treaties so far in force and under negotiation is still only a tiny fraction of the money spent by states on their military forces. In order to prevent erosion of treaties in force and to allow further progress in arms control, especially nuclear arms control, the case will have to be made that expenditures on arms control can still increase security far more cost-effectively than equivalent or even much greater expenditures on military hardware. Senators Nunn and Lugar made that case well in selling the Cooperative Threat Reduction Program, and ACDA Director Holum makes it well when he points out that Russian ICBM silos, which were once targeted by U.S. nuclear warheads, are now being destroyed under START, "with far higher confidence, without fear of bloody retaliation, and at cost three orders of magnitude lower."[182]

The case for international verification of the Chemical and Biological weapons conventions is not quite so easy to make, as we have seen. It must be made by showing that these regimes will significantly increase the difficulty for states to acquire and use chemical and biological weapons, and that the institutions and norms the conventions establish will be capable of isolating, and stigmatizing, violators and non-parties to a degree that makes it highly desirable for all states to be members in good standing. Such a regime already exists in the NPT and the IAEA Safeguards that support it. One of the most important steps the world community could take to demonstrate its belief in the cost-effectiveness of such regimes

would be to increase the IAEA Safeguards budget, which has been level for more than a decade despite rapidly increasing demands for coverage.

The most important conclusion of this study is that while arms control is not cheap, neither is it all that expensive. Costs have risen rapidly because so many treaties have entered into force in such a short time, and the great majority of costs of each treaty must be paid during the early implementation years. Awareness of cost has risen even faster than the costs themselves, largely because the old perceptions of threat that made rigorous verification seem so important have been replaced by a more diffuse perception of threat and a concern with weapons far less easy to identify than the ones that dominated arms control negotiations during the Cold War. These new concerns will not be easy to assuage, but an international regime that prohibited weapons of mass destruction, placed stronger limits on the deployment and transfer of advanced conventional weapons, and created effective institutions to monitor the entire regime would go a long way toward achieving that goal. The benefits of such a regime would be worth many times the amount so far spent on arms control.

List of Acronyms

ABM	Anti-Ballistic Missile Treaty
ACDA	Arms Control and Disarmament Agency
ARPA	Advanced Research Projects Agency
BDA	Bilateral (Chemical Weapon) Destruction Agreement
BWC (VEREX)	Biological Weapons Convention (Verification Expert Group)
CBO	Congressional Budget Office
CFE	Conventional Forces in Europe Treaty
CIO	Central Imagery Office
CPPM	Continuous perimeter-portal monitoring
CSBM	Confidence and Security Building Measures
CTBT	Comprehensive Test-Ban Treaty
CTR	Cooperative Threat Reduction
CWC	Chemical Weapons Convention
DNA	Defense Nuclear Agency
EIF	Entry into force
FMCT	Fissile material cutoff treaty
GAO	General Accounting Office
GCMS	Gas chromatograph mass spectrometer
GLCM	Ground-launched cruise missile
GPS	Global Positioning System
IAEA	International Atomic Energy Agency
IC	Intelligence Community
IDA	Institute for Defense Analysis
INF	Intermediate Nuclear Forces Treaty
IRBM	Intermediate Range Ballistic Missile
LTBT	Limited Test Ban Treaty
MASINT	Measurement and signatures intelligence
MOU	Wyoming Memorandum of Understanding
NIF	National Ignition Facility
NNWS	Non-Nuclear Weapons States
NPT	nuclear Non-Proliferation Treaty
NRO	National Reconnaissance Office
NSA	National Security Agency
NTM	National Technical Means
NTS	Nevada Test Site
NWS	Nuclear Weapon States
OPCW	Organization for the Prevention of Chemical Weapons
OSI	On-site inspection
OSIA	On-site Inspection Agency
OTA	Office of Technology Assessment
PNET	Peaceful Nuclear Explosions Treaty
START	Strategic Arms Reduction Treaty
TTBT	Threshold Test Ban Treaty

Notes and References

[1] Allan S. Krass, *The Challenge of Leadership: The United States and Arms Control*, in preparation.
[2] Jeffrey H. Grotte and Julia L. Klare, *Balancing Cost and Effectiveness in Arms Control Monitoring* (Alexandria, VA: Institute for Defense Analysis, September 1992), III-23.
[3] The CTBT raises questions of cost-effectiveness of verification quite clearly. We will return to it at the conclusion of the paper.
[4] Patricia M. Lewis, "Organizing for Effective Implementation," SIPRI Research Report No. 8, in *Implementing the Comprehensive Test Ban: New Aspects of Definition, Organization and Verification*, ed. Eric Arnett (Oxford: Oxford University Press, 1994), 86-102.
[5] See the Summary of VEREX Evaluations of Potential Verification Measures, BWC/CONF.III/ VEREX/8, Attachment to the Summary Report, reprinted in *The Arms Control Reporter*, 1994, 701.D.5-15.
[6] IAEA, *Activities of the International Atomic Energy Agency Relevant to Article III of the Treaty on the Non-Proliferation of Nuclear Weapons*, International Atomic Energy Agency, February 1, 1995.
[7] GAO, *Former Warsaw Pact Nations' Treaty Compliance and U.S. Cost Control*, U.S. General Accounting Office, December 1993, 28-29.
[8] GAO, *Intermediate-Range Nuclear Forces Treaty Implementation*, U.S. General Accounting Office, September 1991, 56-57.
[9] ACDA, *Report of Inspection*, U.S. Arms Control and Disarmament Agency, Office of Inspector General, August 1995, 38.
[10] One example is Belarus, which is not only saddled with major CFE elimination obligations because of all the Soviet equipment left on its territory, but is also faced with the massive expense of cleaning up after the Chernobyl accident and caring for its victims. The latter activity alone is reported to require 12 percent of the Belarussian national budget (*Baltimore Sun*, September 29, 1995).
[11] OTA, *Verification Technologies: Managing Research and Development for Cooperative Arms Control Monitoring Measures*, U.S. Congress, Office of Technology Assessment, May 1991, 8.
[12] Figure 1 is adapted from one provided by Lee Minichiello of SAIC. The author thanks Mr. Minichiello for his permission to use and update the figure.
[13] One exception to this rule is a rough order-of-magnitude estimate of the cost of administering U.S. nonproliferation export controls, for which the author assumes full responsibility (see below).
[14] GAO, *Intermediate-Range Nuclear Forces Treaty Implementation*, 43.
[15] Douglas MacEachan, Statement for the Record on the START II Treaty, Senate Foreign Relations Committee, February 28, 1995 (Washington, D.C.: CIA Office of Public Affairs), 9.
[16] Jeffrey T. Richelson, *The U.S. Intelligence Community*, 3rd ed. (Boulder, CO: Westview Press, 1995), 12.
[17] Walter Pincus, "Spy Agency Hoards Secret $1 Billion," *Washington Post*, 24 September 1995.
[18] The Hubble Space telescope, which cost approximately $2 billion, is similar in many ways to the KH-11.

[19] Associated Press, "Intelligence Agencies Seek More Cash, Report Says," *New York Times*, 29 August 1994.
[20] Richelson, *The U.S. Intelligence Community*, 27.
[21] CBO, *U.S. Costs of Verification and Compliance Under Pending Arms Treaties*, U.S. Congress, Congressional Budget Office, September 1990, 25.
[22] R. James Woolsey, *World Threat Assessment Brief*, Senate Select Committee on Intelligence, January 10, 1995, 3.
[23] Personal communication, CIA official.
[24] For an excellent survey of current U.S. space-based monitoring systems see Dwayne A. Day, "Capturing the High Ground: The U.S. Military in Space 1987–1995," *Countdown* (January/February 1995): 31-41.
[25] GAO, *Arms Control: Improved Coordination of Arms Control Research Needed*, U.S. General Accounting Office, April 1992, 35.
[26] Richelson, *The U.S. Intelligence Community*, 233-234.
[27] Personal communication, Lawrence Livermore National Laboratory.
[28] GAO, *Arms Control: Improved Coordination of Arms Control Research Needed*, 15.
[29] GAO, *Intermediate-Range Nuclear Forces Treaty Implementation*, 45.
[30] Joseph P. Harahan, *On-site Inspections Under the INF Treaty* (Washington, D.C.: On-Site Inspection Agency, 1993), 100-101.
[31] CBO, *U.S. Costs of Verification and Compliance Under Pending Arms Treaties*, 18.
[32] GAO, *Intermediate-Range Nuclear Forces Treaty Implementation*, 48.
[33] Personal communication, Lee Minichiello.
[34] CPPM has been substantially downgraded in START, largely because of its poor benefit-cost ratio (see below).
[35] CBO, *U.S. Costs of Verification and Compliance Under Pending Arms Treaties*, 18.
[36] Grotte and Klare, *Balancing Cost and Effectiveness in Arms Control Monitoring*, III-26.
[37] These salaries in fact represent a significant fraction of OSIA's total budget. Former Director Gregory Govan has pointed out that while OSIA's nominal budget is under $100 million, it also benefits from about $30 million in "free" salaries for military personnel. Gregory Govan, "An In-Depth Look at On-Site Inspections," *Arms Control Today* (September 1995): 15.
[38] SFRC, *The INF Treaty*, Senate Foreign Relations Committee, April 14, 1988, 178.
[39] GAO, *INF Treaty: Army and Air Force Personnel Reductions*, U.S. General Accounting Office, June 1989.
[40] This suggests that most of the benefits (political if not intelligence) from OSI under INF may have already been achieved, and that it may not be cost-effective to carry out all of the remaining short-notice inspections through 2001. Any attempt to terminate or reduce the frequency of these inspections would be a matter for discussion in the Special Verification Commission.
[41] Sidney Graybeal and Michael Krepon, "The Limitations of On-site Inspection," *Bulletin of the Atomic Scientists* (December 1987): 26.
[42] CBO, *U.S. Costs of Verification and Compliance Under Pending Arms Treaties*, 32.
[43] SFRC, *The CFE Treaty*, Senate Foreign Relations Committee, November 19, 1991, 51.
[44] GAO, *Former Warsaw Pact Nations' Treaty Compliance and U.S. Cost Control.*
[45] The author thanks Col. Brinn Colenda of OSIA for providing this chart as well as other useful information on OSIA's role in implementation and inspection.
[46] Grotte and Klare, *Balancing Cost and Effectiveness in Arms Control Monitoring*, III-30.

[47] It was originally contemplated that special tags would be used to provide unique identifiers for each piece of equipment. In the final stages of negotiation this was deemed to be unnecessary, and according to OSIA personnel the serial number identifier has worked satisfactorily.
[48] GAO, *Former Warsaw Pact Nations' Treaty Compliance and U.S. Cost Control*, 28-29.
[49] SFRC, *The CFE Treaty*, 51.
[50] GAO, *Former Warsaw Pact Nations' Treaty Compliance and U.S. Cost Control*, 26.
[51] The acronym stands for Continuous Reflectometry for Radius versus Time Experiment.
[52] OTA, *Seismic Verification of Nuclear Testing Treaties, U.S. Congress, Office of Technology Assessment*, OTA-ISC-361, May 1988.
[53] See Allan Krass, *The Verification Revolution* (Cambridge, MA: Union of Concerned Scientists, 1989), and U.S. Congress, Office of Technology Assessment, *Seismic Verification of Nuclear Testing Treaties*, for discussions of the implications of different accuracies of seismic and CORRTEX yield measurements.
[54] OTA, *Seismic Verification of Nuclear Testing Treaties*, 126. SFRC, *Threshold Test Ban and Peaceful Nuclear Explosions Treaties*, Senate Foreign Relations Committee, September 14, 1990.
[55] SFRC, Threshold Test Ban Treaty and Peaceful Nuclear Explosions Treaty, Hearings before the Senate Foreign Relations Committee, January 13, 15, 1987.
[56] CBO, *U.S. Costs of Verification and Compliance Under Pending Arms Treaties*, 34-37.
[57] OTA, *Seismic Verification of Nuclear Testing Treaties*, 137.
[58] Krass, *The Verification Revolution*, 54-55.
[59] SFRC, Threshold Test Ban Treaty and Peaceful Nuclear Explosions Treaty, Hearings before the Senate Foreign Relations Committee, January 13, 15, 1987, 74.
[60] Spurgeon M. Keeny, Jr., "Notes from Underground," *Arms Control Today* (June 1988): 2.
[61] See, for example, the letter from National Security Advisor Brent Scowcroft in *Threshold Test Ban and Peaceful Nuclear Explosions Treaties*, Senate Foreign Relations Committee, Exec. Rept. 101-31, September 14, 1990.
[62] OSIA briefing chart, January 25, 1995.
[63] IAEA, *Activities of the International Atomic Energy Agency Relevant to Article III of the Treaty on the Non-Proliferation of Nuclear Weapons*, 26, 41.
[64] Ibid., 27, 29.
[65] David Fischer, "Innovations in IAEA Safeguards to Meet the Challenge of the 1990s," in *A New Nuclear Triad: The Non-Proliferation of Nuclear Weapons, International Verification and the International Atomic Energy Agency* (Southampton, England: Mountbatten Centre for International Studies, 1992), 28.
[66] IAEA, *Activities of the International Atomic Energy Agency Relevant to Article III of the Treaty on the Non-Proliferation of Nuclear Weapons*, 40.
[67] Safeguards account for only about one-third of the IAEA's total regular budget, so the full U.S. contribution to IAEA is close to $50 million per year.
[68] IAEA, *Activities of the International Atomic Energy Agency Relevant to Article III of the Treaty on the Non-Proliferation of Nuclear Weapons*, 39.
[69] Fischer, "Innovations in IAEA Safeguards to Meet the Challenge of the 1990s," 30-31.
[70] IAEA, *Activities of the International Atomic Energy Agency Relevant to Article III of the Treaty on the Non-Proliferation of Nuclear Weapons*, 21.
[71] This figure includes only the U.S. share of IAEA Safeguards. This could be misleading, since Safeguards are only one portion of the IAEA operation, and it is unlikely that they

would exist without the other aspects. The United States must also administer its own export control system at considerable expense (see below).

[72] Anthony Fainberg, *Strengthening IAEA Safeguards: Lessons from Iraq* (Stanford, CA: Stanford University Center for International Security and Arms Control, April 1993). David Albright and Mark Hibbs, "Iraq and the Bomb: Were They Even Close?" *Bulletin of the Atomic Scientists* (March 1991): 16-25. Albright and Hibbs, "Hyping the Iraqi Bomb," *Bulletin of the Atomic Scientists* (March 1991): 26-28. David Albright and Mark Hibbs, "Iraq's Nuclear Hide-and-Seek," *Bulletin of the Atomic Scientists* (September 1991): 14-23.

[73] David Albright, "How Much Plutonium Does North Korea Have?" *Bulletin of the Atomic Scientists* (September/October 1994): 46-53.

[74] ACT, "Agreed Framework Between the United States Of America and the Democratic People's Republic of Korea," *Arms Control Today* (December 1994): 19. Jon B. Wolfsthal, "U.S., Pyongyang Reach Accord On North's Nuclear Program," *Arms Control Today* (November 1994): 25, 32.

[75] Lawrence Scheinman, "Lessons From Post-War Iraq for the International Full-Scope Safeguards Regime," *Arms Control Today* (April 1993): 4.

[76] Fischer, "Innovations in IAEA Safeguards to Meet the Challenge of the 1990s."

[77] Ibid.

[78] Scheinman, "Lessons From Post-War Iraq for the International Full-Scope Safeguards Regime."

[79] ACT, "IAEA Director Hans Blix: Keeping an Eye on a Nuclear World," *Arms Control Today* (November 1991): 3-6.

[80] There are additional "hidden costs" to safeguards that result from the traditional insistence by developing states that any increases in the safeguards budget be matched by increases in voluntary contributions of technical aid from states with developed nuclear industries. In the past this has effectively doubled the marginal cost of improving or expanding safeguards.

[81] Lewis A. Dunn, "High Noon for the NPT," *Arms Control Today* (July/August 1995): 3-9.

[82] ACT, "U.S.-Russian Strategic Weapons Dismantlements," *Arms Control Today* (May 1995): 32.

[83] Cost played an important role in getting the United States to settle for fewer CPPM sites and for special access visits instead of genuine challenge inspections. Special access visits are less intrusive, allow more time for preparation by the challenged party, and can be refused if the challenged party can find an alternative way of satisfying the concerns of the challenging party. (Grotte and Klare, *Balancing Cost and Effectiveness in Arms Control Monitoring*, III 27-28.) With respect to CPPM, the number of proposed sites dropped from five in the initial U.S. draft to only one in the final treaty. Even that one has now been dropped by both sides, primarily because of costs (Lee Minichiello, personal communication).

[84] CBO, *U.S. Costs of Verification and Compliance Under Pending Arms Treaties*, 29.

[85] SFRC, *The START Treaty*, Senate Foreign Relations Committee, September 18, 1992, 159.

[86] Grotte and Klare, *Balancing Cost and Effectiveness in Arms Control Monitoring*, III-26.

[87] Some original investment costs may be recovered through conversions of ICBMs to commercial space launch vehicles, and there may be other opportunities for such recoveries as well. In its implementation of the INF Treaty, the Air Force was able to recover and adapt to other uses over $500 million worth of equipment and more than $40 million in previously

approved construction funding due to project cancellations (SFRC, *The INF Treaty*, Senate Foreign Relations Committee, April 14, 1988, 360-361).
[88] Note that the total obligated funds ($883 M) are less than the $1.2 billion appropriated because of bureaucratic and political delays in authorizing and funding individual projects.
[89] James E. Goodby, "Dismantling the Nuclear Weapons Legacy of the Cold War," *Strategic Forum*, National Defense University Institute for National Strategic Studies, February 1995.
[90] Robert S. Norris and William M. Arkin, "Estimated Russian (CIS) Nuclear Stockpile, September 1994," *Bulletin of the Atomic Scientists* (September/October 1994): 61.
[91] SFRC, The START Treaty.
[92] Ibid., 191-205.
[93] ACDA, *States Parties to the Open Skies Treaty*, U.S. Arms Control and Disarmament Agency, Office of Public Affairs, September 28, 1995.
[94] SSCI, *Intelligence and Security Implications of the Treaty on Open Skies*, Senate Select Committee on Intelligence, May 19, 1993, 19.
[95] "OC-135B Ready for Open Skies Flights," *Aviation Week & Space Technology* (July 5, 1993): 21.
[96] SSCI, *Intelligence and Security Implications of the Treaty on Open Skies*, 4.
[97] In its assessment of CFE Treaty implementation the General Accounting Office called attention to the expectation that all U.S. agencies "aggressively implement the treaty," and "take maximum advantage of U.S. inspection rights." (GAO, *Former Warsaw Pact Nations' Treaty Compliance and U.S. Cost Control*, 27-29.) OSIA officials have confirmed in personal communications to the author that this policy still applies to INF, START, and other treaties as well as to CFE.
[98] SSCI, *Intelligence and Security Implications of the Treaty on Open Skies*, 11-12.
[99] USD(A&T), *Program Plan for Research, Development, Test and Evaluation For Arms Control, Fiscal Years 1995-96*, U. S. Department of Defense, Office of the Under Secretary of Defense (Acquisition and Technology), May 10, 1995, 26-27.
[100] SFRC, *Treaty on Open Skies*, Senate Foreign Relations Committee, August 2, 1993, 170.
[101] Data collected by other states must be carefully monitored by U.S. personnel to ensure that sensor resolutions remain within permitted limits and that no unauthorized imagery was collected.
[102] SFRC, *Treaty on Open Skies*, Senate Foreign Relations Committee, August 2, 1993, 172.
[103] OSIA briefing chart, 25 January 1995.
[104] SFRC, *Treaty on Open Skies*, 142.
[105] Ibid., 145.
[106] Of particular interest to the United States is the portion of Russia east of the Ural Mountains, which is not available for inspections under CFE or the Vienna CSBMs.
[107] SFRC, *Treaty on Open Skies*, 103.
[108] Ibid., 143.
[109] GAO, *Chemical Weapons Destruction: Issues Affecting Program Cost, Schedule, and Performance*, U.S. General Accounting Office, January, 1993, 15.
[110] The $10 billion estimate applies only to the actual U.S. stockpile. There are also thousands of tons of old chemical weapons and agents buried in many locations around the United States. The Army estimates that it will cost $17.7 billion to clean up these sites. [Michael Renner, *Budgeting for Disarmament: The Costs of War and Peace* (Worldwatch Institute, 1994).] This expense is not attributable to the CWC because the Convention

specifically exempts chemical munitions buried on a party's own territory before 1 January 1977 or dumped at sea before 1 January 1985 (Article IV.17).

[111] SSCI, *U.S. Capability to Monitor Compliance With the Chemical Weapons Convention*, Senate Select Committee on Intelligence, September 30, 1994, 65.

[112] The congressional action, taken in 1985 at the height of an intense debate over the future of chemical weapons, did not represent a renunciation of CW, as President Bush's did six years later. The Congress mandated the destruction of the stockpile of obsolete and dangerous *unitary* chemical weapons. However, many members of Congress, as well as the Reagan administration, still had high hopes for the deployment of *binary* chemical weapons, which were supposed to be safer and more militarily effective than the old unitary weapons.

[113] The United States formally agreed to eliminate "the preponderance of [its] chemical weapons stockpile" when it signed the BDA in June 1990. ["Joint Statements, Chemical Accord, and Summary of Testing Protocols," *Arms Control Today* (June 1990): 24.] President Bush's announcement renouncing the use of CW under any circumstances was made in May 1991 and was intended to move CWC negotiations forward in the Conference on Disarmament in Geneva. (Statement by President George Bush on Chemical Weapons Initiative, White House Press Secretary, May 13, 1991.) However, Bush's renunciation of CW use will become effective only after the CWC enters into force. So, until the United States ratifies the CWC it is still not legally committed either to complete chemical disarmament or to its promise never to use chemical weapons in warfare.

[114] John Shalikashvili, Chemical Weapons Convention ratification, Senate Armed Services Committee, August 11, 1994.

[115] OTA, *The Chemical Weapons Convention: Effects on the U.S. Chemical Industry*, U.S. Congress, Office of Technology Assessment, August 1993, 28-29.

[116] This is obtained by assuming an average cost per inspection of $100,000 and 50 inspections per year in the years immediately after EIF. (SSCI, *U.S. Capability to Monitor Compliance With the Chemical Weapons Convention*, Senate Select Committee on Intelligence, September 30, 1994, 47.) Note also that some inspections each year may be conducted at government-owned facilities, in which case the costs would not be borne by industry.

[117] OTA, *The Chemical Weapons Convention: Effects on the U.S. Chemical Industry*, 24.

[118] The Chemical Manufactures Association estimates that compliance with U.S. environmental regulations alone already costs the chemical industry nearly $5 billion per year (OTA, *The Chemical Weapons Convention: Effects on the U.S. Chemical Industry*, 20). This can be placed in perspective by noting that in 1991 the U.S. chemical industry had total sales of $380 billion and employed 846,000 people with a payroll of $31 billion. [Elizabeth A. Palmer, "For Businesses, a High Price for Chemical Weapons Ban," *Congressional Quarterly Weekly Report* (17 September, 1994): 2584-87).]

[119] Jessica Eve Stern, "Co-operative Security and the CWC: A Comparison of the Chemical and Nuclear Weapons Non-proliferation Regimes," *Contemporary Security Policy* (December 1994): 50.

[120] Igor Khripunov, "The Human Element in Russia's Chemical Weapons Disposal Efforts," *Arms Control Today* (July/August 1995): 21.

[121] OSIA briefing chart, 25 January 1995. OSIA has only minor responsibilities under the CWC, so the cost estimates are almost entirely attributable to the bilateral agreement.

[122] CBO, *U.S. Costs of Verification and Compliance Under Pending Arms Treaties*, 37-40.

[123] GAO, *Status of U.S.-Russian Agreements and the Chemical Weapons Convention*, U.S. General Accounting Office, March 1994, 32-34.
[124] CW inspections appear to be an exception to the rule that actual costs are less than early projection. In this case the CBO estimates made in 1990 appear to have been too low.
[125] Kathleen C. Bailey, "Why the Chemical Weapons Convention Should Not Be Ratified," in *Ratifying the Chemical Weapons Convention*, ed. Brad Roberts (Washington, D.C.: Center for Strategic and International Studies, 1994), 54.
[126] John Shalikashvili, Chemical Weapons Convention ratification, Senate Armed Services Committee, August 11, 1994.
[127] Jessica Eve Stern, "Co-operative Security and the CWC: A Comparison of the Chemical and Nuclear Weapons Non-proliferation Regimes," 50.
[128] Ibid., 39.
[129] ACDA, *Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction* (Washington, D.C.: U.S. Arms Control and Disarmament Agency, 1993), 142.
[130] Stern, "Co-operative Security and the CWC: A Comparison of the Chemical and Nuclear Weapons Non-proliferation Regimes," 32.
[131] Ibid., 52.
[132] In fact, this feature of the treaty forms the basis of another conservative argument against its ratification. (Frank J. Gaffney, Jr., "A Noxious Treaty on Chemical Weapons," *Wall Street Journal*, 29 September 1994.)
[133] Bailey, "Why the Chemical Weapons Convention Should Not Be Ratified," 52, 58.
[134] According to Antonia and Abram Chayes, "Unlike deterrence, which relies on strategic interactions between opposed states, the key to reassurance is a reliable normative and institutional structure." Antonia Handler Chayes and Abram Chayes, "Regime Architecture: Elements and Principles," in Global *Engagement: Cooperation and Security in the 21st Century*, ed. Janne E. Nolan (Washington, D.C.: Brookings Institution, 1994), 65.
[135] OTA, *The Chemical Weapons Convention: Effects on the U.S. Chemical Industry*, 43-59.
[136] Personal communications, Lawrence Livermore National Laboratory.
[137] OTA, *Technologies Underlying Weapons of Mass Destruction*, U.S. Congress, Office of Technology Assessment, December 1993, 93.
[138] SIPRI, *Sipri Yearbook 1995* (London: Oxford University Press, 1995), 747.
[139] See the Summary of VEREX Evaluations of Potential Verification Measures, BWC/CONF.III/VEREX/8, Attachment to the Summary Report, reprinted in the *Arms Control Reporter*, 1994, 701.D.5-15.
[140] OTA, *Export Controls and Nonproliferation Policy*, U.S. Congress, Office of Technology Assessment, May 1994, 21-30.
[141] DOC, *Toward a National Export Strategy*, U.S. Department of Commerce, Trade Promotion Coordinating Committee, September 30, 1993, 8-9.
[142] Ibid., 2.
[143] SGAC, *Bomb Prevention vs. Bomb Promotion: Exports in the 1990s*, Senate Governmental Affairs Committee, May 17, 1994.
[144] For detailed references on Clinton administration export control policy changes see John R. Harvey, et al., *A Common-Sense Approach to High-Technology Export Controls* (Stanford, CA: Stanford University Center for International Security and Arms Control, March 1995).
[145] OTA, *Export Controls and Nonproliferation Policy*, 67.

[146] These numbers have no empirical basis but represent the author's intuitive judgment that the average cost per application is certainly larger than $10 and certainly smaller than $10,000. The only estimate of person-hours the author could find was one from the Department of Energy that found that DOE license reviewers could spend at most 40 minutes on the average application and probably substantially less than that. (DOC, *Toward a National Export Strategy*, 20.) (Thanks to Randy Rydell for calling my attention to this estimate.) But DOE is already the second step of the process, which means that someone at Commerce or State reviewed the application first. An important contribution to "overhead" is the time spent by military, DOE, and intelligence personnel in support of license reviews. All three bureaucracies have people who devote most or all of their time to research and consultations on issues related to export controls but who do not directly review licenses. The $100-$1,000 estimate is meant to include these indirect contributions as well as the time spent by officials in interagency meetings on disputed applications. (Thanks to Seymour Goodman for a helpful discussion of this point.)

[147] OTA, *Export Controls and Nonproliferation Policy*, 25.

[148] The other 9 out of 100 are "returned without action," a decision that covers a multitude of confusing categories and has even earned the right to its own acronym: RWA.

[149] DOC, et al., *The Federal Government's Export Licensing Processes for Munitions and Dual-Use Commodities*, Special Interagency Review, Department of Commerce, September 1993. GAO, *Nuclear Nonproliferation: Export Licensing Procedures for Dual-Use Items Need to Be Strengthened*, U.S. General Accounting Office, April 1994.

[150] It is worth emphasizing again that the cost estimates presented here are highly intuitive and should not be taken more seriously than they deserve. However, the author has not been able to find any other quantitative estimates of administrative costs and has been persuaded by several experts that such estimates probably do not exist.

[151] OTA, *Export Controls and Nonproliferation Policy*, 27.

[152] The phrase "to some extent" is not explained in the Council's report but suggests that some discount should be applied to the figures quoted.

[153] COC, *Economic Security: The Dollar$ and Sense of U.S. Foreign Policy*, Council on Competitiveness, February 1994, 8.

[154] J. David Richardson, *Economic Costs of US Export Controls*, Trade and Environment Subcommittee on Economic Policy, House Committee on Foreign Affairs, November 18, 1993.

[155] Senate Governmental Affairs Committee, *Bomb Prevention vs. Bomb Promotion: Exports in the 1990s*.

[156] OTA, *Export Controls and Nonproliferation Policy*, 28.

[157] Ibid., 70.

[158] OTA, *Technologies Underlying Weapons of Mass Destruction*. OTA, Export Controls and Nonproliferation Policy.

[159] K. Scott McMahon and Dennis M. Gormley, *Controlling the Spread of Land-Attack Cruise Missiles* (American Institute for Strategic Cooperation, January 1995), 18-25.

[160] David Albright, "South Africa and the Affordable Bomb," *Bulletin of the Atomic Scientists* (July/August 1994): 37-47.

[161] Peter D. Zimmerman, "Proliferation: Bronze Medal Technology Is Enough," *Orbis* (Winter 1994): 67-82.

[162] OTA, *Technologies Underlying Weapons of Mass Destruction*, 94.

[163] OTA, *Export Controls and Nonproliferation Policy*, 38.

[164] GAO, *Nuclear Nonproliferation: U.S. International Nuclear Materials Tracking Capabilities Are Limited*, U.S. General Accounting Office, December 1994, 1.
[165] OTA, *Export Controls and Nonproliferation Policy*, 25.
[166] CBO, *U.S. Costs of Verification and Compliance Under Pending Arms Treaties.*
[167] Michael Renner, *Budgeting for Disarmament: The Costs of War and Peace.*
[168] Council on Competitiveness, *Economic Security: The Dollar$ and Sense of U.S. Foreign Policy*, 34.
[169] Recall, however, that three potentially large costs have been left out of the total in Table 2: chemical weapon destruction, loss of sales owing to export controls, and the costs of operating national technical means for arms control monitoring.
[170] SIPRI, *SIPRI Yearbook 1995*, 706.
[171] Richard Rhodes, *Dark Sun: The Making of the Hydrogen Bomb* (New York: Simon & Schuster, 1995), 401.
[172] DOE, *The Stockpile Stewardship and Management Program*, U.S. Department of Energy, May 1995, iii.
[173] The Department of Energy hopes that organization improvements will lower this cost somewhat by the end of the decade, but such hopes have too often proved illusory in the past.
[174] DOE, *The Stockpile Stewardship and Management Program*, 11.
[175] It is true, as Gusterson argues, that the facility will in fact have little relevance to maintenance problems that are likely to arise in the weapon stockpile. Nevertheless, the Energy Department has sold the facility to Congress and to the Administration almost entirely on the basis of its necessity for a test ban, and it is highly unlikely that it would be funded without this rationale.
[176] Hugh Gusterson, "Nif-ty Exercise Machine," *Bulletin of the Atomic Scientists* (September/October 1995): 22-26.
[177] Total lifetime costs for the NIF are estimated at more than $4.5 billion for 30 years. See FY 1996 DOE Congressional Budget Request, Vol. 1, Project Data Sheets, Weapons Activities, p. 332.
[178] DOE, *The Stockpile Stewardship and Management Program*.
[179] Frans Berkhout, "A Fissile Cut-off and Its Impact on Britain as a Nuclear-Weapon State," in *Verification 1995*, ed. J.B. Poole and R. Guthrie (Boulder, CO: Westview Press, 1995), 85-96.
[180] OTA, *Nuclear Safeguards and the International Atomic Energy Agency*, U.S. Congress, Office of Technology Assessment, April 1995, 44-45.
[181] ACDA, *Threat Control Through Arms Control*, U.S. Arms Control and Disarmament Agency, July 13, 1995, 1.
[182] Ibid.

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