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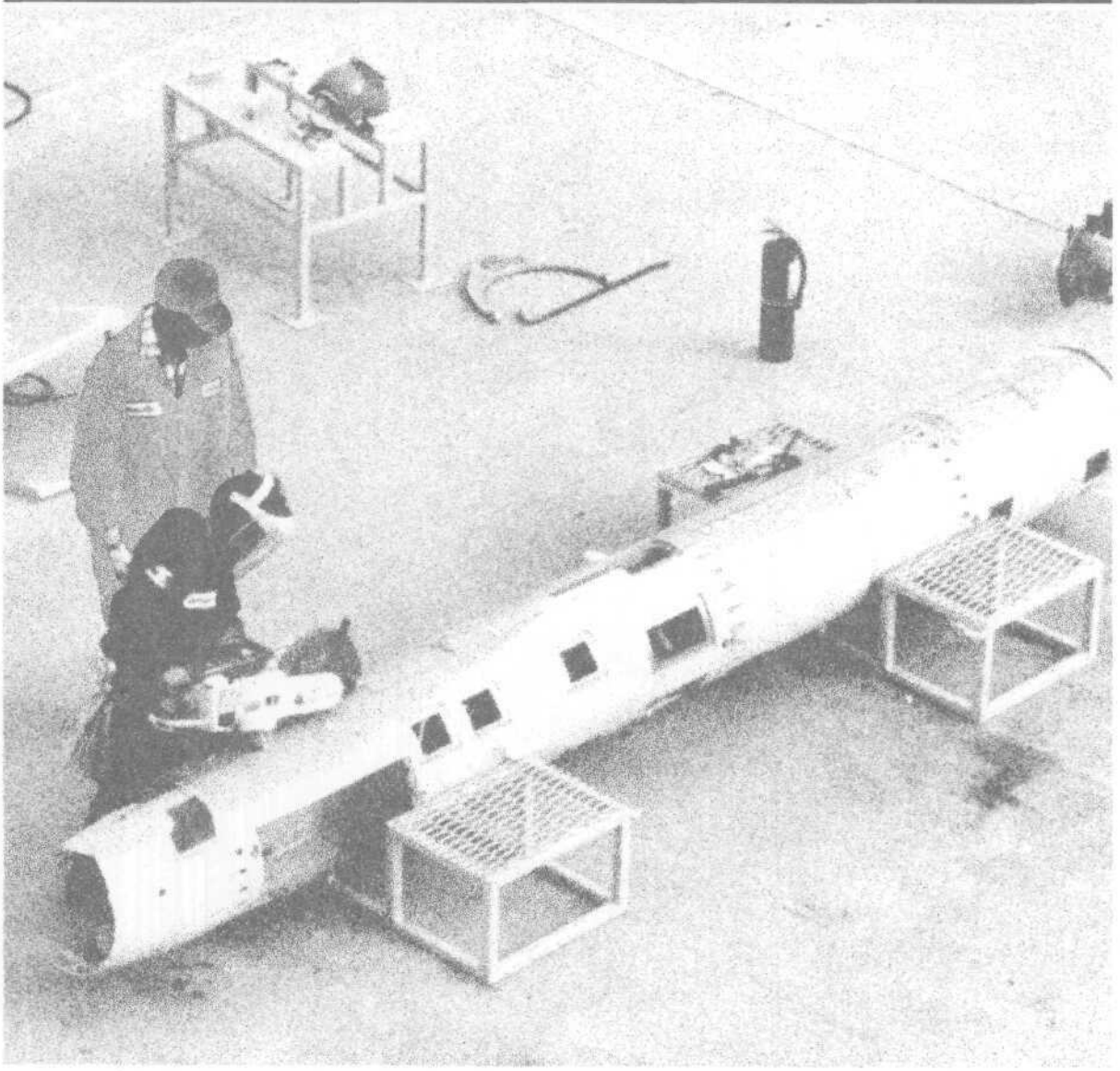
U.S. Costs of Verification and Compliance Under Pending Arms Treaties



A CBO STUDY

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CBO STUDY ON U.S. COSTS OF VERIFICATION AND COMPLIANCE UNDER PENDING ARMS TREATIES

The United States is currently negotiating four arms control treaties and one arms agreement. A study by the Congressional Budget Office, *Costs of Verification and Compliance Under Pending Arms Treaties*, prepared at the request of the Ranking Minority Member of the Senate Budget Committee, finds that, for the five accords together, compliance and on-site inspection could entail one-time costs to the United States of between $0.6 billion and $3.0 billion. One-time costs would be concentrated in the first two or three years after the treaties took effect. Recurring costs, beginning the first year of implementation and continuing throughout the lifetime of the treaties, would amount to between $0.2 billion and $0.7 billion a year.

These expected costs are associated with the proposed Strategic Arms Reduction Talks (START) treaty, which would reduce nuclear arms, and the Conventional Forces in Europe (CFE) treaty, which would limit European arms. Costs also include those for two U.S.-Soviet treaties on nuclear testing, which were recently ratified by the Senate, as well as a U.S.-Soviet agreement that would eliminate chemical weapons. The costs would arise largely from on-site inspections and from the elimination of excess equipment. The START treaty alone would account for more than half of the total costs.

The estimates are based on information about the status of the accords as of the summer of 1990, and their wide range reflects uncertainty about many factors involved in compliance and verification, such as the number and types of inspections, and how much equipment would be destroyed. But factors not reflected in the range of estimates could influence costs. Costs could be higher if a broader Chemical Weapons Convention--which could involve many countries--is completed and signed soon, or if the United States chooses to expand its satellite capabilities to enhance verification. Added costs could be lower if some of the retired equipment was reused or salvaged or if some new verification and compliance functions were performed with existing equipment or personnel.

The eventual savings from the arms accords should be greater than the estimated costs of compliance and on-site inspection. Previous CBO studies estimated that cuts in military forces and procurement required by the treaties could eventually reduce defense spending by at least $9 billion a year below its 1990 level. In the long run these savings, which would result almost entirely from the START and CFE treaties, should substantially exceed the added costs of compliance and verification. However, in the first year or two after the treaties took effect, net costs could actually increase because the one-time costs of compliance and on-site inspection would be substantial while the savings associated with the treaties would not yet have been fully realized.

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U.S. COSTS OF VERIFICATION AND COMPLIANCE UNDER PENDING ARMS TREATIES

The Congress of the United States
Congressional Budget Office

PREFACE

Verification of arms control treaties is an important function of the national security community, and has been a key concern of arms negotiators as well as members of the Congress for a number of years. New types of verification procedures have been introduced recently, giving a prominent role to various types of on-site inspections. Such inspections can improve the verifiability of treaties and contribute to a better spirit of cooperation among treaty signatories. There have been concerns, however, that such measures could prove costly. This study, performed at the request of the Ranking Minority Member of the Senate Budget Committee, addresses the costs of verification and compliance of five pending arms control accords.

Michael O'Hanlon of CBO's National Security Division prepared the study under the general supervision of Robert F. Hale and John D. Mayer. Jonathan Ladinsky and Robert Ahearne assisted at various stages of the project, and Philip Webre provided a very helpful internal review at CBO. The author is very grateful for the assistance of officials from the On-Site Inspection Agency, Office of Management and Budget, Arms Control and Disarmament Agency, Office of the Undersecretary of Defense for Acquisition, the military services, and the intelligence community. Amy Woolf and Stanley Sloan of the Congressional Research Service, Thomas Karas and Chris Waychoff of the Office of Technology Assessment, and John Pike of the Federation of American Scientists also provided assistance. (Advice and review from personnel outside of CBO implies no responsibility for the final product, which rests solely with CBO.) Frank Pierce edited the manuscript; Darlene Miller-Young and Kathryn Quattrone prepared it for publication.

Robert D. Reischauer
Director

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SUMMARY

This study examines the costs to the United States of compliance and verification associated with four new arms control treaties and one arms agreement. All five of these major accords are in advanced stages of negotiation or ratification.

The five accords are:

- A Strategic Arms Reductions Talks (START) treaty between the United States and the Soviet Union, which would require reductions in numbers of deployed long-range nuclear weapons by both countries;

- A Conventional Forces in Europe (CFE) treaty, which would involve 23 countries of the North Atlantic Treaty Organization and the Warsaw Treaty Organization. This CFE treaty would require reductions in major types of conventional combat equipment located in Europe;

- A Threshold Test Ban Treaty (TTBT) between the United States and the Soviet Union, signed in 1974 but not yet ratified, limiting the yield of all underground nuclear detonations;

- A related Peaceful Nuclear Explosions Treaty (PNET) between the United States and the Soviet Union, signed in 1976 but not yet ratified, limiting all individual explosions used for peaceful purposes; and

- A Chemical Weapons Agreement (CWA) between the United States and the Soviet Union, signed in 1990, which would ban all production of chemical weapons and require major reductions in existing stockpiles of chemical weapons.

The cost estimates in this study are based on information about the status of the accords as of the summer of 1990. Estimates may well

change over time, but actual costs are likely to fall within the ranges given here.

PROCEDURES IN COMPLIANCE AND VERIFICATION

Compliance with the accords would involve several types of procedures. Each country would have to bring its own military forces into line with the treaties' provisions, which in some cases would require the destruction and dismantling of weapons and facilities. Each country would also have to take steps to enable inspectors from the other country or countries to verify that it was in compliance.

Verification would continue a trend that began in 1988 with ratification of the Intermediate-Range Nuclear Forces (INF) treaty, which accords an important role to on-site inspection. The numbers of deployed, stored, and manufactured weapons limited by a treaty would be declared in the treaty or in accompanying data bases. Each party to a treaty would be subject to visits by inspection teams on short notice. Some visits would involve routine inspections of sites declared to have items limited under the treaty. Visits to sites suspected of containing such items, but not listed in the official data bases, would also be permitted under several treaties. In some cases, countries would be permitted to monitor key facilities with permanent inspection teams, fences, and special sensors--possibly including X-ray monitoring devices.

On-site inspection is not the only means of verification. Countries would continue to monitor arms control agreements by using space satellites and other techniques commonly referred to as "national technical means." Because of the highly classified nature of these systems and their costs, they are not analyzed in great detail in this study. Rather, the focus is on that subset of total compliance and verification costs that might be referred to as compliance and on-site inspection costs.

COSTS OF COMPLIANCE AND ON-SITE INSPECTION

CBO has divided costs of compliance and on-site inspection into two categories--one-time costs and recurring costs. For the five accords together, the total one-time costs of compliance and on-site inspection would range from $0.6 billion to $3.0 billion in 1990 dollars (see Summary Table). These one-time costs would cover destruction of equipment and facilities, restructuring of forces and bases, inspections to verify declarations made in the treaties, and the setting up of facilities for on-site inspection. The one-time costs would be incurred over a period of five to ten years after a treaty took effect, but would probably be concentrated in the first two to three years. The wide range of costs reflects uncertainty about many factors such as the number and types of inspections, how much equipment would be destroyed, and how much reconfiguration of certain military bases would be required.

More than half of these total one-time costs would be associated with the START treaty. Of the accords considered in this study,

SUMMARY TABLE. COMPLIANCE AND ON-SITE INSPECTION COSTS FOR ARMS CONTROL TREATIES
(In millions of 1990 dollars)

Treaty or Agreement	One-Time Costs	Annual Costs
Strategic Arms Reduction Talks Treaty	410 to 1,830	100 to 390
Conventional Forces in Europe Treaty	105 to 780	25 to 100
Threshold Test Ban Treaty and Peaceful Nuclear Explosions Treaty	85 to 200	50 to 100
Chemical Weapons Agreement	45 to 220	15 to 70
Total	645 to 3,030	190 to 660

SOURCES: Congressional Budget Office based on data from the On-Site Inspection Agency, the Arms Control and Disarmament Agency, the Office of Management and Budget, the Office of the Undersecretary of Defense for Acquisition, and the military services.

START would be the most expensive to implement and verify because of procedures associated with destroying equipment and continuously monitoring key production facilities.

Recurring costs, beginning with the first year of implementation and continuing indefinitely, are estimated to range from $0.2 billion to $0.7 billion per year for the five accords (see Summary Table). Among other things, these costs would pay for routine inspections, inspections at sites suspected of clandestinely holding treaty-limited equipment, and continuous monitoring of some sites. Again, more than half the costs are associated with the START treaty.

Not all of these costs would necessarily result in net increases in the federal budget. For example, transport aircraft might be diverted from lower-priority tasks to carry inspecting teams and equipment; alternatively, pilots for these aircraft might log some of their training hours by carrying inspectors instead of flying other routes. Current military personnel might be employed to carry out occasional inspections and escort assignments while still completing their other duties. The costs presented here should not be regarded as required budgetary additions, therefore, but rather as the total economic costs of compliance and on-site inspection--what it might cost the government to contract out all of these tasks to a private firm. Necessary budgetary additions should not exceed the ranges of costs presented here.

The estimates depend on judgments as to which costs should be ascribed to arms control and which should not. For example, the costs of destroying chemical weapons are not attributed to arms control in this study because they seemed certain to be incurred even before the Chemical Weapons Agreement showed promise. Nor do the estimates include the costs of retiring old nuclear submarines, though they do reflect the costs of cutting the missile tube sections out of retired submarines--a procedure directly attributable to arms control.

COSTS OF SPACE SATELLITES USED IN VERIFICATION

The United States would also use space satellites in verifying arms control treaties. Official information about these satellites is highly

classified; the information in this study is all from unofficial and unclassified sources.

The satellites that would be most useful in verifying the treaties reportedly are expensive. For example, a KH-11 imaging satellite may cost as much as the Space Telescope, suggesting a price tag of around $1.5 billion apiece. A Lacrosse imaging satellite may cost about $0.75 billion. It is conceivable that, as part of verifying arms control treaties, several imaging satellites could be added to those now in orbit in order to provide more continuity of coverage and more images per unit of time. Adding satellites could substantially increase the costs of verification.

Added satellite costs are not inevitable, however. Much of the information needed to verify arms treaties is already being gathered for other intelligence purposes. Moreover, it is possible that arms control treaties would reduce military tensions, and reduce the number of facilities that must be monitored intensively, and so reduce the need for satellites somewhat. At any rate, recent plans to add a large number of U.S. satellites appear to have run into budgetary roadblocks. It seems unlikely that many more satellites will be procured for purposes of verifying arms control treaties.

COMPARING COSTS WITH SAVINGS

The focus of this study is on the costs of complying with arms control agreements and verifying them. But it is also of interest to compare the added costs with the savings that arms control may bring about, especially in a period when defense budgets are falling sharply.

The START and CFE treaties would require reductions in U.S. military forces, and would permit cuts in the procurement of new weapons. A conservative estimate suggests that, once they had fully taken effect, the two treaties would reduce defense spending by at least $9 billion a year below its 1990 level. The other three treaties examined in this study would add only modestly to total savings, bringing them to about $9.2 billion a year.

These savings would substantially exceed the added costs of compliance and on-site inspection, which for all five treaties together should not exceed about $3 billion in one-time costs and about $0.7 billion a year in recurring costs. Net savings could actually be even higher to the extent that some of the eliminated equipment was salvaged or reused.

Net savings might be lower, though, if the Chemical Weapons Agreement leads to a broader Chemical Weapons Convention involving many countries. Such a convention would not save any more money than the narrower Chemical Weapons Agreement, but would cost more to verify. Even so, the higher costs of the convention would almost certainly not approach the magnitude of the savings associated with the five treaties.

The treaties might not yield much in the way of immediate savings. Indeed, they could lead to added net costs for the first year or so, when the one-time costs of compliance and on-site inspection would be substantial and the savings associated with reduced numbers of military forces would not yet have been fully realized.

CHAPTER I

INTRODUCTION

The United States has been very active in arms control in recent years. In December 1987, President Reagan signed the Treaty on Intermediate-Range Nuclear Forces (the INF treaty) with the Soviet Union; the agreement entered into force on June 1, 1988, and is now being carried out. In addition, the United States has been engaged in a number of other arms control negotiations with various countries. The Bush-Gorbachev summit in the spring of 1990 led to an agreement limiting chemical weapons and to new verification protocols for treaties limiting nuclear testing. Two key types of U.S. and Soviet military capabilities--strategic nuclear arms and conventional arms based in Europe--are currently the subject of the Strategic Arms Reduction Talks (START) and the talks on Conventional Forces in Europe (CFE).

Each of these new treaties or agreements is path-breaking in some way, even in cases where its military importance may be modest. The INF treaty mandates elimination of an entire category of weapons systems--land-based missiles with ranges between 500 and 5,500 kilometers (roughly 300 and 3,400 miles). A START treaty, if signed and ratified, would require reductions in deployed long-range nuclear arms. A CFE treaty would result in the destruction of significant amounts of military equipment, particularly by the Soviet Union; it would reduce the actual military capability of Soviet forces in Europe and would also codify those Soviet reductions that are already taking place because of political changes within the other members of the Warsaw Pact. The nuclear test treaties, signed in 1974 and 1976 but never ratified because of concerns about verification, limit the yields of underground nuclear bursts. The Chemical Weapons Agreement will, for the first time, limit stockpiles of toxic agents and ban new production.

In addition to their individual traits, these treaties and agreements all share one characteristic that sets them apart from nearly all

previous arms control accords: they contain explicit verification provisions that give a prominent role to on-site inspection. Questions have arisen about the cost of such verification efforts. Could these additional costs, which have been estimated at billions of dollars per year, more than offset the savings from arms reductions? How much will compliance and verification add to defense costs in a period when overall budgets are falling sharply? While arms control treaties may serve the interests of the United States and other countries regardless of costs, the expenses involved in complying with the treaties and verifying them cannot be overlooked in a period of intense fiscal restraint.

This study focuses on the costs to the United States of compliance and verification. Most of it deals with the subset of costs associated with compliance and on-site inspections; these costs are the most amenable to unclassified analysis, and probably are larger than other additional monitoring costs that may be incurred.

The remainder of this chapter describes the five treaties or agreements and the methods that will be used to monitor other countries' compliance with them. (From this point on, the term treaties should be understood to refer to both treaties and agreements.) As an example of how verification is conducted and how much it costs, this chapter also presents information on the verification procedures under the existing INF treaty, as well as estimates of the costs of compliance and on-site inspection for that treaty.

PROVISIONS OF THE TREATIES

The five treaties or agreements that are the subject of this study are in various stages of negotiation and approval. This section describes their provisions as of the summer of 1990. All but the nuclear test treaties seem likely to undergo changes before negotiations and ratification are complete. For that reason, estimates of the costs of compliance and verification are also subject to change.

Strategic Arms Reduction Talks

In the spring of 1990, Presidents Bush and Gorbachev signed a joint statement of agreed principles intended to govern the final form of the START treaty.[1] This discussion is based primarily on that statement.

The START treaty would establish ceilings of 1,600 for deployed strategic nuclear launchers (including intercontinental ballistic missiles or ICBMs, submarine-launched ballistic missiles or SLBMs, and long-range bombers) and 6,000 for warheads deployed on strategic launchers. Up to 4,900 warheads could be on ballistic missiles; as many as 1,100 of these 4,900 warheads could be on mobile land-based missiles that are designed to avoid detection by moving over large areas.

The START treaty would also impose other limitations. No more than 154 large or "heavy" land-based missiles could be deployed by either side, and no new types of heavy missiles of any type would be permissible. Existing heavy missiles could not be made mobile or put at sea. The aggregate payload, or throwweight, of each country's ballistic missiles would be limited to roughly 50 percent of the level of current Soviet missile throwweight (this stipulation would require no reductions in U.S. missile throwweight). ICBM launchers designed to be reloaded rapidly after an initial nuclear attack would be banned. No ballistic missiles deployed after implementation of the treaty could carry more than 10 independently targetable warheads, and no current missile could be tested or deployed carrying more warheads than permitted in the text of the START treaty.

Cruise missiles (which are small, pilotless missiles powered by jet engines) could not carry multiple warheads. Also, no existing or future U.S. bombers could be equipped with the capacity to carry more than

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1. For general information on this prospective treaty and its verification regime, see, among others, Steven A. Hildreth and Amy F. Woolf, "Arms Control: Negotiations to Reduce Strategic Offensive Nuclear Weapons," Congressional Research Service (March 1990); Steven A. Hildreth, "Arms Control: Negotiations to Limit Defense and Space Weapons," Congressional Research Service, (March 1990); Amy F. Woolf, "On-Site Inspection in Arms Control: Verifying Compliance with INF and START," Congressional Research Service (November 1989); Sidney N. Graybeal and Patricia Bliss McFate, "Getting Out of the STARTing Block," *Scientific American* (December 1989), pp. 61-67.

20 air-launched cruise missiles; existing and future Soviet bombers could not exceed a capacity for 12 such cruise missiles.

A political agreement tied to the START treaty would require each side to declare the number of long-range nuclear-tipped cruise missiles that it intends to deploy at sea, subject to the understanding that this number not exceed 880. This understanding would not constrain either superpower since neither currently plans to deploy more than 880 nuclear sea-launched cruise missiles (SLCMs). Nor could the limit be verified with high confidence: deployed SLCMs cannot be counted easily by satellite, nuclear-tipped versions cannot be distinguished from conventional ones by satellite, and no on-site inspections would be allowed for SLCM verification purposes. Rather, this understanding would be intended only to alleviate each country's concerns about the other's deployments. SLCMs could not carry more than one warhead each by the terms of the agreement. Nuclear SLCMs would not count against aggregate START ceilings.

Since both the United States and the Soviet Union currently have inventories of about 12,000 strategic nuclear warheads, the limit of 6,000 warheads would seem to require reductions of about 50 percent in total warheads. Actual reductions would be smaller, however, because of special counting rules and exemptions in the treaty. Most notably, bombers that are designed to penetrate enemy airspace while carrying only short-range munitions would be considered to carry only one warhead regardless of their actual loads. Also, bombers carrying cruise missiles would be considered as carrying only 10 weapons if they are U.S. bombers and 8 weapons if they are Soviet bombers.[2] In addition to the special bomber rules, the two sides may agree that up to 72 missiles from submarines in overhaul status could be exempted from the ceilings on launchers and warheads. These various special rules and exemptions were designed to meet interests expressed by each country. But they are likely to result in a START treaty that

2. This latter special counting rule would apply only to the first 150 U.S. bombers so equipped, and to the first 210 Soviet bombers so equipped; beyond those points, the aircraft would be considered as carrying their maximum loadings. The rule would also apply only to bombers carrying nuclear-capable cruise missiles with ranges in excess of 600 km; the U.S. conventionally armed Tacit Rainbow is thus excluded from treaty limitations.

would reduce actual numbers of warheads by between 10 percent and 30 percent rather than by 50 percent.

The statement of principles did not resolve all of the issues in START. It is not clear, for example, to what degree stockpiles of non-deployed missiles and warheads would be limited by this treaty, though some requirements for destruction of excess equipment seem likely. Limitations on the number of Soviet Backfire bombers (a medium- to long-range bomber that can carry nuclear weapons) may also be agreed to, but the issue apparently remains highly contentious.

The START treaty also would contain specific provisions for verification (though in some cases they have not yet been agreed to). For example, it would permit on-site inspections of sites where nuclear weapons and their launchers are produced, tested, deployed, or maintained. Moreover, the treaty would specify how many and what kinds of inspections are permitted. One important type would be continuous on-site monitoring of the entrances and exits, or "portals," of some missile production facilities as well as the fenced-in "perimeters" of those facilities. The treaty would also permit challenge inspections of sites not on declared data bases but suspected nevertheless of holding treaty-limited equipment. The signed statement of principles does not, however, spell out the details of verification, many of which are still being negotiated. Thus, the discussion of the costs of verification in this study must make certain assumptions about the scope and details of future verification plans.

The START treaty would take effect over a period of no longer than seven years. The total duration of the treaty would be 15 years unless superseded by another strategic arms treaty before then; the treaty could be extended for successive five-year intervals if so desired by both parties. The Soviet Union has explicitly reserved the right to exceed treaty limits on deployed offensive systems should the United States deploy a system of strategic defenses.

Conventional Forces in Europe

The CFE treaty is currently being negotiated in Vienna.[3] It is hoped that a completed treaty, or at least a statement of principles, can be ready for signing by the end of 1990. The description of the treaty contained below generally reflects the proposal of the North Atlantic Treaty Organization (NATO) in the spring of 1990, but also reflects information in some press reports about more recent changes--especially those concerning the deployments and sizes of American and Soviet armed forces in Europe.

The CFE treaty would reduce the major conventional weaponry of NATO and the Warsaw Pact. Forces in Europe between the Atlantic Ocean and the Ural Mountains (referred to as the ATTU region) would be reduced by between 7 percent and 15 percent relative to current NATO levels, to arrive at equal ceilings for both alliances. In particular, each alliance would be limited to totals of roughly 20,000 tanks, 30,000 armored personnel carriers, 16,500 artillery pieces, 1,900 helicopters, and 5,200 fixed-wing aircraft (of those aircraft types subject to limitation). There would be additional restrictions on how many pieces of major equipment could be deployed in each of several subregions within the ATTU area. Also, the contributions of any one country to the total weapons inventories of its alliance would have to be less than about 60 percent of the total; this limit would apply to each category of equipment. Weapons in the ATTU region at the time the treaty took effect and that exceeded these various limitations would have to be destroyed. In addition, the CFE treaty might limit U.S. and Soviet equipment stocks on foreign soil.

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3. For background see Michael D. Scanlan, *Conventional Armed Forces in Europe (CFE) Negotiations: Facts and Figures*. Congressional Research Service (March 1990); Elizabeth J. Kirk, "Verifying a CFE Agreement," American Association for the Advancement of Science,Washington, D.C., 1990; Stanley R. Sloan, "Verifying Compliance with a Conventional Arms Control Accord: Considerations for the Congress," Congressional Research Service (January 1990); Russell Maxfield and Arend J. Meerburg, "Two Techniques for Verifying Conventional Reductions," *Arms Control Today* (August 1989), pp. 18-21; Timothy J. Pounds and Lewis A. Dunn, "The Implications of Conventional Arms Control Verification for Monitoring Technology R&D," Los Alamos National Laboratory Workshop (McLean, Va.: Science Applications International Corporation, 1989); and Congressional Budget Office, *Budgetary and Military Effects of a Treaty Limiting Conventional Forces in Europe* (January 1990).

Verification provisions for the CFE treaty have not yet been completed. But it is virtually certain that on-site inspections would be permitted, just as with the START treaty. Unlike START, however, CFE would not contain provisions for continuous monitoring of production sites. But it might contain provisions not found in START for occasional aerial overflights of the ATTU region as an additional verification measure.

Threshold Test Ban Treaty and Peaceful Nuclear Explosions Treaty

These two treaties were signed in 1974 and 1976, respectively, and the limits they prescribe appear to have been complied with by both the United States and the Soviet Union.[4] But the treaties have never been ratified because of U.S. concerns over verifying Soviet compliance. Procedures permitting on-site verification of the treaties were agreed to during the summit meeting between Bush and Gorbachev in the spring of 1990, and both treaties have now been submitted to the U.S. Senate for ratification.

The treaties would limit underground nuclear tests to yields of 150 kilotons or less. (The Hiroshima and Nagasaki bombs were in the range of 15 kilotons to 20 kilotons, but current strategic warheads generally range in size from 40 kilotons to about 2,000 kilotons.) In the case of the Peaceful Nuclear Explosions Treaty, simultaneous explosions with a total yield of over 150 kilotons are allowable, but advance notification must be provided so that the other party may send an inspection team to verify that none of the individual explosions exceeds 150 kilotons.

4. For additional information on these treaties, see, for example, Congressional Research Service, "Soviet-U.S. Relations: A Briefing Book" (March 1990); Office of Technology Assessment, *Seismic Verification of Nuclear Testing Treaties* (1988); Lynn R. Sykes and Jack F. Evernden, "The Verification of a Comprehensive Nuclear Test Ban," *Scientific American* (October 1982).

Chemical Weapons Agreement

This agreement was signed at the Bush-Gorbachev summit.[5] It is intended largely to provide impetus to the global Chemical Weapons Convention now being negotiated under the auspices of the United Nations, which would ban production, stockpiling, and use of chemical agents. The Chemical Weapons Agreement does not require Senate ratification but only approval of implementing legislation by simple majorities in both Houses of the Congress. (Some members of the Senate have argued, however, that this agreement should be submitted to the Senate for ratification as a treaty.)

The agreement would halt all U.S. and Soviet production of chemical weapons, and would require periodic exchanges of data bases specifying the size and nature of each country's stockpile of chemical weapons. The agreement also would mandate destruction of 50 percent of each country's existing stock by the end of 1999, with continued reductions down to a ceiling of 5,000 tons of chemical agents for each country by the year 2002.

On-site inspections would be permitted to verify destruction and inventories, though many details about verification remain unclear. Inspection and destruction protocols still are being negotiated, with a target date for completion envisioned for late 1990.

PROCEDURES FOR COMPLIANCE AND VERIFICATION

Complying with a treaty includes two main types of activities: bringing one's own military forces into accord with the treaty, and doing what is necessary to allow other parties to verify that one is in compliance. Verification involves various types of monitoring--perhaps including on-site visits to military facilities by teams of inspectors--and analysis of the information obtained by such monitoring to determine whether or not another party is in compliance.

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5. For background, see Steven R. Bowman, "Chemical Weapons: U.S. Production, Destruction, and Arms Control Negotiations," Congressional Research Service (March 1990).

This section explains the techniques and terminology involved in procedures for compliance and monitoring. It begins with a brief history of one of the most controversial types of procedures--on-site inspection.

A Glance at the History of On-site Inspection

The concept of on-site inspections for major arms treaties dates back several decades. Early proposals for international control of nuclear weapons--the Acheson-Lilienthal Plan and the Baruch Plan, both in 1946--contained provisions for inspections. So, of course, did Eisenhower's "Open Skies" speech of 1955, which in addition to aerial overflights also recommended exchanges of detailed data bases on military forces among the Four Powers. Along similar lines, a Soviet proposal made at the United Nations two months before Eisenhower's famous speech called for international monitoring of ports, airfields, rail lines, and roads to ensure that no military attack could be prepared clandestinely. On-site inspections also were proposed, primarily by the United States, at various points during the negotiations to ban nuclear testing in the late 1950s.

A number of precedents exist for verifying arms agreements through on-site inspections: the Antarctica Treaty of 1959, the Seabed Treaty of 1971, the Stockholm Agreement on Confidence-Building Measures of 1986, and the specialized roles for such inspections in the functioning of the International Atomic Energy Agency, which was created in 1957.

During most of the early postwar decades, however, Moscow refused to agree to the procedures necessary to verify arms control treaties, viewing them less as confidence-building devices than as espionage. After objecting to Open Skies in 1955, Moscow opposed U.S. reconnaissance satellites from their first use in 1960 and shot down Gary Powers' U-2 aircraft that same year.[6] Shortly after orbiting its own

6. U-2 flights had been taking place since 1956, despite Moscow's rejection of the Open Skies concept, but it was not until 1960 that the Soviet Union had a surface-to-air missile (SAM) capable of shooting down the high-flying aircraft. See William E. Burrows, *Deep Black: Space Espionage and National Security* (New York: Random House, 1986), pp. 80-81.

photo-reconnaissance satellite in 1962, however, it dropped its objection to satellite overflights. Indeed, during the strategic arms limitations talks (SALT) that led to the ABM Treaty in 1972, the Soviet Union agreed to provisions that ensured the unimpeded operation of satellites and other of the so-called "national technical means" of verification.[7] But the Soviet Union continued to oppose most types of on-site inspections through the SALT era, and the United States was willing to accept this position because of its confidence in the capabilities of its national technical means.[8]

In the late 1970s and 1980s, however, the United States began to advocate more exacting standards for verification and new types of arms control measures. Together, these initiatives made on-site inspection more important. The prevailing wisdom of the SALT era--that verification should be "adequate," capable of detecting militarily significant violations with very high confidence but not necessarily capable of detecting all small violations--was challenged during the ratification debates for the SALT II treaty in 1979 and was gradually abandoned as U.S. policy by the Reagan Administration. The United States then adopted a more exacting standard for verification, generally referred to as "effective." The new U.S. position held that any future arms treaty should be signed only if potential Soviet violations of that treaty would be detectable with a very high or certain probability. This new way of thinking led the United States to push hard for on-site inspections, though at first it probably was not particularly optimistic about getting Soviet agreement to them.

During the 1970s and early 1980s, verification was probably better than some of its critics maintained. Indeed, the alleged Soviet treaty violations and the accompanying Soviet military buildup that the critics put forward in making their case for a higher standard of verifiability had been detected by the very system of verification they

7. See for example, Article XII of the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems, May 26, 1972.

8. John Lewis Gaddis, "The Evolution of a Reconnaissance Satellite Regime," in Alexander L. George, Philip J. Farley, and Alexander Dallin, *U.S.-Soviet Security Cooperation* (New York: Oxford University Press, 1988), pp. 354-358; Ronald E. Powaski, *March to Armageddon* (New York: Oxford University Press, 1987), pp. 80-92; McGeorge Bundy, *Danger and Survival* (New York: Vintage Books, 1988), pp. 130-200.

considered inadequate. Among the questionable Soviet activities uncovered during this period were the construction of the Krasnoyarsk radar, the encoding of missile telemetry during tests, the development of the SS-25 land-based missile, and the use of small air-defense radars during testing of ballistic missile defenses. In most of these and other cases, the difficulty lay not in U.S. verification but in the Soviet Union's unwillingness to alter its behavior. Thus, an important lesson of this period was that the capability to detect and recognize violations does not guarantee being able to deter or prevent them.[9]

The new emphasis on on-site inspections had important arguments in its favor. Symbolically, it put the Soviet Union on notice that its past compliance with arms control agreements was not acceptable to the United States. The U.S. position constituted a demand for greater military "glasnost" and for more political restrictions on military operations. It was also a recognition that on-site inspections can improve the verification process and permit the scope of arms control measures to be broadened. On-site inspections allow observations inside buildings, more accurate counting of small pieces of equipment, accurate measurement of the flows of materials out of factories, and more scrupulous inspection of the technical characteristics of weapons and production facilities (though with attendant risks to both sides of revealing sensitive information). On-site inspections may also make certain types of verification easier or cheaper by reducing the need for elaborate monitoring equipment such as satellites.

Verification Techniques and Technologies

For the treaties or accords considered here, the process of compliance and on-site inspection would begin with initial declarations--usually attached to the treaty in question--listing the bases and facilities containing equipment that is to be controlled by the treaties, as well as how much equipment is located at each place. Next, one or more of several types of activities would be specified for verifying the declarations and for making sure that equipment or personnel prohibited by

9. For discussions of these issues, see James A. Schear, "Arms Control Treaty Compliance," *International Security* (Fall 1985), pp. 141-199; and Kerry M. Kartchner, "Soviet Compliance with a START Agreement: Prospects Under Gorbachev," *Strategic Review* (Fall 1989), pp. 47-57.

the treaty are no longer present. For purposes of understanding costs, it is useful to note which procedures take place only once, during the period of implementation, and which begin with a treaty's entry-into-force but go on for as long as the treaties remain in force. Each of the main types of activities is described in more detail below.[10]

One-Time Procedures and Inspections. Several types of procedures and inspections would take place at specified times and for specified purposes. During the first few months after the treaty's entry-into-force, the quantities of treaty-limited items at individual bases would be checked against the quantities listed in the data bases. In addition, characteristics of certain weapons, such as the weapons capacities of bombers and ballistic missiles, could be ascertained. Another type of inspection, known as a close-out inspection, could take place when all treaty-limited equipment was removed from a given base.

Other specified types of one-time inspections would be permitted under the Threshold Test Ban Treaty and the Peaceful Nuclear Explosions Treaty; they would be one-time in the sense that one inspection would be allowable for each individual nuclear test that exceeded certain thresholds of explosive yield. Depending on the circumstances, these inspections could involve sampling the geology near nuclear test sites, installing special equipment for measuring the size of nuclear explosions, and determining whether simultaneous explosions were being employed during peaceful nuclear explosions.

Other types of one-time procedures and inspections are discussed below in the sections on eliminations, portal monitoring, and aerial reconnaissance.

Eliminations. To dismantle or destroy equipment, signatories to a treaty first move equipment from declared sites (that is, sites that, according to the treaty, contain equipment controlled by it) to destruction

10. For good overviews of verification techniques and technologies, see North Atlantic Assembly Scientific and Technical Committee, "General Report on Verification Technology for Arms Control," 1989; Lewis A. Dunn with Amy E. Gordon, "On-Site Inspection for Arms Control Verification: Pitfalls and Promise," Center for National Security Negotiations (McLean, Va.: Science Applications International Corporation); William C. Potter, *Verification and Arms Control*, (Lexington, Mass.: Lexington Books, D.C. Heath and Company, 1985); and a forthcoming study by the Office of Technology Assessment, Washington, D.C., 1990.

facilities. An inspecting party observes the destruction procedures; a complying party carries out the dismantlement/destruction procedures, and also escorts the inspecting party's representatives.

Destruction procedures for missiles can involve launching or blowing up the entire missile, or burning up missile fuel with the booster fixed horizontally and then cutting up the casing. If the START treaty does not require that excess missiles be destroyed, compliance could involve simply removing missiles from silos or submarines and placing them in some type of storage. Procedures for aircraft and ground-combat equipment can involve blowing up, melting, or cutting up the equipment.

Additional destruction procedures may involve blowing up missile silos and cutting the launch tubes out of submarines that are retired under a treaty. In this case, however, satellites and other national technical means could provide sufficient monitoring capabilities without on-site inspections (indeed, they already do so in order to verify compliance with the SALT treaties).

Short-Notice Quota Inspections. Some routine inspections are called quota inspections because a treaty sets a maximum allowable number of them. Typically, not all bases and facilities would be inspected each year. Rather, the inspecting country would have a right to select some sites from an official data base.

The main purpose of short-notice quota inspections would be to confirm that weapon systems do not exceed the numbers or the capabilities assigned to them in the official declarations and data bases. In general, these inspections would be short-warning, in the sense that the inspecting party would not need to provide more than about nine hours of advance notification as to which base it wished to inspect (if the INF treaty is any guide). Inspecting teams generally would be accompanied by escorting teams of comparable size from the other side.

Suspect-Site Inspections. Suspect-site inspections (SSI), referred to as challenge inspections in chemical weapons treaties, would not take place at sites declared to contain treaty-limited equipment but rather at sites suspected of illicitly holding or producing such equipment.

Presumably, either national technical means or human intelligence sources would have provided a basis for suspicion. Alternatively, some suspect-site inspections could be conducted without any particular basis, in order to keep the other side uncertain about one's intelligence capabilities.

In suspect-site inspections, the delay between notification that a given base was to be inspected and the actual arrival of the inspecting team at that base might be longer than in normal quota inspections. A delay of 24 hours, for example, would permit a certain level of shrouding or other concealment to protect sensitive information that was not relevant to the treaty (though, to provide the inspecting country with some confidence that the site had not been materially altered, access into and out of the suspect facility might be curtailed soon after notification). As with short-notice quota inspections, escorts would accompany inspectors.

A country might be allowed to refuse other countries' individual requests for these types of inspections, or to "manage access" to an inspected site so as to protect sensitive information not related to the treaty in question. Right of refusal might be afforded to protect industrial or high-technology secrets that could be revealed by inspections at highly sensitive sites. Countries might also be able to refuse suspect-site inspections in order to avoid excessive disruption costs from shutting down operations. Finally, in the United States the right of refusal might occasionally be invoked on constitutional grounds, given the Fourth Amendment's protection against unreasonable search and seizure.

A party invoking the right of refusal would probably be obliged to satisfy the curiosity of the would-be inspector through some other method. An industrial facility, for example, might have to release detailed records of outputs and of raw-material inputs.

Portal-Perimeter Monitoring. Portal-perimeter monitoring is an expensive type of inspection that involves continuous surveillance of key production facilities. Fencing is built around the facilities. Points of ingress and egress are established and equipped with combinations of sensors, gates, and perhaps weigh stations and X-ray devices to in-

spect the contents of containers that pass through. Treaty-limited equipment leaving the portal sites could be also be "tagged" with some type of counterfeit-proof device that would make that weapon clearly identifiable, and make any clandestine production of similar equipment easier to uncover. For example, mobile ICBMs controlled under the START treaty might be tagged.

The use of X-ray machines in portal monitoring may be problematic. The U.S. "Cargoscan" X-ray machine has proved contentious at times under the INF treaty. The Soviet Union is concerned that X-rays of missiles, intended to ensure that no mobile SS-20 missiles banned under the INF treaty are leaving a plant (perhaps inside the casing of a nonbanned missile), might also reveal sensitive information about SS-25 missiles that are not banned and that are produced at the same plant.

Portal monitoring can be very costly, both for the country performing the inspections and for the host country. Escorts must accompany portal inspectors whenever they leave their barracks. Translators must be on station at all times. Security personnel may be needed to ensure the safety of the visiting inspectors, and also to prevent them from conducting espionage. Substantial logistics costs are involved in flying teams of about 30 inspectors to and from portal sites every three weeks or so--the typical length of a rotation.

Aerial Reconnaissance. Aerial reconnaissance would involve flights by aircraft equipped with various sensors. Negotiations have not yet resolved which types of sensors would be permitted on board the aircraft, or whether or not the inspecting party would be escorted during the flight.

A CFE treaty might permit a specified number of aerial reconnaissance flights. (A multilateral Open Skies accord, proposed by President Bush, is another example of this type of verification procedure even though it would not be directly tied to any one treaty; it is treated along with CFE aerial reconnaissance inspections in this study.)

Aerial reconnaissance probably would accomplish relatively little that satellites cannot do. Indeed, it would be inferior to satellite coverage in some respects because it would provide the inspected party ample time to prepare for the announced flyovers. But it could be helpful, especially for NATO and Warsaw Pact countries that do not have their own imaging satellites. It would also be a further symbolic demonstration of military glasnost and reduced tensions.

Monitoring Using National Technical Means

Most of the procedures for on-site inspection are relatively new. By contrast, the two major powers possess intelligence-gathering devices generically referred to as "national technical means" which have been the basis of their intelligence operations for several decades. The most important of these devices are intelligence-gathering satellites, but they also include various types of reconnaissance aircraft, ground stations, and naval vessels. Virtually all of these sources of information are used to verify arms control treaties. National technical means are discussed more fully in Chapter III.

The INF Treaty as an Example

The Treaty on Intermediate-Range Nuclear Forces was signed on December 8, 1987, was ratified by the Senate in May 1988, and entered into force on June 1, 1988. It involves several of the main types of procedures for compliance and on-site inspection, and is thus a useful example of the costs and problems likely to be encountered. Suspect-site inspections and aerial reconnaissance are the only major types of verification procedures not illustrated by the treaty.

The INF Treaty bans ground-based ballistic and cruise missiles that can hit targets at ranges between 500 kilometers and 5,500 kilometers. The treaty prohibits the production and testing of such missiles, and mandates destruction of all existing missiles and launchers within three years of its taking effect.

The INF treaty illustrates most of the major verification procedures noted above. The treaty contains declarations that list the sites containing equipment controlled by the treaty as well as the amount of equipment at each site. As part of the one-time procedures, baseline inspections were used to verify these declarations. Baseline inspections included one visit to each of the 31 declared U.S. bases at 18 sites for deployment, production, training, and repair of treaty-limited items, and to each of the 133 declared Soviet bases at 117 sites. These visits took place during a 60-day baseline-inspection period, which began 30 days after the treaty took effect. Each of these bases can be revisited during a close-out inspection once all treaty-limited equipment is removed from it; some sites have already had their close-out inspections. Parties also are obliged periodically to update data bases specifying the remaining inventories of treaty-limited items at declared sites.

The INF treaty requires that each country destroy all missiles banned by the treaty; elimination inspections are thus an important part of the one-time procedures. Reportedly, a total of perhaps 60 to 80 elimination inspections will take place to verify destruction of U.S. equipment, as well as a total of about 110 to 130 inspections to verify destruction of Soviet equipment. Again, most of these inspections have already occurred. For U.S. equipment, destruction has involved cutting up ground-launched cruise missiles, firing off the boosters of Pershing ground-launched ballistic missiles while the missiles are held statically in the horizontal position, and cutting up missile launchers. Soviet elimination techniques have included both launching and exploding missiles.

In addition to these one-time procedures, the INF treaty provides for annual quota inspections at declared sites (even after they have been subjected to close-out inspections). The quota inspections at declared sites number 20 per party for each of the first three years of the treaty, 15 per year for each of the next five years, and 10 per year for each of the next five years.

The treaty also permits portal monitoring in each country at one site that produced treaty-limited missiles or that continues to produce

TABLE 1. COMPLIANCE AND ON-SITE INSPECTION COSTS FOR THE INTERMEDIATE-RANGE NUCLEAR FORCES TREATY
(In millions of 1990 dollars)

	One-Time Costs	Annual Costs
One-Time Procedures		
Eliminations		
At U.S. bases	55 to 135	n.a.
At Soviet bases	15 to 30	n.a.
Baseline/Close-Out Inspections		
At U.S. bases	10 to 55	n.a.
At Soviet bases	15 to 25	n.a.
Establishment of Portal		
In Magna, Utah	105 to 110	n.a.
In Votkinsk, USSR	45 to 50	n.a.
Initial Planning and Management	5 to 15	n.a.
Research and Development	50 to 100	n.a.
Recurring Procedures		
Quota Inspections		
At U.S. bases	n.a.	1 to 10
At Soviet bases	n.a.	1 to 2
Portal Monitoring		
At U.S. site	n.a.	20 to 30
At Soviet site	n.a.	10 to 20
Management and Oversight	n.a.	5 to 15
Total Costs	300 to 520	35 to 75

SOURCES: Congressional Budget Office based on data from the On-Site Inspection Agency, the Arms Control and Disarmament Agency, the Office of Management and Budget, the Office of the Undersecretary of Defense for Acquisition, and the military services.

NOTE: n.a. = not applicable.

missiles "outwardly similar" to such treaty-limited missiles.[11] The U.S. portal site is at the Hercules Plant at Magna, Utah, and the Soviet

11. See Department of State, Bureau of Public Affairs, "Treaty between the United States of America and the Union of Soviet Socialist Republics on the Elimination of their Intermediate-Range and Shorter-Range Missiles" (December 1987).

site is at an SS-25 final-assembly plant at Votkinsk, Russia (roughly 700 miles east of Moscow, just west of the Ural Mountains). Roughly 15 rotations of personnel are needed at each site each year to carry out the monitoring.

The site at Votkinsk was equipped in early 1990 with a Cargoscan X-ray machine. This is a sophisticated device intended to distinguish the SS-25 missiles leaving the final-assembly plant--which are not controlled under the INF Treaty--from the banned SS-20 missiles, and to ensure that no SS-20s could be hidden within an SS-25 casing. The machine is designed to make this distinction without revealing data about the design of the SS-25 rocket motors or other sensitive information. The machine cost roughly $40 million, including research and development. The Soviet Union uses no such imaging device, apparently having confidence in visual-inspection techniques and preferring to economize on INF treaty verification. (Correspondingly, it also relies on the commercial Soviet airline Aeroflot to transport many inspectors to the United States, sacrificing part of the surprise factor of on-site inspection but reducing costs in the process.)

The U.S. government deemed it necessary to improve communications security in the vicinity surrounding the Magna, Utah, portal site to prevent Soviet inspectors from gathering data not related to INF treaty verification. These security measures, which are reported to have cost roughly $100 million, indicate another type of expenditure that may be incurred as arms control treaties take effect.

One-time costs under the INF Treaty, consisting of compliance and on-site inspection costs, are estimated by CBO at between $300 million and $520 million (see Table 1 on page 18). These costs are distributed over the three-year period from mid-1988 through mid-1991. Annual recurring costs are expected to fall between $35 million and $75 million. Thus, total costs through fiscal year 1991 are likely to be in the range of $425 million to $800 million, and for the lifetime of the treaty in the range of $775 million to $1,550 million (in 1990 dollars). Chapter II provides more detail about the methods used to estimate these costs.

CHAPTER II

COSTS OF COMPLIANCE AND ON-SITE INSPECTION

This chapter estimates the costs of compliance and on-site inspection of five arms control accords: the treaties being negotiated in the Strategic Arms Reduction Talks (START) and the Conventional Forces in Europe (CFE) discussions; the Threshold Test Ban Treaty (TTBT) signed in 1974; the Peaceful Nuclear Explosions Treaty (PNET) signed in 1976; and the Chemical Weapons Agreement of 1990 (CWA) for which the inspection protocols are still being negotiated.

The estimates suggest that, for all five treaties combined, one-time costs to the United States should not exceed about $3 billion, and recurring costs should amount to no more than about $0.7 billion a year. These and other estimates of costs in this chapter reflect the expected nature of the treaties as of summer 1990. Since several of the treaties are still being negotiated, the provisions for verification, and hence the likely costs of verification, could change.

Not all of the expenses of compliance and on-site inspection would result in increases in the federal budget. Some costs might be borne by federal agencies without further funding. For example, an on-site inspection by the United States in the Soviet Union might involve the use of C-141 transport aircraft, but these could be existing Air Force aircraft. Some lower-priority tasks that would have been accomplished using C-141 aircraft might be left undone or postponed, or training missions might be conducted while carrying inspectors and equipment. To give another example, some military personnel might be assigned to preparing for or conducting treaty inspections instead of performing lower-priority tasks, or they might work extra hours. In some of these cases, the tasks left undone could be considered opportunity costs associated with verification.

In other cases, verification activities might result in increases in the federal budget. Specialists would be needed to carry out many

on-site inspection tasks. Hiring, training, and equipping these specialists could increase costs. Some of the transit costs and per diem costs associated with sending inspection teams abroad or hosting visiting teams at U.S. sites would require additional direct budgeting, as would most of the costs of portal monitoring.

Some of these costs might have to be borne initially by the military services and other agencies out of funds appropriated for other purposes, since the Congress may not wish to appropriate funds for treaty-related activities before those treaties have been formally approved. For example, lodging might have to be built for Soviet inspectors, portal-perimeter monitoring sites prepared, and weapons-destruction facilities constructed before the Congress has the opportunity to appropriate funds for these purposes. Many of these costs would represent direct drains on the budgets of the agencies concerned, and would have to be met later through direct budgeting.

It is difficult to determine how much of the costs presented in this chapter would result in net additions to the federal budget. On balance, it seems best not to interpret these costs as net additions but rather as the total economic costs associated with compliance and on-site inspection--those that a private firm might identify if asked to perform the same functions using its own personnel and equipment. Actual budgetary additions should not exceed the ranges of costs presented here.

In estimating total costs, one must make judgments about which costs should be attributed to compliance and on-site inspection and which should not. In some cases, the retirement of obsolete weapons that are covered by the treaties might have occurred even in the absence of the treaties. When this is clearly so, the costs of retiring the weapons are not attributed to the treaties. In other cases, when the specific provisions of the treaties, or the environment created by their negotiation, seem a necessary prerequisite to retirement of the weapons, costs of retirement are attributed to the treaties. For example, the costs of destroying chemical weapons are not attributed to formal arms control, since destruction of these weapons had been mandated by the Congress before chemical arms talks had made much progress. Similarly, retirement costs for Poseidon submarines would have been in-

curred in the near future anyway and are not attributable to arms control, though the costs of cutting out their missile tube sections are associated with START. Finally, the costs of drawing down military forces in Europe are attributed to arms control, because U.S. plans to reduce forces in Europe had not gained momentum before the CFE talks were under way.

METHODS FOR ESTIMATING COSTS

CBO took several approaches in estimating costs. Where possible, statements in the draft treaties were used as a basis for estimating key factors such as the frequency of inspection. In some cases, however, the drafts' verification sections are not yet specific; and even where they are specific, uncertainty remains as to how a country would perform its allowed inspections. For virtually all of its information, therefore, CBO has relied on interviews with experts in various federal agencies, including the military services and the intelligence community, in order to estimate factors such as the length and frequency of on-site inspections and the equipment needed for such inspections. The judgments of these experts, and therefore CBO's estimates, were guided wherever possible by experience with verifying the INF treaty, which employs many of the types of inspections that would be used for future treaties.

The cost estimates are presented as ranges, reflecting uncertainty about a number of factors including how many inspections of various types would be conducted, how they would be conducted, what equipment would be employed, how much equipment would be destroyed, how much equipment would have been retired or destroyed even in the absence of arms control, and to what extent certain bases and weapons factories would be reconfigured. In most cases, more precise estimates of the costs will be possible only upon further clarification of treaty provisions, as well as after the parties decide how to comply with the provisions.

Actual Costs for Certain Types of Inspections

The actual costs for various types of inspections, which are based largely on experience under the INF treaty, include expenses for personnel, travel, food, and lodging associated with an individual inspection (see Table 2).

Personnel costs are based on figures of $250 per military person per day and $500 per private contractor per day--including salary and benefits, per diem, overtime, and hardship costs. The duration of quota inspections is taken as between two and seven days, even though most inspections associated with the INF Treaty last the full seven days

TABLE 2. ACTUAL INSPECTION AND ESCORT COSTS INCURRED BY THE UNITED STATES

Type of Inspection[a]	Number of U.S. Personnel Required	Duration (Days)	Costs (Thousands of 1990 dollars)	
			Personnel	Transit
Elimination				
At U.S. base	10 to 15	21	105 to 160	30 to 80
At Warsaw Pact base	10 to 15	21	105 to 160	45 to 80
Short-Notice Quota				
At U.S. base	10	2 to 7	10 to 35	8 to 80
At Warsaw Pact base	10	2 to 7	10 to 35	12 to 80
Suspect-Site Quota				
At U.S. base	10	4 to 7	20 to 35	15 to 80
At Warsaw Pact base	10	4 to 7	20 to 35	20 to 80
Air Reconnaissance				
Over U.S. territory	5 to 10	2	5 to 10	0
Over Pact territory	10 to 20	2 to 4	10 to 40	30 to 80
Portal Rotation				
At U.S. base	50 to 60	21	750 to 1250	60 to 160
At Soviet base	30	21	600 to 700	45 to 80

SOURCES: Congressional Budget Office based on data from the On-Site Inspection Agency, the Arms Control and Disarmament Agency, the Office of Management and Budget, the Office of the Undersecretary of Defense for Acquisition, and the military services.

a. For descriptions of the inspections, see Chapter I.

once all travel and in-country briefings are accounted for. The range of two to seven is based on the assumption that efficiencies of scale may be incorporated into inspections under the START and CFE treaties, with a given inspection team performing perhaps two to four inspections during each trip abroad. Personnel costs are assumed to be incurred over a period twice as long as the duration of the actual inspection, thus including time for preparation, debriefing after the inspection, and rest. Finally, transit costs are taken as the sum of operations costs and capital depreciation. The depreciation incurred in a single long flight of a C-141 transport aircraft is assumed to be $10,000 to $20,000, based on the assumptions that a cargo plane costs $50 million to $100 million, that it has a lifetime of roughly 50 years, and that it flies roughly 100 days per year.

The costs in Table 2 also reflect assumptions about which country pays for which costs, and these assumptions vary according to the treaty being evaluated. In most cases, these costs would be apportioned between the inspecting and inspected parties. The inspecting country would pay its own personnel, of course; in the case of the United States, personnel costs include salary as well as per diem allowances for living expenses. The inspecting country would also pay the international travel costs of reaching points of entry in the country to be inspected. The host country would pay for subsequent travel within its borders, for its own personnel to escort the inspectors, and for meals and lodging for the inspectors. In the case of the prospective CFE treaty, the country being inspected would pay for escort personnel at its bases. Travel, meals and lodging, and escort from entry points to the bases would probably be paid for by the country on whose territory the inspected base is located, which may or may not be the same country as the one running the base. Finally, for the TTBT and PNET nuclear testing treaties, it appears that the inspecting party will pay all costs except those for construction of lodging.

Costs of Other Types of Compliance and On-Site Inspection Activities

Other costs associated with compliance and on-site inspection, such as those for destruction of equipment, are summarized in Table 3. These estimates represent rough approximations, since the actual costs

TABLE 3. COMPLIANCE AND ON-SITE INSPECTION COSTS LIKELY TO BE INCURRED BY THE UNITED STATES
(In millions of 1990 dollars)

Type of Procedure[a]	Approximate Unit Cost
Early Implementation Period	
Construction of Portal	
In the United States	15 to 110
In the Soviet Union	3 to 50
Construction of Destruction Sites	10 to 100
Establishment of Oversight	5 to 50
Modifications to Bases, plus Planning and Practicing Inspections	.25 to 1.0
Preparation of Plans and Shrouds for Suspect-Site Inspections	.05 to .25
Procurement of Air Reconnaissance Aircraft	40 to 60
Entire Implementation Period	
Destruction/Dismantling	
Items limited by nuclear treaty	.01 to .25
Submarines	10 to 20
Items limited by CFE Treaty	.005 to .02
Closing Bases/Relocating Functions	1 to 10
Treaty Lifetime	
Disruption Costs	
At bases	0 to 1.0
At factories	0.1 to 5.0
Annual Oversight and Management	5 to 25

SOURCES: Congressional Budget Office based on data from the On-Site Inspection Agency, the Arms Control and Disarmament Agency, the Office of Management and Budget, the Office of the Under-Secretary of Defense for Acquisition, and the military services; and Jeffrey Grotte, Stanley Horowitz, and Julia Klare, "The Cost of Suspect Site Inspections Under START" (IDA Paper P-2159, Institute for Defense Analyses, Alexandria, Va., 1989).

a. For descriptions of the procedures, see the text.

would vary somewhat for each treaty. Cost estimates are based on interviews with experts and, where possible, on experience under the INF treaty. These costs fall into three main categories: costs that would occur during the early phases of treaty implementation, costs that would be borne during the entire period of implementation, and costs that would continue during the entire period the treaty is in force.

Costs during early implementation--typically the initial 6 to 12 months after the treaty takes effect--would be associated with the following activities: establishment of portal monitoring facilities and lodging for inspectors; communications security work near U.S. sites that would be subject to portal monitoring; establishment of oversight groups and joint verification commissions; construction of destruction sites and lodging for inspectors; physical modifications to U.S. bases needed to protect sensitive information from inspectors; training of personnel and mock inspections at U.S. bases; preparation of shrouding materials and operations procedures for suspect-site inspections at U.S. factories and other sensitive locations; and procurement or modification of C-135 aircraft for the aerial reconnaissance mission.

Other costs would be incurred during the entire period of treaty implementation, not just for the first 6 to 12 months. These costs include expenses for destruction of weapons and equipment. (Actually, some destruction costs could continue over the entire lifetime of the treaties, since the START and CFE treaties would allow continued modernization of weapons as long as older weapons were disabled or destroyed concurrently. But dismantling and destruction costs are likely to be heavily concentrated during the implementation periods.) There would also be expenditures associated with closing down military bases, and with transferring the necessary functions of those bases that were shut down to other bases.

Finally, some costs would be incurred over the lifetime of a treaty. These costs include disruption costs during inspections at bases and factories--for example, compensation to private owners for lost output, and expenditures for continued operation of oversight groups and commissions.

The estimates of costs for these activities reflect specific assumptions about which country would pay for the various costs incurred by different inspection activities. In terms of infrastructure, countries must of course build destruction facilities for their own equipment; they also must pay for any changes to their military bases that are necessary or desirable because of treaty implementation. Each also must pay for its sensors at the portal monitoring sites it operates, and must build the portal-perimeter fences and roads at those sites where it is itself monitored as well as the lodging for the other country's inspectors. The division of responsibility for CFE aerial reconnaissance--and for a similar "Open Skies" agreement discussed below--is yet to be determined.

COSTS OF COMPLIANCE AND ON-SITE INSPECTION

This section summarizes the total costs of compliance and on-site inspection for the five accords.

Costs Under a START Treaty

One-time costs associated with compliance and on-site inspection for a START treaty would range from $410 million to $1,830 million (see Table 4). The one-time costs would be incurred over a seven-year period beginning with ratification of the treaty, though they probably would be concentrated in the first two or three years. Recurring costs should range from $100 million to $390 million each year-- beginning when the treaty takes effect and continuing throughout its lifetime.

One-Time Costs. Baseline inspections and initial planning would be among the first types of one-time costs to be incurred under a START treaty. Baseline inspections are designed to ensure the accuracy of declarations about the numbers and types of equipment at each base. Baseline inspections are likely to involve one visit to each of 100 to 200 Soviet bases, plus escorting Soviet inspectors as they make one visit to each of 20 to 30 U.S. bases.

TABLE 4. COMPLIANCE AND ON-SITE INSPECTION COSTS UNDER A START TREATY (In millions of 1990 dollars)

	One-Time Costs	Annual Costs
One-Time Procedures		
Elimination of U.S. Equipment	260 to 1,090	n.a.
Observation of Soviet Eliminations	10 to 50	n.a.
Baseline Inspections of Declared Sites, Close-Out Inspections, Technical Characteristics Inspections		
In United States	10 to 50	n.a.
In Soviet Union	5 to 25	n.a.
Preparation of Portals in United States	60 to 350	n.a.
Preparation of Portal Sites/Tags in Soviet Union	10 to 100	n.a.
Initial Planning and Management	5 to 15	n.a.
Research and Development	50 to 150	n.a.
Recurring Procedures		
Short-Notice Quota Inspections		
In United States	n.a.	5 to 50
In Soviet Union	n.a.	2 to 5
Suspect-Site Quota Inspections		
In United States	n.a.	1 to 100
In Soviet Union	n.a.	1 to 2
Portal Monitoring		
In United States	n.a.	55 to 135
In Soviet Union	n.a.	25 to 75
Management and Analysis	n.a.	10 to 25
Total Costs	410 to 1,830	100 to 390

SOURCES: Congressional Budget Office based on data from the On-Site Inspection Agency, the Arms Control and Disarmament Agency, the Office of Management and Budget, the Office of the Undersecretary of Defense for Acquisition, and the military services.

NOTE: n.a. = not applicable.

Most of the one-time costs under the START treaty would be associated with destruction of equipment and construction of portal monitoring sites. The START treaty could require that the United States destroy as many as 1,000 ICBM silos and up to 2,000 ICBM and SLBM missiles; it might also require destruction of 100 to 300 bombers and 25 to 30 ballistic-missile submarines. Many of these systems would be retired in the near future even in the absence of arms control, but they generally would not be dismantled or destroyed in the same fashion. For example, ICBM silos probably would not be destroyed by explosions, bombers would not be cut up, and submarine missile tube sections would not be cut out of the vessels. A total of between 30 and 200 inspections might be conducted in each country to observe the elimination of equipment.

Verification of a START treaty is likely to involve portal monitoring at four or five sites in the Soviet Union. This monitoring would require installation of equipment, possibly including the expensive Cargoscan X-ray machine mentioned in the preceding chapter. Portal monitoring probably would be used to ensure that the Soviet Union adhered to limits on the construction of first-stage boosters for mobile ICBMs. For its part, the Soviet Union would probably employ portal monitoring at four or five U.S. sites, requiring substantial infrastructural improvements and construction by the United States. Several of these sites may be near sensitive communications facilities, and the United States might want to modify the facilities to prevent eavesdropping. These modifications, similar to some undertaken in connection with the INF treaty, would add to one-time costs of verifying a START treaty. Finally, portal monitoring may involve tagging missiles with signatures that are difficult to reproduce, so as to facilitate the accurate counting of missile inventories. Although the tags and related equipment probably would be inexpensive, the research and development required might not be.

In the course of drawing down forces to comply with START ceilings, the United States might also have to spend money to reconfigure certain military bases or close others down.

Recurring Costs. Portal monitoring would account for the largest portion of the annual recurring costs of verifying a START treaty. The

recurring costs of portal monitoring would be chiefly personnel costs associated with monitoring Soviet sites and watching Soviet inspectors who were monitoring U.S. facilities. Some 60 to 80 rotations of portal monitoring teams would be likely to take place in each country annually, assuming that the rotations continued to last roughly three weeks as they do under the INF treaty.

Annual inspections would account for another major part of recurring costs. Probably between 25 and 35 of the short-notice quota inspections would be made in each country every year, and perhaps another 10 to 15 special inspections of missile and bomber loadings and 10 to 20 inspections of suspect sites.

Costs Under a CFE Treaty

Costs associated with compliance and on-site inspection under the CFE treaty would probably be several times smaller than those associated with a START treaty, largely because there would be no portal monitoring. One-time costs for a CFE treaty would probably fall between $105 million and $780 million (see Table 5). In all likelihood, these one-time costs would be incurred over a period of two to five years. Recurring costs would range between $25 million and $100 million a year, including the costs of an Open Skies treaty, which is treated here because of its possible overlap with CFE aerial reconnaissance inspections.

One-Time Costs. Baseline inspections designed to verify the declarations in the treaty, and inspections to verify elimination of equipment, would account for much of the one-time costs associated with a CFE treaty. There might be 50 to 200 baseline inspections at U.S. bases in Europe, and 100 to 300 inspections conducted by the United States or U.S.-led teams at bases of the Soviet Union and its Warsaw Pact allies. (The CFE treaty would involve all 16 countries in NATO and all 7 countries in the Warsaw Pact. For purposes of estimating costs, the United States is assumed to lead and pay for 20 percent to 25 percent of all NATO inspections and be the subject of 20 percent to 33 percent of all inspections conducted by Pact members.)

TABLE 5. COMPLIANCE AND ON-SITE INSPECTION COSTS UNDER A CFE TREATY (In millions of 1990 dollars)

	One-Time Costs	Annual Costs
One-Time Procedures		
Observations of Soviet/Warsaw Pact Eliminations	10 to 50	n.a.
Baseline Inspections		
At U.S. bases	20 to 385	n.a.
At Warsaw Pact bases	2 to 15	n.a.
Baseline Suspect-Site Quota Inspections		
At U.S. bases	3 to 30	n.a.
At Warsaw Pact bases	2 to 5	n.a.
Establishment of Aerial Reconnaissance	40 to 180	n.a.
Initial Planning and Management	5 to 15	n.a.
Research and Development	25 to 100	n.a.
Annual Recurring Procedures		
Short-Notice Quota Inspections		
At U.S. bases	n.a.	5 to 25
At Warsaw Pact bases	n.a.	1 to 15
Suspect-Site Quota Inspections		
At U.S. bases	n.a.	1 to 10
At Pact bases	n.a.	0 to 2
Air Reconnaissance		
Over U.S. bases	n.a.	5 to 15
Over Warsaw Pact territory	n.a.	5 to 15
Management and Analysis	n.a.	10 to 25
Total Costs	105 to 780	25 to 100

SOURCES: Congressional Budget Office based on data from the On-Site Inspection Agency, the Arms Control and Disarmament Agency, the Office of Management and Budget, the Office of the Undersecretary of Defense for Acquisition, and the military services.

NOTE: n.a. = not applicable.

Inspections designed to verify elimination of weapons would also be numerous and would account for a substantial part of one-time costs. U.S. inspections at Soviet and other Pact bases could total 50 to 200. There might also be 30 to 60 inspections of suspect sites in the Soviet Union and a comparable number at U.S. facilities in Europe, as the parties sought to ensure that declarations in the treaty were complete and accurate.

Other one-time costs would arise in closing some military bases and reconfiguring others so as to preserve necessary functions. During the initial period, 10 to 50 U.S. bases in Europe might need to be closed, and some of their functions relocated to other bases. It is difficult to determine whether these costs should be attributed to the CFE treaty. Given the improvement in the European security environment that has taken place since CFE negotiations began, many of these bases might be closed even if a CFE treaty is not completed. But if for some reason the CFE negotiations were to be terminated without a treaty, the Soviet Union probably would retain much more combat equipment than the treaty's current provisions would allow, and reductions in NATO forces would probably be more difficult to make. This study thus assumes that the costs of closing the bases would be part of the costs of compliance with the CFE treaty.

A final type of one-time cost would be that of procuring or equipping aircraft to carry out reconnaissance missions under the expected CFE aerial reconnaissance system. This system would be very similar to the much-publicized "Open Skies" arrangement being discussed among the NATO and Warsaw Pact countries, though Open Skies would not be tied to any particular treaty or limited geographically to the ATTU region (between the Atlantic and the Urals). Each reconnaissance regime might require the United States to procure one or two aircraft. One cost is estimated for aerial reconnaissance under both CFE and Open Skies, since they might share some equipment and since they would involve the same countries, even though Open Skies would not be tied formally to CFE.

While substantial, the one-time costs associated with a CFE treaty would be much smaller than those associated with a START treaty because CFE would not require the United States to destroy much

equipment and would not permit portal monitoring. Portal monitoring of production facilities under the CFE treaty apparently has been rejected, primarily because many European countries find the prospect unacceptably asymmetric. They would have risked losing certain technical secrets to inspectors, and their production of arms for foreign sale would have been subjected to greater scrutiny than they might have preferred. Meanwhile, the United States and Canada would not have had to cope with loss of sensitive information during portal monitoring because their production facilities are outside the Atlantic-to-the-Urals region controlled by the treaty; the same would be true of those Soviet production sites east of the Ural Mountains. Similar arguments defeated proposals for electronic "sentries" at various key points along transportation routes in the ATTU region.

Recurring Costs. Like the one-time costs, the annual recurring costs associated with a CFE treaty would be much lower than those for a START treaty--$25 million to $100 million for a CFE treaty compared with costs of $100 million to $390 million under a START treaty. No one type of cost would heavily influence annual recurring costs under the CFE treaty. Perhaps 50 to 150 short-notice quota inspections would be made each year at U.S. bases, and 50 to 200 inspections by the United States at Pact bases, as well as perhaps 10 to 30 U.S.-directed overflights per year under the aerial reconnaissance program. A comparable number of Open Skies flights are accounted for in this section because they might share equipment with the CFE aerial reconnaissance regime.

Costs Under the Threshold Test Ban and Peaceful Nuclear Explosions Treaties

Compliance and on-site inspection costs for the TTBT and PNET treaties dealing with nuclear testing should amount to $85 million to $200 million in one-time costs and $50 million to $100 million in annual recurring costs (see Table 6). The one-time costs probably will all be incurred by the end of the first year after the treaties come into force; many of the research and development costs already have been incurred.

This estimate of recurring costs assumes that the United States would monitor about two to six nuclear tests in the Soviet Union each year, with the actual number depending on how many nuclear detonations the Soviet Union carries out. The treaties permit on-site monitoring of any explosion with a yield over 50 kilotons (kT) through hydrodynamic means. Tests with yields over 35 kT would be subject to on-site sampling of the soil and rock near the detonation point before the test. In the case of the PNET Treaty, any group of explosions with

TABLE 6. COMPLIANCE AND ON-SITE INSPECTION COSTS FOR NUCLEAR TEST TREATIES (In millions of 1990 dollars)

	One-Time Costs	Annual Costs
One-Time Procedures		
Procurement of Equipment	20 to 25	n.a.
Site Preparation	10 to 15	n.a.
Initial Planning and Management	5 to 10	n.a.
Research and Development	50 to 150	n.a.
Recurring Procedures		
On-Site Measurements		
In United States	n.a.	10 to 25
In Soviet Union	n.a.	15 to 40
Equipment Procurement	n.a.	25 to 30
Management and Analysis	n.a.	1 to 5
Total Costs	85 to 200	50 to 100

SOURCES: Congressional Budget Office based on data from the On-Site Inspection Agency, the Arms Control and Disarmament Agency, the Office of Management and Budget, the Office of the Undersecretary of Defense for Acquisition, and the military services.

NOTES: The nuclear test treaties are the Threshold Test Ban Treaty and the Peaceful Nuclear Explosions Treaty.

n.a. = not applicable.

an expected total yield over 150 kT also could be monitored with a local seismic network.[1]

Every June, each party would have to inform the other of all planned tests for the next calendar year with yields that would exceed the notification thresholds of 35 kT and 50 kT. Within 20 days of such notification, the other party would have to indicate its plans for inspections. During the first five years of the treaties, if one country planned fewer than two tests exceeding the notification threshold during a particular calendar year, the other country would have the right to measure the yields of two tests of its choice through hydrodynamic techniques. After the first five years, this minimal annual allowance would be reduced to one per year. Extra on-site inspections would be allowed for several years in the event that a new test site was established by one of the parties.

Tests over 50 kT also could be monitored with three seismic stations located near the test site (and run by the inspecting party). CBO's cost estimate assumes that the United States monitors Soviet tests using a technique for hydrodynamic yield measurement termed CORRTEX (for Continuous Reflectometry for Radius Versus Time Experiments). Developed by the Department of Energy, it involves placing a coaxial cable into a hole near the weapons-emplacement hole, taking samples of the soil, and then measuring the rate at which the cable is destroyed by the explosion as a means of inferring yield. During the U.S.-Soviet Joint Verification Experiment of 1988, this method was employed by the United States at a Soviet test site.

CORRTEX is believed capable of measuring yields with an error of no more than about 30 percent. This is better than methods that rely on seismic sensors at sites remote from the nuclear detonation; remote seismic methods typically err by 50 percent or more.[2]

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1. The United States has not conducted any peaceful nuclear explosions since 1973 and plans none; the Soviet Union has not conducted any since 1988 but has sought to preserve future rights to do so. See White House Fact Sheet, "The Nuclear Testing Protocols," June 1, 1990.

2. For more detail on this subject, see Office of Technology Assessment, *Seismic Verification of Nuclear Testing Treaties* (1988), pp. 113-139.

This cost estimate assumes that CORRTEX measurements continue indefinitely. But since they are expensive, they might be discontinued after several years. By that time, experience might have allowed calibration of the geology and geophysics at the site in question, permitting remote seismic devices to make measurements as accurate as those made by the CORRTEX method. Still, it is assumed here that on-site CORRTEX measurements would be continued anyway--if only for their symbolic value.

In contrast to the START and CFE treaties, the inspecting party probably would pay all logistics and meal costs under the TTBT and PNET treaties. The host country apparently would provide lodging.

Costs Under the Chemical Weapons Agreement

Compliance and on-site inspection costs for the Chemical Weapons Agreement are likely to range from $45 million to $220 million in one-time costs and from $15 million to $70 million in annual recurring costs (see Table 7). These figures do not include the treaty-mandated elimination costs, since the Congress had mandated elimination of all existing U.S. chemical weapons before the U.S.-Soviet negotiations or U.N. negotiations showed promise of succeeding. The one-time costs would be incurred primarily during the first one to two years of the agreement; indeed, they already are being incurred.

One-time costs include those for visits under a "Phase I" and "Phase II" of inspections. The United States and the Soviet Union currently are conducting several Phase I visits at those declared sites where chemical weapons were produced or where they currently are stored, and will complete this process in calendar year 1990. Each visit is expected to resemble INF inspections in number of personnel, duration, and general procedures. A Phase II series of inspections may begin shortly thereafter, contingent on progress at the multilateral U.N. talks, and may involve 5 visits to declared sites and 10 challenge inspections at other sites (such as pharmaceutical factories).

TABLE 7. COMPLIANCE AND ON-SITE INSPECTION COSTS UNDER THE CHEMICAL WEAPONS AGREEMENT
(In millions of 1990 dollars)

	One-Time Costs	Annual Costs
One-Time Procedures		
Elimination Costs		
In United States	10 to 20	n.a.
In Soviet Union	1 to 10	n.a.
Baseline Inspections		
In United States	1 to 2	n.a.
In Soviet Union	2 to 10	n.a.
Suspect-Site Inspections		
In United States	1 to 5	n.a.
In Soviet Union	1 to 2	n.a.
Equipment Procurement	1 to 10	n.a.
Initial Planning and Management	5 to 10	n.a.
Research and Development	25 to 150	n.a.
Recurring Procedures		
Elimination Costs		
In United States	n.a.	5 to 10
In Soviet Union	n.a.	5 to 15
Short-Notice Quota Inspections		
In United States	n.a.	1 to 2
In Soviet Union	n.a.	1 to 10
Suspect-Site Quota Inspections		
In United States	n.a.	1 to 10
In Soviet Union	n.a.	1 to 5
Equipment Procurement and Maintenance	n.a.	1 to 10
Management and Oversight	n.a.	5 to 10
Total Costs	45 to 220	15 to 70

SOURCES: Congressional Budget Office based on data from the On-Site Inspection Agency, the Arms Control and Disarmament Agency, the Office of Management and Budget, the Office of the Undersecretary of Defense for Acquisition, and the military services.

NOTE: n.a. = not applicable.

After Phase I, Phase II, and the baseline inspections, the agreement provides for annual inspections of three main types: elimination inspections, short-notice quota inspections, and challenge (suspect-site) inspections. The elimination inspections may involve the continuous presence of inspectors at each of the eight anticipated U.S. sites and at each of an undetermined number of Soviet sites. The short-notice quota inspections may involve one inspection per year at each storage site and each former production site--perhaps 10 to 30 inspections per year per country. Finally, the challenge inspections may number 10 to 20 per year, if the START, CFE, and Phase II inspection programs offer any guide.

Other costs will be incurred for the sampling and testing equipment needed to acquire and process samples of various chemicals. The initial equipment is expected to be rather simple. More sophisticated devices may be employed in the future as they become available. (The more sophisticated devices may be used largely as a means of assessing their effectiveness before a potential United Nations-sponsored multilateral Chemical Weapons Convention takes effect, which could be even more of a challenge to verify.) These equipment costs show up partly as one-time implementation costs in Table 7, and partly as annual recurring costs in future years as sampling equipment is upgraded. There also would be one-time costs associated with building lodging for Soviet inspectors at destruction sites.

Destruction costs for existing chemical weapons, recently estimated at $3.4 billion or more by the General Accounting Office, are not included here as treaty-related expenditures. In the mid-1980s the Congress mandated destruction of U.S. unitary chemical weapons by 1997, primarily on safety grounds, and Congressional support for funding the program has not wavered. (The delays in destroying these stocks have arisen from technical difficulties in building destruction facilities and transporting chemicals to them safely.) The level of funding for this function thus does not seem tied to the U.S.-Soviet Chemical Weapons Agreement.[3] The modest destruction costs

3. See, for example, General Accounting Office, *Chemical Weapons: Obstacles to the Army's Plan to Destroy Obsolete U.S. Stockpile* (1990).

itemized here are for lodging Soviet inspectors and procuring sampling devices for U.S. inspectors.

The intent of U.S. policy is that the Chemical Weapons Agreement between the United States and the Soviet Union will lead to a broader multilateral treaty under U.N. auspices. A Chemical Weapons Convention currently being negotiated would ban the production, stockpiling, and use of all toxic chemical agents. Since the convention does not seem likely to be completed in the near term, and since its verification provisions remain very sketchy, no attempt has been made to provide detailed estimates of verification and compliance costs in this study. Nevertheless, because verification could be expensive, it is useful to estimate possible costs, even if in a very rough and approximate fashion.

A Chemical Weapons Convention (CWC) would undoubtedly cost much more to verify than the Chemical Weapons Agreement, but it seems unlikely that annual recurring costs would exceed about $0.5 billion or that one-time costs would exceed $1 billion. There are roughly three to five times as many chemical factories worldwide as there are in the United States and the Soviet Union combined. Thus, the costs of verifying a CWC might be roughly three to five times those of verifying the Chemical Weapons Agreement between the United States and the Soviet Union--assuming that the necessary numbers of inspections are proportional to the number of inspectable sites, and that the sampling equipment used for the CWC would be similar to that used for the Agreement.

Another approach, which results in a slightly higher estimate, is to use the CFE and START drafts as a basis for estimating CWC verification costs. The CFE treaty would involve hundreds of individual inspections during the baseline period and during each subsequent year of the treaty; a CWC probably would involve a comparable number or even more. The number of inspections would be large because there are tens of thousands of chemical plants capable of producing chemical agents; even if only 1 percent to 10 percent were inspected each year, the number of inspections would be substantial. The costs per inspection might be comparable with those under the

TABLE 8. COMPLIANCE AND ON-SITE INSPECTION COSTS FOR ARMS CONTROL TREATIES (In millions of 1990 dollars)

Treaty or Agreement	One-Time Costs	Annual Costs
Strategic Arms Reduction Talks Treaty	410 to 1,830	100 to 390
Conventional Forces in Europe Treaty	105 to 780	25 to 100
Threshold Test Ban Treaty and Peaceful Nuclear Explosions Treaty	85 to 200	50 to 100
Chemical Weapons Agreement	45 to 220	15 to 70
Total	645 to 3,030	190 to 660

SOURCES: Congressional Budget Office based on data from the On-Site Inspection Agency, the Arms Control and Disarmament Agency, the Office of Management and Budget, the Office of the Undersecretary of Defense for Acquisition, and the military services.

CFE treaty. But there would be additional costs of reimbursing private companies for losses in output caused by the inspections, and these costs might be comparable with those for suspect-site inspections at private factories under the START treaty. This line of reasoning suggests that inspection costs for a CWC might run to hundreds of millions of dollars each year.[4]

Summary of Costs and Their Division by Agency

Costs for all five accords--START, CFE, TTBT, PNET, and CWA--are summarized in Table 8. Together, compliance and on-site inspection for all of them would involve one-time costs of between $645 million and $3 billion. Annual recurring costs would range from $190 million to $660 million per year over the lifetimes of the treaties.

The majority of these costs--in some cases, as much as three-quarters of them--would be borne by the military services and the

4. For more information on a CWC, see, for example, Kyle B. Olson, "The U.S. Chemical Industry Can Live with a Chemical Weapons Convention," Arms Control Today (November 1989), pp. 21-25.

agencies that make up the intelligence community. Another substantial portion would appear in the budget of the On-Site Inspection Agency, a Defense Department agency set up to carry out the on-site inspection provisions of the INF treaty. The remainder of the costs would be paid by the Department of Energy, the Defense Nuclear Agency, the Office of the Secretary of Defense, and the Arms Control and Disarmament Agency. Appendix A provides more detailed estimates of the costs borne by these federal agencies.

CHAPTER III

COSTS OF NATIONAL TECHNICAL MEANS OF VERIFICATION

On-site inspections are only the newest element of extensive intelligence and verification networks operated by the United States and the Soviet Union. The two military superpowers have long had other ways of examining each other's arsenals. Aside from human intelligence, they also have elaborate technologies for gathering intelligence known as "national technical means," or NTM. This chapter, based on unclassified data, discusses the potential costs of expansions in the U.S. NTM system that could result, at least in part, from pending arms control accords.

National technical means reportedly include hundreds of assets, many of which are very sophisticated and expensive: satellites, various types of reconnaissance aircraft, and sensors located at ground stations and on naval vessels. Purchasing and operating these systems costs the United States many billions of dollars per year--much more than the potential costs associated with on-site inspections.

Through NTM it is possible to make images of other countries' military and industrial equipment, listen to their communications, gain information about their radars, observe the tactical operations of their military forces, monitor their missile tests, provide early warning of any concentration of adversarial forces or of an imminent attack, detect possible nuclear detonations in the atmosphere or beneath the Earth's surface, and obtain scientific data on meteorological conditions, gravitational fields, and other countries' geographies. Some of these same assets also provide communications capabilities. Although the intelligence budget as a whole probably has grown only slightly

since the early 1950s, that part of it dedicated to NTM has reportedly grown greatly (primarily at the expense of spending on covert activities).[1]

Satellites and seismic ground stations are the most relevant of all these national technical means for verifying most arms control agreements, because of their ability to monitor what takes place deep within the territories of other countries. Satellites are the more expensive of these two categories. Since there has been considerable discussion within the government about whether or not satellite fleets should be expanded to verify prospective arms accords, the remainder of this chapter focuses on satellites.

All the information presented in this chapter, and throughout this study, has been derived from unclassified sources. Official statements about the costs, operations, and planned deployments of satellites and other national technical means are not publicly available.

THE COST OF ADDITIONAL SATELLITES

Deployment of more satellites to aid in verifying arms control treaties could add substantially to the costs of verification. Precise costs are highly classified, but these satellites are expensive. For example, the KH-11 and KH-12 satellites, which use optical and infrared techniques to make detailed images of objects on Earth, probably cost nearly as much as the Space Telescope, since they are believed to be similar in size and basic operation. This analogy suggests that each satellite costs between $1.25 billion and $1.75 billion, including launch costs of around $0.2 billion. The so-called Lacrosse satellites, which use a synthetic-aperture radar to form images of ground objects, are believed to cost somewhere in the range of $0.5 billion to $1.0 billion apiece,

1. For useful overviews of the U.S. intelligence and communications network, see Bruce D. Berkowitz and Allan E. Goodman, *Strategic Intelligence for American National Security* (Princeton, N.J.: Princeton University Press, 1989); the estimates of how intelligence spending has changed over the last four decades appear on p. 144. Other useful general references are Allan Krass, *The Verification Revolution* (Cambridge, Mass.: Union of Concerned Scientists, 1989); Robert E. Harkavy, *Bases Abroad*, Stockholm International Peace Research Institute (New York: Oxford University Press, 1989); Jeffrey T. Richelson, *The U.S. Intelligence Community* (Cambridge, Mass.: Ballinger, 1989).

again including launch costs (see Table 9). Some signals intelligence satellites, also useful for verifying treaties, reportedly have comparable unit costs.

The deployment of more satellites, particularly several additional imaging satellites, could enhance U.S. ability to verify arms control treaties.[2] The need to verify arms control treaties places a premium on certain intelligence activities, such as watching the movements of mobile missiles and making highly accurate counts of deployed weapons. Such concerns may cause the United States to want more frequent coverage of certain targets than would have been the case without the treaties. Increased coverage might not require a high percentage of any single satellite's time, but it might require the kind of near-continuity in surveillance coverage that is only possible with a large constellation of satellites (see Appendix B). Arms control could also increase the political importance of accurately assessing equipment inventories, making it more important to monitor certain sites more closely than in the past.

Satellites may also be more likely to receive budgetary support if arms control agreements are pending. 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.

IS THERE A CASE FOR ADDITIONAL SATELLITES?

These arguments notwithstanding, verification of prospective arms control treaties may not require deployment of more satellites. Most if not all of the satellite information necessary to verify arms control treaties is already being gathered to meet other intelligence needs. Indeed, arms control could even reduce the need for certain types of satellite coverage, at least in some measure. If the Soviet Union were

2. A "Boren-Cohen Initiative" may provide one indication of the sentiment for adding more satellites. This initiative was reportedly attached, at least informally, to the Senate's ratification of the INF Treaty in 1988. The initiative apparently called for adding more imaging satellites, perhaps enough to bring the number in orbit and operation to between 5 and 12 satellites compared with the 2 to 3 satellites now thought to be in orbit. Doing so would entail buying and launching about 1 to 3 satellites per year *indefinitely*, given the short lifetimes of low-orbit satellites.

to shut down some bases and production facilities, fewer of those sites would have to be monitored intensively. Data bases and on-site inspections associated with the treaties may provide information previously gained from satellites. Moreover, an arms control treaty that significantly reduced the military threat to the United States--for example, the prospective CFE treaty--could reduce the acute need for prompt detection of troop movements or expanded military production, and thus reduce the need for satellites.

TABLE 9. ESTIMATED DATA ON U.S. RECONNAISSANCE SATELLITES
(Costs in billions of 1990 dollars)

Satellite	Number in Orbit 1990	Number in Orbit 2000	Lifetime in Years	Unit Cost
Lacrosse	1 to 2	2 to 6	3 to 8	0.5 to 1.0
KH-12/KH-11+	1 to 3	3 to 6	3 to 8	1.25 to 1.75
KH-11	1 to 2	0	3 to 4	1.25 to 1.75
Magnum	2	4	5 to 10	0.25 to 0.75
Jumpseat	2	0	5 to 10	0.05 to 0.25
White cloud	16	16	5 to 10	0.05 to 0.25
Navstar GPS	18	24	5 to 10	0.05 to 0.1
Milstar	0	9	5 to 10	0.75 to 1.0
TDRSS	2	0	5 to 10	0.05 to 0.1
DSP	5	0	2 to 5	0.25 to 0.5
BSTS	0	5	5 to 10	0.5 to 1.25

SOURCES: Congressional Budget Office estimates based on Ashton B. Carter, "Satellites and Anti-Satellites: The Limits of the Possible," *International Security* (Spring, 1986), pp. 46-98; Eric H. Arnett, "Antisatellite Weapons" (American Association for the Advancement of Science, Washington, D.C., 1990); Jeffrey T. Richelson, *America's Secret Eyes in Space* (New York: Harper and Row, 1990); William E. Burrows, *Deep Black: Space Espionage and National Security* (New York, N.Y.: Random House, 1986); Union of Concerned Scientists, *The Fallacy of Star Wars* (New York: Random House, 1983). All sources are unofficial and unclassified.

Estimates for the year 2000 are based on the Congressional Budget Office's understanding of current plans.

NOTES: Navstar GPS = Navigation Satellite with Timing and Ranging Global Positioning System; Milstar = Military Strategic and Tactical Relay; TDRSS = Tracking and Data Relay Satellite System; DSP = Defense Support Program; BSTS = Boost Surveillance and Tracking System.

Unfortunately, this study cannot resolve the issue through a review of U.S. planning documents, since virtually all data on satellite systems--whether technical, budgetary, or operational--is highly classified. It is clear, however, that in the current fiscally austere environment added satellites will be difficult to buy. The Boren-Cohen Initiative, which sought more satellites to help verify the INF Treaty and other treaties being negotiated, is reportedly unlikely to receive full funding in the next few years.

In summary, the cost of additional satellites could add substantially to verification costs. But despite the efforts of those who believe that more satellites will be needed to achieve acceptable levels of verification for the prospective arms accords, not many seem likely to be procured.

CHAPTER IV

COMPARING COSTS WITH SAVINGS

This study has focused on the costs associated with compliance and verification. A comparison of these costs with the savings that could result from the arms control treaties is also useful, particularly in an era of declining military budgets. This chapter presents estimates of the net savings after deducting the costs of verification that were estimated in preceding chapters. The estimates suggest that the arms treaties--particularly the START and CFE treaties--would eventually be likely to result in savings over and above the costs of compliance and verification. However, in the first year or two after the treaties are put into effect, costs could exceed savings.

SAVINGS ASSOCIATED WITH REDUCED FORCES AND LOWER PROCUREMENT

The START and CFE treaties, if successfully completed, seem likely to result in reductions both in the numbers of U.S. military forces and in the procurement of associated weapons that would lead to substantial savings. Much smaller savings are likely to be associated with the other three treaties discussed in this study.

The START and CFE Treaties

In an analysis completed earlier this year, CBO estimated that the START and CFE treaties would require changes that would eventually reduce the annual level of defense spending by about $9 billion compared with its 1990 level.[1] That analysis assumed that NATO's proposed version of the CFE treaty, and the then-current version of the

1. Congressional Budget Office, "Meeting New National Security Needs: Options for U.S. Military Forces in the 1990s," CBO Paper (February 1990), p. x.

START treaty, would be agreed to and implemented; those versions are quite similar to the versions used in this study to estimate costs.

In estimating possible budgetary effects, CBO assumed that the NATO allies would divide up the cuts among themselves in proportion to the numbers of military forces each ally currently has in Europe. The United States could accommodate its share of the CFE reductions in many ways. To illustrate budgetary effects, CBO assumed that the United States removed from Europe--and eliminated from its military forces--two of the four and two-thirds armored divisions that the Army currently has stationed in Europe, and two of the approximately eight tactical fighter wings currently stationed there. These reductions would reduce U.S. military forces in Europe by more than 80,000 personnel, almost 25 percent of today's level of about 325,000 personnel.

As with a CFE treaty, the United States could accommodate a START treaty in many different ways, some of which would save more money than others. For purposes of illustrating the minimal budgetary savings consistent with implementation of a treaty, CBO assumed that the United States would comply with START primarily by retiring older forces, thus permitting continued modernization of the remaining U.S. strategic forces. As a result, CBO assumed that the United States would retire Minuteman land-based missiles, B-52 strategic bombers, and Poseidon submarines. (The Poseidon submarines and some of the B-52s were scheduled for retirement independent of any arms treaty.)[2]

Averaged out over a long time period, CBO's estimate of the minimal savings from START and CFE is $9 billion, a reduction in military spending of about 3 percent compared with the 1990 level. These savings include the operating and procurement costs associated with the military units that would be removed. In addition, the savings assume reductions in the overhead activities that support these units.

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2. Congressional Budget Office, "Budgetary and Military Effects of the Strategic Arms Reduction Talks (START) Treaty," CBO Memorandum (February, 1990).

The estimate of $9 billion represents a conservative assessment of savings. Savings could be substantially larger if the United States accommodated the START treaty by buying fewer new weapon systems, or if--together with its European allies--the United States reacted to the CFE treaty by deciding that threats had subsided enough to permit even larger reductions in U.S. forces than those assumed by CBO.

A different approach to estimating savings could lead to the conclusion that the START and CFE treaties themselves would generate little or nothing in the way of budgetary reductions. The lessened threat to U.S. security posed by the Soviet Union and its Warsaw Pact allies has already created a security environment that could enable reductions in forces much larger than those CBO assumed would be associated with the START and CFE treaties. Some or all of the force reductions associated with the treaties might therefore take place even without the treaties, suggesting that the treaties themselves would lead to little or no cost savings. However, the treaties seem to be prerequisites to certain reductions in forces by both sides. For example, it seems unlikely that the Soviet Union would destroy SS-18 ICBMs or thousands of tanks currently deployed in Europe unless this was mandated by the START and CFE treaties. Without the assurance of such Soviet force reductions, the United States might not choose to make large cuts in its own forces.

Other Treaties

In contrast to the START and CFE treaties, the others examined in this study would probably not result in any substantial budgetary savings. The Chemical Weapons Agreement could lead to the cancellation of chemical weapons production programs, yielding savings of about $0.2 billion per year.[3] The nuclear test treaties are not expected to add to savings.

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3. See Congressional Budget Office, *Reducing the Deficit: Spending and Revenue Options* (February 1990), pp. 45-46.

POTENTIAL SALVAGE AND COST AVOIDANCE

In addition to resulting in smaller, less costly military forces, arms control treaties may permit salvage of some materials. They may also free up certain assets that could be used for other functions, thus avoiding some costs or yielding other benefits.

Salvage and cost avoidance would probably be associated primarily with START. The most obvious example is fissile materials, which are the explosive materials in nuclear warheads. Some fissile materials might be reclaimed for reuse from warheads retired as a START treaty was carried out (in theory, warheads also could be reused in their entirety in some cases, though it is doubtful that this would take place in practice given current Department of Energy policies). Reuse would be especially important in the case of tritium, a radioactive material that is put into warheads to increase their explosive yield. Tritium decays quickly--half of any given amount changes atomic form within 12 years--and is currently not in production in the United States because of problems at the Savannah River production facility. Reusing tritium would reduce the need to produce new tritium, thus lessening the need to restart the Savannah River facility quickly. There would be costs associated with disassembling the warheads in order to reach the tritium. But these costs would have been realized at some point even in the absence of arms control, whereas the cost avoidance associated with reclaiming a large supply of tritium would not have been realized without a treaty requiring cutbacks in deployed weapon systems.

Other types of cost avoidance could be realized through arms control. Most notably, some retired ICBMs might be used as launching vehicles for small satellites. Certain small electronic components and guidance systems from retired warheads, missiles, and aircraft also might be reused.

A CFE treaty might also produce benefits of a sort--though probably not cost avoidance in the usual sense--if it allowed the United States to give retired military equipment to a NATO ally rather than destroy it. The ally, perhaps Turkey, could then destroy a corresponding amount of its own older equipment, so that NATO as a whole would

be in compliance with overall treaty limits. This transfer of equipment would constitute a form of security assistance, but might not replace money that would otherwise have been donated. While not eliminating actual expenditures, it might produce benefits in the form of enhanced alliance security that could be assigned a dollar-equivalent value.

If all these potential areas of salvage and cost avoidance were pursued aggressively, the United States might avoid costs of as much as $6 billion (see Table 10). Estimates for the dollar values associated with these items are little more than informed guesses. Retired missiles are assumed to be worth from $5 million to $20 million each, roughly the range of values for boosters currently used to launch small satellites. Tritium is assumed to be worth 5 percent to 10 percent of the value of a warhead, roughly $100,000 per warhead. Salvageable electronic components are assumed to be worth as much as 10 percent of the value of a small missile, or $50,000 to $100,000.

While the potential for savings is substantial, one cannot predict how many of these areas of cost avoidance would actually be pursued

TABLE 10. POSSIBLE COST AVOIDANCE FROM SALVAGE AND REUSE RESULTING FROM TREATY-MANDATED REDUCTIONS IN WEAPON SYSTEMS
(In millions of 1990 dollars)

	Cumulative Cost Avoidance
Reuse of Warheads or Their Tritium	50 to 500
Salvage of Other Electronic Components	0 to 500
Use of Intercontinental and Sea-Launched Ballistic Missiles	0 to 4,000
Transfer of Conventional Equipment as Security Assistance	0 to 1,000
Total Possible Cost Avoidance	50 to 6,000

SOURCE: Congressional Budget Office.

and by how much the costs would be reduced. Most likely, tritium from some retired warheads would be reused, though it is not clear how much money would be saved as a consequence. Because tritium decays so quickly, the United States will eventually have to restart its source of production even if a START treaty is put into effect. A hypothetical "START II" treaty that cut forces even further, however, could probably defer this need until the next century.

Other forms of cost avoidance are less likely to occur, such as the reuse of whole warheads or the recycling of electronic components into other pieces of equipment. Nor is it clear whether retired missiles could be used for launching satellites, since their reliability as launchers for expensive satellites is uncertain. Moreover, the Administration may not be willing to risk its plan for commercialization of the satellite-launch market by saturating that market with low-cost boosters.[4] Finally, a CFE treaty may place limits on equipment held by individual countries or in particular zones that would require the United States to destroy some equipment currently deployed in Europe rather than transfer it to allies.

The timing of these potential benefits would vary with the item. Tritium, other components of warheads and missiles, and CFE-limited equipment represent assets whose reuse could result in quick payoffs. Missiles would be used over a longer period in all likelihood, especially because the U.S. space-launch market typically demands no more than about 10 small boosters per year. If a large strategic defense system was eventually deployed, it might use boosters at a fast rate; they also could be used extensively during testing of such a system. But missiles would probably become unreliable because of aging before more than 100 to 200 could be used.

4. For general descriptions of this issue, see Office of Technology Assessment, *Access to Space* (1990), pp. 41-52; General Accounting Office, *Space Launch* (1990); Department of Defense and National Aeronautics and Space Administration, "National Space Launch Program: Report to Congress," March 14, 1989.

COMPARING COSTS WITH SAVINGS

How would the savings estimated in this chapter compare with the costs of compliance and verification? Savings associated with reductions in military forces would eventually total about $9 billion a year (see Table 11). Costs of compliance and verification for the five treaties included in this study would total no more than about $3 billion in one-time costs and about $660 million a year in recurring costs. These treaties thus should result in substantial net savings.

Net savings could even be larger than those suggested in Table 11. As was mentioned earlier, some of the activities required for compliance and verification might not result in additions to the budget but instead might be accommodated by forgoing lower-priority activities. To the extent that military items eliminated because of the treaties could be salvaged or reused, net savings could also be increased.

TABLE 11. BALANCE SHEET OF THE COSTS AND SAVINGS FROM ARMS CONTROL (In billions of 1990 dollars)

	One-Time Costs	Annual Costs	Annual Savings
Strategic Arms Reduction Talks Treaty and Conventional Forces in Europe Treaty	0.52 to 2.61	0.13 to 0.49	9.0
Threshold Test Ban Treaty, Peaceful Nuclear Explosions Treaty, and Chemical Weapons Agreement	0.13 to 0.42	0.07 to 0.17	0.2
Total	0.65 to 3.03	0.20 to 0.66	9.2

SOURCES: Congressional Budget Office based on data from the On-Site Inspection Agency, the Arms Control and Disarmament Agency, the Office of Management and Budget, the Office of the Undersecretary of Defense for Acquisition, and the military services.

NOTE: The balance sheet does not include the possible costs of additional satellites or of a Chemical Weapons Convention under U.N. auspices. But it does include many costs that might not require budgetary additions. The balance sheet also does not include possible savings from salvage or reuse, or from major reductions in military forces that, while not directly tied to arms control, might be facilitated by it.

Net savings, however, could also be at least somewhat smaller than those shown in Table 11--for example, if the United States completed and signed a Chemical Weapons Convention involving most or all countries. Such a convention would entail additional costs of compliance and verification of up to $1 billion in one-time costs and up to $0.5 billion in annual recurring costs.

Net savings could also be lower if the arms control treaties required more satellite monitoring. One cannot accurately estimate how much it would cost to expand satellite monitoring, although the added costs do not seem likely to be of the same magnitude as potential savings.

While net savings should eventually be realized, arms control treaties could result in higher net costs for the first year or so. During this early period, large one-time costs could be incurred in complying with the treaties and putting verification procedures in place, while the savings associated with smaller military forces would not yet be fully realized. Maximum treaty-related savings might not be realized until about five years after the treaties took effect.

APPENDIXES

APPENDIX A

COMPLIANCE AND ON-SITE INSPECTION PROCEDURES AND COSTS, BY FEDERAL AGENCY

The attached tables itemize the functions associated with compliance and on-site inspection by the U.S. agency or department performing the function and estimate the associated costs. The cost figures are quite approximative, but illustrate the main actors in various types of activities and the scope of their participation.

Most of the costs would be incurred by a category of agencies including the military services and the intelligence community. It is necessary to treat this group of agencies as a single category largely because classification restrictions prevent more detailed descriptions. The On-Site Inspection Agency also would bear a large share of the costs associated with compliance and on-site inspection. The Department of Energy (DoE) and the Defense Nuclear Agency are very active in research and development of verification technologies; DoE also would be very active in verifying the nuclear test treaties.

TABLE A-1. COMPLIANCE AND ON-SITE ACTIVITIES, BY AGENCY AND DEPARTMENT

Military Services and Intelligence Community	On-Site Inspection Agency	Department of Energy	Defense Nuclear Agency	Office of the Secretary of Defense and Arms Control and Disarmament Agency
		Verification R&D	Verification R&D	
Planning, Oversight	Planning, Oversight	CORRTEX (Development)	Cargoscan	Planning, Oversight
Inspections	Inspections	Seismic Monitoring		
Escorts	Escorts	Geological Sampling		
Some Portal Activities	Most Portal Activities	Tagging		
Communications Security	Transit			
Destruction of Equipment				

SOURCE: Congressional Budget Office.

NOTE: CORRTEX = Continuous Reflectometry for Radius Versus Time Experiment.

TABLE A-2. ESTIMATED COSTS OF COMPLIANCE AND ON-SITE ACTIVITIES BY AGENCY (In millions of 1990 dollars)

Time Horizon of Expenditure	Military Services and Intelligence Community	On-Site Inspection Agency	Department of Energy	Defense Nuclear Agency	Office of the Secretary of Defense and Arms Control and Disarmament Agency
Strategic Arms Reduction Talks Treaty					
One-Time	305 to 1500	45 to 120	25 to 50	7 to 35	30 to 125
Annual	35 to 220	60 to 50	0	2 to 10	5 to 10
Conventional Forces in Europe Treaty					
One-Time	60 to 610	20 to 90	10 to 30	5 to 20	10 to 30
Annual	10 to 45	10 to 35	0	2 to 10	5 to 10
Threshold Test Ban Treaty and Peaceful Nuclear Explosions Treaty					
One-Time	20 to 50	5 to 10	50 to 85	10 to 50	1 to 3
Annual	5 to 10	20 to 40	20 to 40	3 to 5	1 to 3
Chemical Weapons Agreement					
One-Time	15 to 85	5 to 20	10 to 50	7 to 30	8 to 35
Annual	5 to 35	5 to 20	0	2 to 5	5 to 10
Intermediate-Range Nuclear Forces Treaty					
One-Time	105 to 190	35 to 60	40 to 80	40 to 50	30 to 40
Annual	10 to 20	20 to 45	0	2 to 5	1 to 3
Total					
One-Time	505 to 2,435	110 to 300	135 to 295	70 to 185	80 to 235
Annual	65 to 330	115 to 290	20 to 40	10 to 35	15 to 35

SOURCE: Congressional Budget Office.

APPENDIX B

NATIONAL TECHNICAL MEANS OF VERIFICATION AND INTELLIGENCE

As noted in the text, intelligence and verification are activities to which the United States has devoted substantial resources for decades. They include far more than the explicit arrangements for on-site inspection in prospective arms control treaties. Although it is possible to calculate the costs of on-site inspections without discussing other types of verification, it is not possible to understand the role and the contribution of such inspections without adopting a much broader perspective.

In particular, to understand verification and verifiability, it is essential to have an understanding of the capabilities and the costs of "national technical means" of intelligence-gathering--especially satellites. Some of the key data and concepts are presented in this appendix for the interested reader, with further references for those who wish greater detail.

It is worth reiterating that these satellite systems have many purposes other than verification of arms control agreements. The purchase of satellites, or an increase in the intelligence budget, thus does not necessarily mean that the resources will be used to improve verification capabilities.[1]

1. Among the most helpful sources on satellites are Ashton B. Carter, "Satellites and Anti-Satellites: The Limits of the Possible," *International Security* (Spring, 1986), pp. 46-98; Eric H. Arnett, "Antisatellite Weapons" (American Association for the Advancement of Science, Washington, D.C., 1990); Jeffrey T. Richelson, *America's Secret Eyes in Space* (New York: Harper and Row, 1990); William E. Burrows, *Deep Black: Space Espionage and National Security* (New York, N.Y.: Random House, 1986); Union of Concerned Scientists, *The Fallacy of Star Wars* (New York: Random House, 1983).

IMAGING SATELLITES

Imaging satellites provide photographic or photographic-like images using cameras or sensors. These satellites, as well as other reconnaissance satellites, reportedly are managed by the National Reconnaissance Office (NRO). The images obtained from these satellites are used by many different agencies in the intelligence community, including the National Photographic Interpretation Center, the Central Intelligence Agency, the Defense Intelligence Agency, the Defense Mapping Agency, the services' intelligence agencies, and the unified and specified military commands.

Photographic imagery uses either film cameras or electro-optical cameras to construct pictures of targets. The main weaknesses of this method of imaging are its inability to see through cloud cover and, usually, its inability to take nighttime images. Thermal imagery uses heat patterns to construct an image of a target at any time day or night, but not through cloud cover. Radar imagery constructs an image of an object by bouncing electromagnetic waves off an area or an object. The data concerning the time it takes the pulses to return, and their strength when they return, are used to create an image. This method is very useful because it can produce images at night and through cloud cover. All three types of imagery are employed by current U.S. satellites, which apparently include several types.

Lacrosse Satellite. The Lacrosse satellite flies in an orbit at about 300 to 500 miles (about 500 to 800 km) above the earth. It uses radar imagery, enabling it to penetrate cloud cover. Its resolution is between 2 and 10 feet, enough to detect all CFE and START treaty-limited items, but not necessarily adequate to distinguish and classify CFE treaty items.

KH-12/KH-11+. The KH-12, also known as the KH-11+ or the KH-11 follow-on, is an instant transmission imaging satellite. Reportedly, its thermal-imaging and light-enhancement capabilities enable it to take pictures at night. It flies in a low-Earth orbit, as low as 200 km or so. Its resolution could be even better than six inches. An advantage of the KH-12 is that it can be refueled in flight by the space

shuttle, giving it a longer life span and greater maneuverability than previous imaging satellites.

KH-11. The KH-11 is an instant transmission imaging satellite orbiting roughly 200 to 500 km above the Earth's surface. Its resolution may be as good as six inches, making it adequate for detailed descriptions of all treaty-related items.

SIGNALS INTELLIGENCE SATELLITES

Signals intelligence satellites intercept electronic and communications signals. The National Security Agency reportedly is the main agency for interpreting signals intelligence. Three main signals intelligence satellites are now in use.

Magnum. The Magnum satellite is used to pick up communications and telemetry signals (the latter are signals sent by missiles during test flights containing data about performance). These satellites reportedly are sensitive enough to pick up signals from a radio the size of a wristwatch.

Jumpseat. Jumpseat satellites are used to monitor Soviet antiballistic missile radars and perform other functions. They are in highly elliptical orbits at 63 degrees inclination, with perigees of 400 km and apogees of 39,000 km.

White Cloud. White Cloud uses receiving antennas and perhaps also infrared sensors to detect and locate Soviet ships. These satellites can monitor signals from as far away as 3,200 km, and operate at an altitude of 1,100 km.

OTHER TYPES OF SATELLITES

Satellites also perform missions other than imaging and signals intelligence. They can be used to give an early warning in case of attack, to help with navigation, and to relay information from other satellites.

Some of the most important satellites performing these and other functions are described below.

Navstar GPS. Navstar GPS satellites are used mainly for navigational and positional data, a secondary mission being the detection of nuclear detonations. This latter mission is accomplished by X-ray and optical sensors.

Milstar. Milstar, or Military Strategic and Tactical Relay Satellites, are communications satellites that would be used for combat support (if they are purchased). The Milstar satellite would be put in a geosynchronous orbit, a circular orbit 36,000 km above the Earth's surface in which objects remain over a single point on the Earth continuously, starting in 1991.

TDRSS. The TDRSS, or Tracking and Data Relay Satellite System, employs circular orbits to provide relays between satellites and ground stations.

DSP. The Defense Support Program satellites' primary function is to provide early warning of missile tests and missile attacks; the other main mission is to detect nuclear explosions. These satellites, which are in geosynchronous orbit, are scheduled to be replaced by the BSTS and by Navstar GPS.

BSTS. The Boost Surveillance and Tracking Satellite is an early-warning satellite expected to have the capability to assess the size of boosters on a missile, to track missiles, and to help with target acquisition for ballistic missile defense.

TECHNICAL INFORMATION ON SATELLITE PERFORMANCE: FIELDS OF VIEW, CONTINUITY OF COVERAGE, AND ORBITAL MANEUVERING

Basic physics can answer several important questions about the capabilities of satellites, even without access to classified information, because electromagnetic waves and celestial bodies have certain invariable properties. It is possible to calculate a satellite's field of view

as a function of its altitude, to calculate the frequency with which it views a given point on the Earth as a function of its orbit, and to calculate how much fuel is required to change its velocity by a given amount as a function of its total weight.

Field of View

The basic formula of importance here is the Pythagorean theorem for triangles: $(R + H)^2 = R^2 + R_H^2$. Here, R is the radius of the Earth--about 6,500 kilometers, H is the altitude of the satellite above the surface of the Earth at the moment in question, and R_H is the radius of an imaginary circle on the ground that encompasses those points visible to the satellite.

Because H is small, compared with the other quantities, for low-Earth orbits, the formula can be simplified to read: $(2RH) = R_H^2$. If H = 500 kilometers, for example, R_H = 2,600 km; if H = 1,000 kilometers, R_H = 3,700 km.

Continuity of Coverage

The circumference of the Earth is about 40,000 km at the Equator (and about 30,000 km if one traces a complete circle at 45 degrees latitude). Thus, it would require about eight evenly spaced satellites, all in the same orbit about 5,000 km apart, to provide continuous coverage of a given point on the Earth.

In reality, however, eight satellites would not be enough to provide continuous coverage for more than a few hours. Because of the rotation of the Earth, a satellite's orbit migrates westward. If it is in a 500-km polar orbit, for example, it will migrate about 2,500 km per orbit as measured by an observer on the Equator. (A single revolution of the Earth at this altitude takes about 90 minutes, or about 1/16th of a day; dividing the circumference of the Earth by 16 yields 2,500 km.) Thus, a given point on the Earth could in theory be seen by any one satellite on two or three consecutive revolutions, but no more. As a result, the string of eight satellites, passing over a given point in sequence, could

maintain continuous coverage for perhaps three to four hours, after which there would be an interruption during which none of the satellites would see the point. The interruption probably would last until the next day, or 20 to 21 hours, if the satellites required daylight for imaging; otherwise, it would last 8 to 9 hours.

To provide truly continuous coverage of the entire Earth, therefore, more than one string of satellites would be necessary. Realistically, 4 separate strings of 8 satellites each would be needed, or a total of roughly 32 satellites. (If the satellites were in a 1,000-km orbit, only about two-thirds as many would be needed along any one "string," and only two-thirds as many strings would be needed; in that case, about 15 satellites might suffice). Moreover, these satellites would have to be of the radar-imaging variety. Optical and infrared detectors, even if capable of night viewing, cannot see through clouds.

Assuming a satellite's lifetime to be about four years, a steady-state constellation of 32 imaging satellites would require an average of eight successful launches per year, and a constellation of 15 would require roughly four. Corresponding annual cost increases probably would be from $5 billion to $15 billion, once launch costs, support satellites, downlink ground stations to receive signals, and analysts are factored in.

Numbers of satellites, and thus costs, could be even greater if satellites are not capable of seeing quite as far as the above hypothetical calculation suggests. Realistically, the true numbers might be 25 percent to 50 percent higher.

Orbital Maneuvering

The rocket equation, derived directly from Newton's laws of motion, allows one to calculate the change in speed of a body that is ejecting mass at a certain rate and a certain relative velocity. In the case of rockets and satellites, this process is accomplished by burning fuel and exhausting the combustion products in the direction opposite from that desired for the rocket or satellite.

If a direct overflight of a given point on the Earth is required, it may be necessary to displace a satellite's orbit through the use of booster rockets. This is done through ground control; similar types of maneuvers are used to maintain a low-flying satellite's orbit against the forces of atmospheric drag.

The rocket equation can be written as: $V_f - V_i = (V_e)(\ln[m_i/m_f])$. Here, the symbols V and m refer to the velocity and mass of the satellite; the subscripts f and i refer to the final and initial values of velocity and mass; and the quantiy V_e refers to the relative velocity of exhaust gases vis-a-vis the satellite. For modern chemical fuels, this value is usually around 3,000 meters per second. The expression ln refers to the natural logarithm of the quantity in brackets.

If the satellite weighs 18,000 kilograms, and if 3,000 kg of this total mass are fuel, consistent with various estimates for the KH-12 satellite, using 1 percent of the total fuel of the satellite to execute a maneuver would produce the following change in satellite velocity (along whatever axis the boosters fired): $V_f - V_i = (3{,}000)(\ln[1.002]) =$ 5 meters/second.

To move 1,000 km at this speed would require about two days.