

AD-A258 579



AD-ES01 594
Copy 25 of 56 copies

(2)

IDA PAPER P-2756

BALANCING COST AND EFFECTIVENESS
IN ARMS CONTROL MONITORING

DTIC
ELECTE
DEC 09 1992
S A D

Jeffrey H. Grotte
Julia L. Klare

September 1992

92-31109



8928

Approved for public release; distribution unlimited.

20030221023



INSTITUTE FOR DEFENSE ANALYSES
1801 N. Beauregard Street, Alexandria, Virginia 22311-1772

92 12 08 049

IDA Log No. HQ 92-42328

DEFINITIONS

IDA publishes the following documents to report the results of its work.

Reports

Reports are the most authoritative and most carefully considered products IDA publishes. They normally embody results of major projects which (a) have a direct bearing on decisions affecting major programs, (b) address issues of significant concern to the Executive Branch, the Congress and/or the public, or (c) address issues that have significant economic implications. IDA Reports are reviewed by outside panels of experts to ensure their high quality and relevance to the problems studied, and they are released by the President of IDA.

Group Reports

Group Reports record the findings and results of IDA established working groups and panels composed of senior individuals addressing major issues which otherwise would be the subject of an IDA Report. IDA Group Reports are reviewed by the senior individuals responsible for the project and others as selected by IDA to ensure their high quality and relevance to the problems studied, and are released by the President of IDA.

Papers

Papers, also authoritative and carefully considered products of IDA, address studies that are narrower in scope than those covered in Reports. IDA Papers are reviewed to ensure that they meet the high standards expected of refereed papers in professional journals or formal Agency reports.

Documents

IDA Documents are used for the convenience of the sponsors or the analysts (a) to record substantive work done in quick reaction studies, (b) to record the proceedings of conferences and meetings, (c) to make available preliminary and tentative results of analyses, (d) to record data developed in the course of an investigation, or (e) to forward information that is essentially unanalyzed and unvaluated. The review of IDA Documents is suited to their content and intended use.

The work reported in this document was conducted under IDA's Central Research Program. Its publication does not imply endorsement by the Department of Defense or any other Government Agency, nor should the contents be construed as reflecting the official position of any Government Agency.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE September 1992		3. REPORT TYPE AND DATES COVERED
4. TITLE AND SUBTITLE Balancing Cost and Effectiveness in Arms Control Monitoring			5. FUNDING NUMBERS Central Research Program	
6. AUTHOR(S) Jeffrey H. Grotte, Julia L. Klare				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Institute for Defense Analyses 1801 N. Beauregard Street Alexandria, VA 22311			8. PERFORMING ORGANIZATION REPORT NUMBER IDA Paper P-2756	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Institute for Defense Analyses 1801 N. Beauregard Street Alexandria, VA 22311			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) This paper provides a qualitative assessment of arms control cost and effectiveness issues. Various chapters characterize some basic requirements for effective verification, summarize the monitoring activities incorporated into the INF, START, CFE, and CWC verification regimes, identify the costs of these monitoring activities as estimated in earlier IDA work, and discuss some reasons for the wide differences in costs among treaties. Drawing on both experience and observation about monitoring costs and effectiveness, the paper indicates where cost-saving modifications can be made to existing agreements and suggests some general principles for structuring monitoring regimes to maintain effectiveness while keeping costs at a minimum. These principles include: requiring the declaration of all facilities that are part of the infrastructure surrounding treaty-limited items and activities during the course of their operational lifetime; validating data at all declared facilities and, subsequently, inspecting those facilities on a quota basis; continuous monitoring of all elimination activities; and incorporating provisions for inspection of undeclared facilities. The paper argues that one frequently-included type of inspection, monitoring of production facilities, is unnecessary and, given the high cost involved, undesirable.				
14. SUBJECT TERMS Arms Control, Monitoring, Verification, On-Site Inspections, Cost-Effectiveness, START, CFE, INF, CWC, Treaty			15. NUMBER OF PAGES 80	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	

IDA PAPER P-2756

BALANCING COST AND EFFECTIVENESS IN ARMS CONTROL MONITORING

Jeffrey H. Grotte
Julia L. Klare

September 1992

Accession For		
NTIS CRA&I		☒
DTIC TAB		☐
Unannounced		☐
Justification		
By		
Distribution /		
Availability Codes		
Dist	Availability / or Special	
A-1		

Approved for public release; distribution unlimited.

DTIC QUALITY INSPECTED 2



INSTITUTE FOR DEFENSE ANALYSES
IDA Central Research Program

PREFACE

This paper has been prepared under the Institute for Defense Analyses' Central Research Program. The views expressed here are solely the authors', and do not represent those of IDA or the Department of Defense.

The intent of the research reported on here has been to review the provisions of recent arms control treaties in order to identify ways to retain effective verification at minimal cost.

The authors wish to thank the IDA reviewers of this work: Mr. Stan Horowitz, Ms. Rebecca Rubin, and Dr. Robert Zirkle, as well as the many people at OSIA who read, commented upon, and clarified the contents.

CONTENTS

PREFACE	iii
I. INTRODUCTION	I-1
II. OBJECTIVES OF MONITORING AND THE EFFECTIVENESS OF VERIFICATION	II-1
III. THE INF, START, CWC, AND CFE VERIFICATION REGIMES	III-1
A. Treaty Goals and Definitions of Cheating	III-1
1. Basic Treaty Rights and Obligations	III-1
a. The Intermediate-range Nuclear Forces (INF) Treaty	III-2
b. The Strategic Arms Reduction Talks (START) Treaty	III-2
c. The Conventional Forces in Europe (CFE) Treaty	III-3
d. The Chemical Weapons Convention (CWC)	III-3
e. Summary	III-4
2. Treaty Obligations and Methods of Cheating	III-4
B. Types of Inspections and Their Functions	III-4
1. General Types of Inspection	III-5
a. Data Declaration and Validation	III-5
b. Monitoring TLI-related Facilities	III-6
c. Monitoring TLI Elimination	III-6
d. Monitoring TLI Production Facilities	III-6
e. Monitoring Potential Production Facilities	III-7
f. Monitoring Undeclared Facilities	III-7
2. Types of Inspection in Specific Treaties	III-9
a. Data Declaration and Validation	III-9
b. Monitoring TLI-related Facilities	III-12
c. Monitoring TLI Elimination	III-15
d. Monitoring TLI Production Facilities	III-15
e. Monitoring Potential Production Facilities	III-18
f. Monitoring Undeclared Facilities	III-19
g. Summary	III-22

C. Costs of Various Approaches.....	III-22
1. General Cost Factors.....	III-23
2. INF, CFE, START, and CWC Inspection Costs.....	III-25
a. The Cost of Monitoring Production	III-26
b. Inspections at Undeclared Sites	III-27
c. Why is CFE so Inexpensive?.....	III-30
d. Why is CWC so Expensive?	III-30
D. Summary and Discussion	III-31
IV. WAYS TO REDUCE THE COST OF VERIFICATION AND IMPLICATIONS FOR EFFECTIVENESS.....	IV-1
A. Reducing Verification Costs	IV-1
1. Monitoring Declared TLI and the TLI Infrastructure	IV-1
2. Inspections at Undeclared Facilities	IV-2
3. Monitoring Production Facilities.....	IV-2
B. Impact on Effectiveness	IV-2
1. Monitoring Declared TLI and the TLI Infrastructure	IV-3
2. Inspections at Undeclared Facilities	IV-3
3. Monitoring Production Facilities.....	IV-5
C. Summary and Conclusions	IV-6

APPENDICES

- A. Baseline Inspections
- B. Quota Inspections
- C. Challenge Inspections

TABLES

II-1. Methods of Cheating at Different Types of Facilities.....	III-3
III-1. Types of Data Required, by Treaty	III-11
III-2. Inspection Types by Treaty	III-22
III-3. U.S. Treaty Verification Costs (\$M ~ 1990).....	III-26

FIGURES

III-1. Percentage of Treaty Verification Costs Devoted to Inspections of Different Types.....	III-34
A-1. Baseline Inspections: Probability of Catching all Discrepancies.....	A-3
B-1. Quota Inspections: Probability of Finding a Discrepancy	B-2
B-2. Quota Inspections: Probability of Catching Cheating as a Function of the Number of Facility Years Required and Duration of Cheating.....	B-4
B-3. Quota Inspections: Probability of Catching Cheating as a Function of the Number of Annual Inspections and the Period Over Which Cheating Takes Place.....	B-6

GLOSSARY

ALCM	Air-Launched Cruise Missile
CFE	Conventional Forces in Europe Treaty
CMA	Chemical Manufacturers Association
CW	Chemical War/Chemical Weapons
CWC	Chemical Weapons Convention
DMNS	Data Management and Notification System
IAEA	International Atomic Energy Agency
ICBM	Intercontinental Ballistic Missile
INF	Intermediate-Range Nuclear Forces Treaty
JCIC	Joint Compliance and Inspection Committee
NTM	National Technical Means
OOV	Object of Verification
PPCM	Portal-Perimeter Continuous Monitoring
RV-OSI	Reentry Vehicle On-Site Inspection
SALT	Strategic Arms Limitation Treaty
SLBM	Submarine-Launched Ballistic Missile
SSI	Suspect Site Inspection
START	Strategic Arms Reduction Talks Treaty
TLI	Treaty-Limited Items

BALANCING COST AND EFFECTIVENESS IN ARMS CONTROL MONITORING

I. INTRODUCTION

Although the costs of implementing arms control agreements do not receive much public attention, agreements that include extensive monitoring provisions¹ can be expensive to implement. A recent review of the costs of the Intermediate-Range Nuclear Forces Treaty (INF)² indicates that the costs of implementing this treaty have to date averaged about \$100 million per year. Roughly half these costs have been for monitoring activities--preparing for and conducting inspections, maintaining a continuous presence at the Votkinsk Machine Building Plant -- and other support activities, such as inspector training and administrative overhead.

Monitoring costs for other new treaties that involve elaborate on-site inspection regimes are likely to be of the same order of magnitude. Implementing the monitoring provisions in the Strategic Arms Reduction Treaty (START), the Conventional Forces in Europe Treaty (CFE), and the Chemical Weapons Convention (CWC) may commit the U.S. to expenditures on the order of hundreds of millions of dollars per year for some time into the future. This is true whether the signatory nations are directly responsible for the monitoring themselves (as with INF, START, and CFE), or whether they contribute to the expenses of an international monitoring body (such as that proposed for the CWC).

With arms control as with any activity where a substantial investment is made, issues of affordability and cost effectiveness must be considered. When arms control decisions involve a variety of agencies and negotiations with foreign powers, it is not always easy to take these factors into account. Nevertheless, as arms control becomes an

¹ We make a distinction in this paper between monitoring--gathering information about activities required by or forbidden by a treaty--and verification, which uses information gathered from monitoring activities and other sources to determine whether or not a nation is complying with the treaty.

² *Intermediate-Range Nuclear Forces Treaty Implementation*, United States General Accounting Office GAO/NSIAD-91-262, September 1991.

increasingly important part of U.S. foreign policy,³ the resources required to monitor agreements will undoubtedly increase. We feel the time is now ripe for an assessment of arms control cost and effectiveness issues.

We will draw on both experience and observation about the costs and effectiveness of monitoring provisions to deduce some conclusions about how to make existing treaties and treaties under negotiation more efficient. These conclusions not only indicate where cost-saving modifications can be made to existing and imminent agreements, but also suggest principles upon which to base future agreements.

OVERVIEW OF PAPER

The next chapter briefly characterizes some basic requirements for effective verification. In the remainder of this paper, we will summarize the monitoring activities incorporated into the INF, START, CFE, and CWC verification regimes. We will further identify the costs of these monitoring activities as estimated by IDA and identify the reasons for the wide differences in costs among treaties. Finally, we will suggest how to structure monitoring regimes generally to maintain effectiveness while keeping costs at a minimum.

³ Indeed, arms control is now defined as a "strategic principle" that will enhance U.S. national security in the future. *National Military Strategy of the United States*, Joint Chiefs of Staff, January, 1992.

II. OBJECTIVES OF MONITORING AND THE EFFECTIVENESS OF VERIFICATION

Before any assessment of verification effectiveness can be made, the objectives of verification need to be defined. Quantitative measures of effectiveness have been the subject of a variety of published papers;⁴ unfortunately, many of these impose simplifying assumptions that are difficult to support⁵ or require data that are very difficult to obtain.⁶ Moreover, the calculations tend to be fairly sophisticated and not transparent to the decisionmaking community. As a result, rigorous approaches to assessing effectiveness tend to remain in the domain of the specialist. While useful for identifying key elements of effectiveness, a mathematical development of effectiveness measures goes beyond the scope of this paper.

Even in the absence of a rigorous mathematical approach, we can characterize some basic requirements for effective verification against which particular monitoring regimes can be measured. Treaties generally constrain nations' actions in three different ways: they can require certain actions, such as the destruction of specific types of weapons; they can permit certain actions, such as modernization, under specified circumstances; or they can prohibit certain actions, such as the deployment of weapons in excess of treaty limits.

⁴ A variety of U.S. and foreign organizations have studied the effectiveness of monitoring and have published approaches and methodologies. Techniques have been borrowed from statistics, game theory, decision theory, and a variety of other disciplines. A complete bibliography would be quite extensive. At IDA, our investigations, which use probabilistic methods, are documented in Levine, D. et al., *The Costs and Effectiveness of Treaty Verification*, Institute for Defense Analyses, P-2650, forthcoming.

⁵ For example, it is frequently assumed that a party to a treaty will fail to comply with treaty provisions at a particular site according to a binomial probability distribution and that such noncompliance is independent of violations at other sites. While this simplifies calculations, and may be a reasonable approximation in certain circumstances, it is unlikely that systematic noncompliance could occur in such a random pattern.

⁶ An example of data difficult to obtain is the probability that an inspection team going to an undeclared site will detect violations. Such information might be obtained through trial challenge inspections with considerable effort, but such activities have only been infrequently undertaken.

Based on these constraints, there are at least two objectives for monitoring in support of verification:⁷

- 1) Monitoring should provide assurance that permitted activities are being conducted in accordance with agreed upon provisions of the treaty; and
- 2) Monitoring should provide a mechanism to detect the conduct of prohibited activities in a provable manner before those activities pose a threat to national security or prestige.

The first objective is straightforward. Treaties variously call for the sharing of information, elimination and/or conversion of weapons and related equipment, cessation or curbs on production, and other specific limitations, such as the number of warheads a missile may carry (as under START). Mechanisms that can be used to monitor these provisions include intelligence collection systems, data exchanges, periodic on-site inspections, continuous presence, and unmanned on-site monitors.

Effectively verifying the first objective depends chiefly on being able to access declared sites and observe treaty-compliant activities. The problem is mainly one of sampling--how much does one need to see to be confident that nations' activities are conducted in accordance with treaty provisions.

Achieving the second objective, detecting cheating if it occurs, is considerably more difficult. There are essentially three methods by which a nation can cheat on its treaty obligations. First, it can fail to declare some of its treaty-limited items (TLI).⁸ Second, it

⁷ A third objective is often mentioned as well--*deterrence* of treaty-violating activities. Because deterrence involves the psychological processes of treaty partners, attempts at measuring it are rarely undertaken; rather, deterrence is usually treated as a secondary benefit. In this case, if the monitoring regime satisfies the two objectives listed above, then one can assume that deterrence follows for the following reasons: Adequate coverage of activities at declared sites should make it undesirable to conduct noncomplying activities at the very facilities where noncompliance would be easiest. The reason declared facilities are declared, after all, is because they are associated with the production, maintenance, and use of treaty-limited items. This forces circumvention out of the established infrastructure, which increases its cost and bother. Presumably, at some level of cost and complexity, a nation will forego circumvention except in extreme circumstances. However, if circumvention is attempted in nondeclared facilities, and the second objective of a monitoring regime is met, it will be picked up before it becomes serious. Therefore, unless a party is intent on abrogating the treaty, a monitoring regime which satisfies both objectives should provide a strong disincentive to attempt to circumvent the treaty provisions, and thus will be deterring.

⁸ Different treaties use different terms to refer to those things they control, limit, or ban. INF uses "treaty-limited items," START uses "item of inspection," and CFE uses "treaty-limited equipment." The CWC does not use any generic term to refer to CW stocks, production facilities, and equipment. For convenience, we will use the term "treaty-limited items (TLI)" as a generic term for all of these things throughout this paper, although we recognize that in some cases the usage will not be precise.

can divert or alter declared items while maintaining that they have been destroyed, converted, or otherwise eliminated. Third, it can covertly produce new TLI.

These methods of cheating are either "only possible" or "considerably more likely" at certain types of facilities. Nations generally are required to declare every facility where TLI are located during the course of their operational lifetime; these facilities together comprise an operational and support infrastructure. Any diversion of declared TLI must, by definition, originate at these facilities.

Illegal TLI production most likely will occur at facilities that either have produced TLI or could easily do so.⁹ While nations could always attempt to produce TLI at other facilities, it may be much more difficult and costly to do so, particularly if TLI production requires highly specialized equipment and materials.

Finally, most treaties require monitoring of all declared TLI. A nation that maintains a stockpile of undeclared TLI is not likely to do so where declared TLI are routinely monitored; undeclared TLI will probably be stored or deployed at undeclared facilities.

These relationships between methods of cheating and types of facilities, illustrated in Table II-1, add variation and complexity to the task of developing a verification regime.

Table II-1. Methods of Cheating at Different Types of Facilities

Method	Types of Facilities Where Possible
Diversion/Alteration of Declared TLI	TLI Infrastructure
Illegal Production of TLI	TLI Production Facilities Potential Production Facilities Undeclared Facilities
Storage or Deployment of Undeclared TLI	Any of the above

⁹ The latter would by and large include facilities that produce items of the same general type as TLI, but that are not limited by the treaty in question. For example, under INF and START, facilities that produce solid rocket motors for space launch vehicles would fall into this category; these will be referred to in this paper as "potential production facilities."

To design a monitoring regime that will detect cheating of various types, three questions must be answered. First, what types of facilities need to be declared? Second, how should different types of declared facilities be monitored? Third, what kind of access should nations be given to undeclared facilities? The different ways treaties answer these questions are discussed in the next chapters.

III. THE INF, START, CWC, AND CFE VERIFICATION REGIMES

A. TREATY GOALS AND DEFINITIONS OF CHEATING

We have said that detecting cheating if it exists is the most demanding objective of monitoring activities. We also have discussed three generic methods of cheating: failure to declare all treaty-limited equipment, diversion or alteration of declared TLI, and illegal production of new TLI. The specific forms cheating may take, however, vary by treaty, and are determined by a treaty's basic provisions. Under INF, for example, the United States was required to destroy all its ground-launched cruise missiles. An intentional failure to do so clearly would have been considered cheating. The START treaty, on the other hand, will not require the United States to destroy any of the ICBMs it removes from deployed status. Cheating in this case is defined only as an intentional deployment of missiles in excess of the limits of the treaty; destruction is not the issue.

While this point may seem obvious, it has important implications for evaluating the effectiveness of verification. It suggests that a single, "best" monitoring regime cannot be developed for all treaties, since the requirements for monitoring will vary. Moreover, in cases where treaties share many of the same monitoring activities, the effectiveness of those activities is likely to vary as well. Some forms of cheating will simply be more difficult to detect than others.

This does not mean, however, that an analytical comparison of different monitoring regimes is without value. There may well be some general rules or principles that can be applied to all monitoring regimes to make them both sufficiently effective and less costly; identifying such principles is the primary goal of this paper.

1. Basic Treaty Rights and Obligations

The treaty rights and obligations associated with INF, START, CFE, and CWC are described in broad terms in the following paragraphs. This discussion is not totally

inclusive; specific details and some minor provisions¹⁰ are omitted. The idea is to confer a general conception of what each treaty requires and, as a consequence, what would be considered cheating under each.

a. The Intermediate-range Nuclear Forces (INF) Treaty

The INF treaty is a bilateral U.S.-Soviet agreement banning ballistic and ground-launched cruise missiles with ranges of 500 to 5500 kilometers. It requires that all existing missiles of these types be destroyed, along with their launchers and associated support structures and equipment. Future production of either INF missiles or launchers is prohibited.

b. The Strategic Arms Reduction Talks (START) Treaty

The START treaty limits the deployed strategic forces (bombers, ICBMs, and SLBMs) of the United States and the former Soviet Union to a level below that at which these forces are currently deployed. Strategic forces must be reduced to conform with treaty limits within seven years of entry into force. Depending on the type of system, reductions can take place via physical destruction, conversion to nonmilitary purposes, or removal from operational status and storage in a physically separate location. For the most part, the treaty does not limit the number of non-deployed systems either nation can maintain at declared storage sites. The major exceptions are mobile missiles and launchers: a maximum of 150 non-deployed missiles and 110 non-deployed launchers can be stored at a given time. Excess mobile missiles and launchers must be destroyed. Empty missile silos must be destroyed as well.¹¹

¹⁰ These provisions are primarily those things that comprise exceptions to general rules. For example, INF requires that all intermediate-range nuclear missiles and ground-launched cruise missiles be destroyed. It does, however, make an exception to this rule by allowing some missiles to be "destroyed" by being placed on static display (as base mascots, in museums, etc.). Modifications and exceptions to general rules abound in all four treaties discussed here; a full description would simply distract from the argument being developed. While we acknowledge that these modifications and exceptions exist, we do not include them in our discussions unless they have a particular impact on the cost or effectiveness of verification.

¹¹ Within some general guidelines, START gives both the U.S. and the former Soviet Union the freedom to design their strategic force structures and make their force reductions as they see fit. Once these decisions have been made, however, they are to some extent locked in by the treaty, at least in the near term. For example, if either nation chooses to reduce its number of deployed silo-based ICBMs, then it must destroy the silos associated with those missiles; it cannot keep those silos in anticipation of a future force structure change that would result in greater reliance on silo-based ICBMs. Should such a decision be made, new silos would have to be built and other systems removed from deployed status, commensurate with treaty limits.

In addition to reduction requirements, the START treaty regulates future changes to strategic force structures. Facilities may be opened or closed, new systems can be deployed, and warheads can be downloaded from deployed ballistic missiles, all within the bounds of the treaty. There are some qualitative restrictions, such as a ban on new types of heavy ICBMs, but for the most part these activities require only that appropriate notifications be provided.

c. The Conventional Forces in Europe (CFE) Treaty

The CFE treaty is a multinational agreement between the nations of NATO and those of the former Warsaw Pact. It limits the number of tanks, helicopters, armored combat vehicles, and combat aircraft that can be deployed with units or stored in the region of Central Europe bounded by the Atlantic Ocean on the west and the Ural Mountains on the east. Within this overall region, or "area of application," the treaty puts sublimits on the numbers of TLI that can be in certain geographic areas, or zones. These zones are formed by three concentric circles centered around the former inter-German border--the second zone incorporates the first zone, and the third zone incorporates the second zone.

Both sides will be required to reduce existing TLI consistent with treaty limits within 40 months of entry into force. Unlike START, excess TLI must be destroyed or, in a few cases, converted to nonmilitary purposes. Any TLI in storage in the region counts against treaty limits. Finally, the CFE treaty does not restrict the production of TLI. New TLI must, however, either be exported or, if assigned to national forces, be associated with an offsetting reduction of older TLI.

d. The Chemical Weapons Convention (CWC)

The Chemical Weapons Convention, like INF, would place an outright ban on a particular category of arms, in this case chemical weapons.¹² This treaty, still under negotiation, would be a multinational agreement open to any interested nation, much like the Non-Proliferation Treaty. It would require a nation to cease chemical weapons production immediately upon signing the Convention and to destroy its CW stockpiles and production facilities within 10 years. At the same time, the Convention would allow participant nations to produce very small amounts of chemical agent at declared facilities for permitted research, medical, pharmaceutical, and protective purposes.

¹² To include both chemical munitions and bulk chemical agent.

e. Summary

INF and CWC create bans on certain types of weapons. Possession of these weapons by a treaty signatory, whether deployed or in storage, is a fundamental treaty violation and would be considered cheating. Cheating under START and CFE, however, is less black and white. These treaties focus intently on restricting weapon deployments, either numerically or geographically. They limit, but do not ban, the weapons associated with them. In both cases, possession of such weapons in excess of treaty limits is not prohibited per se. Rather, it is the way a signatory obtains excess weapons and what it subsequently does with them that determines the legality of their possession.

2. Treaty Obligations and Methods of Cheating

For all of these treaties, the failure to declare TLI as required is patently illegal, as is the diversion of declared TLI from the facilities with which they are associated. Production of TLI after treaty signature, however, is in itself illegal only under INF and CWC. The START treaty will allow the U.S. and the former Soviet Union to continue to produce strategic systems, as long as they are declared and kept in a monitored storage facility.¹³ These systems also can be deployed if done in a manner consistent with START limits. Under CFE, there are no restrictions on the production of TLI for export by signatory nations. A nation is allowed to retain the TLI it produces for its own use if it is kept outside the area of application or, if deployed or stored within the area of application, it does not violate the treaty's numerical and locational limits.

B. TYPES OF INSPECTIONS AND THEIR FUNCTIONS

The monitoring regime established by a treaty can be thought of as a system of firebreaks, cutting off possible methods, or directions, of cheating by making them likely to be detected. The effectiveness of the regime is determined by the level of confidence signatory nations have that the firebreaks established by the treaty will be successful.

On-site inspections are at the heart of the monitoring regimes of all four treaties. In conjunction with national or multinational technical means,¹⁴ they are intended to provide a

¹³ Production of mobile missiles and launchers is allowed only until the numerical limits on these missiles in storage have been met. At this point, production must cease or older mobile missiles must be destroyed.

¹⁴ In addition, the CWC includes provisions for local instrument monitoring to supplement on-site inspections, if necessary.

systematic, effective barrier to cheating. Different types of inspections have different roles and functions within the overall system. The types and functions of inspections, both generally and with reference to specific treaties, are discussed in the sections that follow.

1. General Types of Inspection

a. Data Declaration and Validation

All on-site inspections are made on the basis of data declarations made by inspected nations. Data declarations typically would include the number, type, location, and technical characteristics of banned or limited weapons possessed by the nation, the facilities where such weapons are routinely located, and, in some cases, the facilities where such weapons were produced or could be produced.

The first general type of inspection takes place at declared locations for the purpose of validating declared data. These inspections, sometimes called baseline or data validation inspections, are not themselves directed toward the detection of cheating; nonetheless, they play a critical role in determining the success of other types of inspections.

Once data have been declared and validated through on-site inspection and any discovered discrepancies resolved, they are assumed to be accurate. This process results in a line being drawn: any TLI that are not declared are illegal; discovery of undeclared TLI is direct evidence of cheating. The body of declared data becomes the basis for comparison with data generated during subsequent inspections and, as a consequence, allows for a positive determination of cheating.

In addition, declarations create a variety of risks for signatory nations should they cheat on their treaty obligations. Cheating must physically take place either within or outside of an infrastructure of sites built around the weapons controlled by the treaty. If a nation chooses to cheat within the established infrastructure, it does so at a greater risk of discovery, since presumably these sites will be declared and subject to inspection. If it cheats outside the infrastructure, it will likely have less confidence in the quality and reliability of its TLI. Finally, the black and white character of data declarations (TLI either are or are not declared) makes it very difficult for a nation to explain discovered treaty violations as anything but cheating. Altogether, these risks may well generate a substantial deterrent to potential cheating.

b. Monitoring TLI-related Facilities

The second general type of inspection is conducted at those facilities where TLI are routinely present during the course of their service lives. Such facilities would be part of the declared data and would likely include operating bases, maintenance depots, storage facilities, and others. In toto, these facilities make up the established infrastructure, referred to above, surrounding the weapons controlled by the treaty.

These inspections are referred to by a variety of names, such as quota, declared site, data update, and routine inspections. Whatever the name, they share a common function: to verify that data collected at inspected facilities remain consistent with the declared data. In so doing, the inspections provide a means of deterring and detecting any illegal diversion of declared TLI from declared facilities. They also may detect the use of the established infrastructure to support undeclared TLI, thus increasing either the risk of being caught or the relative difficulty of cheating. Selecting an annual quota for monitoring TLI-related sites requires examination of how such sites could be used to circumvent the treaty. Appendix B examines this issue in some detail.

c. Monitoring TLI Elimination

The third general type of inspection is conducted at facilities where TLI are being destroyed. The goal of these inspections is to verify that treaty-mandated procedures for elimination are implemented correctly and that TLI are in fact destroyed.

Successful diversion of TLI requires either that a credible substitution be made for the real TLI, or that the TLI somehow be erased from declared data so that the possessor nation is no longer accountable for them. The process of TLI elimination provides perhaps the best avenue for diversion, since it is a legal activity that essentially has the second result, removal of TLI from the body of declared data. Making sure that elimination takes place as required¹⁵ is therefore an important function of any verification regime.

d. Monitoring TLI Production Facilities

The fourth general type of inspection takes place at facilities where TLI are being or have been produced. The purpose of these inspections is to verify that no illegal production of TLI occurs at the inspected facility.

¹⁵ Even for treaties that do not mandate destruction, it is important to verify that it takes place if it is scheduled.

If a nation chooses to cheat by producing illegal TLI, the easiest place to do so will be at facilities where TLI have been produced in the past. If inspections provide sufficient confidence that cheating at these facilities will be detected, the cheating nation will be forced to produce TLI elsewhere, at clandestine facilities or at facilities configured for other purposes. This adds to the deterrent effect of the verification regime by making cheating either riskier or more difficult.

e. Monitoring Potential Production Facilities

The fifth type of inspection takes place at facilities that do not and never have produced TLI, but could do so easily. The production of some TLI can be very similar to the production of other, legal weapons or civilian products. When this is the case, there is little cost to a cheating nation to produce TLI illegally at a facility ordinarily used for production of other items. Treaties frequently require nations to declare facilities such as these; inspections are then conducted to detect any illegal production and to increase the deterrence of easy cheating.

f. Monitoring Undeclared Facilities

The sixth type of inspection, frequently called challenge inspection, allows a signatory nation to gain access to undeclared facilities if it has reason to believe cheating of some kind is taking place there.

There is always a chance some nation will cheat, in whole or in part, at clandestine facilities or at facilities with no apparent connection to TLI. In fact, assuming the verification regime at declared facilities is robust, it is very likely that cheating would occur at undeclared facilities. It could range from the storage of undeclared or diverted TLI, to illegal production or even deployment in violation of treaty provisions.

This is the only type of inspection that does not occur on the basis of declared data. By definition, declared data cannot provide any information that could be used to distinguish one undeclared facility from another. If a nation needed to rely solely on data declared under the treaty, it could do no better than to randomly inspect a few of the virtually infinite number of undeclared facilities. The possibility of discovering cheating under these circumstances is close to zero.

To have any real opportunity to detect cheating at undeclared facilities, data from other sources, primarily intelligence activities, must be used to cue inspections. All nations have the ability to gather at least some information from open source literature and human

intelligence. A few nations, such as the United States, have a vast array of sources they can use to gather data that may indicate cheating, including national technical means, signals intelligence, human intelligence, etc.

Even for nations with very capable intelligence assets, however, the ability to discover evidence of cheating at undeclared facilities will vary, depending on the type of cheating. Some activities, such as ballistic missile production, are typically associated with the physical signatures that identify them. Examples include the existence of unusual safety features, the use of specialized equipment, proximity to a rail network, and the use of large amounts of electrical power. The presence of physical signatures will not prove cheating, since they may also be associated with legitimate activities, but they will allow certain facilities to be designated for closer monitoring and, ultimately, inspection. Other types of cheating, such as storage of undeclared TLI, may have no discernable characteristics at all. In these cases, detection will be much more difficult.

In addition to the physical characteristics of cheating activities, the scale on which they are conducted will be an important factor in detection. Cheating that involved large numbers of people and many facilities would be easier to detect than cheating with only a handful of people at a single location.¹⁶

In summary, a nation's ability to detect cheating of a particular type at an undeclared facility depends on the intelligence and other information-gathering resources it has available, the physical signatures associated with that type of cheating, and the scale on which the cheating is taking place. Inspections, in and of themselves, will provide almost no ability to detect cheating in the absence of cueing information. In this case (and this case only), inspections can only be used to confirm or resolve suspicions generated from sources of data unrelated to the treaty.¹⁷ The relationship among these factors is explored numerically in Appendix C.

¹⁶ Although beyond the scope of our discussion, the effectiveness of a monitoring regime is frequently evaluated not so much by its ability to detect cheating per se, as it is by its ability to detect a militarily significant level of cheating, however defined. As the scale of cheating increases, clearly so does its military significance. Unfortunately for the cheating nation, this also makes it easier to detect.

¹⁷ Of course, NTM (National Technical Means) and other types of intelligence play an important role in supplementing inspections at declared facilities. Good NTM, for example, can generate confidence in compliance at declared sites with fewer numbers of inspections, while poor NTM may lead to a requirement for larger numbers of inspections. In either case, because the sites are known, inspections provide an independent means of detecting cheating at declared sites. This is not, however, the case at undeclared sites, the existence of which cannot become known in the absence of NTM.

2. Types of Inspection in Specific Treaties

The INF, START, and CFE treaties and the Chemical Weapons Convention each incorporate some or all of the six general types of inspection described above. While a given type of inspection will perform the same basic function for all treaties in which it occurs, it may vary in form, depending on specific treaty provisions and objectives. The ways in which individual treaties incorporate general types of inspection are described and compared in the following sections.¹⁸

a. Data Declaration and Validation

All four treaties require nations to make specified types of data available to all treaty signatories, in the form of declarations, exchanges, or memoranda of understanding. Because most types of inspection are based on declared data, this process determines the nature and scope of the inspections that follow. The types of data required under each treaty are shown in Table III-1.

There is a surprising similarity among all four treaties in the type of data they require nations to provide. All require extensive accounting of the TLI possessed by signatory nations, including the number and types of TLI, their technical characteristics, and the locations at which they may be during the routine course of their operational life.

The treaties differ most in the requirement to declare TLI production facilities and potential production facilities. As will be seen, this is where they differ most in incorporating inspections of various types as well: treaties that do not include production facilities in the requirements for declared data place a proportionately greater burden on national technical means and other forms of national intelligence.

Finally, the last row in Table III-1 displays the number of declared facilities that will be inspected under each treaty; this table is provided largely to show the relative scale on which verification activities will be conducted. The difference between INF and START on the one hand and the CWC on the other is in the number of production and potential production facilities declared under each. The INF treaty now monitors two U.S. and formerly Soviet production or potential production facilities; START will monitor nine

¹⁸ When referring to an inspection in the context of a particular treaty, the term the treaty text uses for that inspection is used in the discussion here. These terms will be underlined and should be understood to mean the specific treaty usage for the general type of inspection listed in the section heading.

such facilities, including the two already inspected under INF¹⁹. The number of declared CWC facilities, however, is on the order of 1,050 production and potential production facilities.²⁰ Excluding production facilities, the number of TLI-related facilities is quite small under all three treaties.

The number of declared objects of verification (OOVs) under CFE, by contrast, is a great deal larger, despite the fact that it does not include any production facilities at all. This reflects the simple fact that nations typically maintain many thousand times as many conventional weapons as they do nuclear or chemical weapons. As a result, the related infrastructure is much larger.

In addition to requirements for submitting data, all four treaties provide for validation of these data through on-site inspections. In all cases, these inspections will adhere to a standard form: a group of inspectors will travel to the facility, inventory that facility using whatever equipment is allowed, compare collected data to declared data, resolve any disputes to the extent possible, and then leave.²¹ In many cases, the inspection must be completed within a designated period of time; others may take as much time as the inspectors deem necessary to adequately complete their mission.

Under INF, baseline inspections were conducted at all declared U.S. and Soviet missile operating bases, missile support facilities (excluding missile production facilities), and elimination facilities. These inspections took place over a 60-day period starting 30 days after the treaty entered into force.

The START treaty likewise calls for baseline data inspections at all declared facilities. These inspections will take place over a 120-day period beginning 45 days after the treaty enters into force. In addition, the treaty mandates that one-time technical exhibitions, or displays, of one TLI of each type covered by the treaty be conducted prior to baseline data inspections. These exhibitions serve two purposes: they allow nations to

¹⁹ This includes three production facilities subject to continuous monitoring and six potential production facilities subject to mandatory suspect-site inspections.

²⁰ There are no exact estimates of the number of production and potential production facilities that must be declared under the CWC in its present draft form. Fifty is a reasonable number of actual chemical weapons production facilities worldwide. The number of potential production facilities—commercial facilities producing commercial toxic chemicals or precursors to chemical agents—is widely believed to be on the order of 1,000 worldwide.

²¹ This "standard" form of inspection is the norm throughout the verification regimes of all four treaties. Some types of inspection, however, will be conducted quite differently. From this point onward, inspections are assumed to adhere to the standard form, unless noted otherwise.

Table III-1. Types of Data Required, by Treaty

Declared Data Category		INF	START	CFE ¹	CWC
TLI	Numbers/Types	Yes	Yes	Yes	Yes
	Technical Characteristics/Drawings	Yes	Yes	Yes	Yes
Facilities	Operating Bases	Yes	Yes	Yes	N/A
	Storage Facilities	Yes	Yes	Yes	Yes
	Support Facilities (Maintenance, Repair)	Yes	Yes	Yes	N/A
	Test and Training	Yes	Yes	Yes	N/A
	Destruction/Conversion	Yes	Yes	Yes	Yes
	Production Facilities	Yes	Yes	No	Yes
	Potential Production Facilities	No	Yes	No	Yes ²
Total Number of Declared Facilities		164	115*	3,679	1,050* ³

* estimated

- 1 The CFE treaty is unique in that it will not monitor facilities per se. Rather, it requires declaration and inspection of *objects of verification (OOVs)*, which are essentially military units. By definition, OOVs include military units at the brigade or wing level, independent or separately located battalions and squadrons, separately located storage sites, maintenance and repair facilities, training sites, and reduction sites. Data declared about objects of verification must include their peacetime locations; these locations are then defined as *declared sites* by the treaty. Thus CFE provides for inspections of OOVs at declared sites. The distinction is made in recognition of the fact that some peacetime locations (declared sites) typically have more than one unit (OOV). If all declared sites were treated equally, inspecting nations would almost certainly conduct most of their inspections at sites with more than one unit, maximizing the amount of information that can be gained from a single inspection. Nations that tended to concentrate units at a few locations would then be penalized by having a greater percentage of their forces subject to inspection than would nations that tended to disperse its units. Incorporating the concept of OOVs provides a leveling factor that results in a more comparable inspection burden among all signatories.
- 2 Under the CWC, declared potential production facilities can be of three types, depending on the type and amount of chemicals produced there. *Schedule 1 chemicals* are those that have little or no commercial utility and either have been produced for use as chemical weapons, are similar in structure to known agents, or are of sufficient lethality that they could easily be used as chemical weapons. Nations will be allowed to produce very small quantities of these chemicals for research, medical, pharmaceutical, and protective purposes. *Schedule 2 chemicals* are either key precursors—chemicals used in the final stage in the process of producing a Schedule 1 chemical—or supertoxic lethal chemicals not included in Schedule 1. *Schedule 3 chemicals* are dual-purpose or precursor chemicals that are distinguished from Schedule 1 and Schedule 2 chemicals by virtue of the large amount produced for commercial purposes. Although agreement has not yet been reached on precisely which chemicals should be included on these lists, there is a general consensus that the verification regime should differentiate among them, depending on the relative risk they pose to the goals of the Convention.
- 3 Since the number of declared facilities is provided to indicate the relative scale on which inspections will be conducted under each treaty, the number of declared chemical facilities does not include Schedule 3 facilities. Although these facilities may well number in the several thousands worldwide, they will not be subject to inspection under the current draft Convention. Therefore, including them would tend to distort the scale of the Convention relative to other treaties.

validate the declared technical characteristics of TLI, and, in the case of heavy bombers, they allow inspectors to identify technical characteristics distinguishing bombers carrying ALCMs from those that do not.

Primarily because of the large number of objects of verification (OOVs) involved, the CFE treaty relies on a limited sampling of declared OOVs via declared site inspections. During the treaty's baseline validation phase (the first 120 days following entry into force), 20 percent of each nation's OOVs will be inspected.

With the exception of Schedule 3 commercial chemical production facilities,²² the CWC will require initial inspections at all declared facilities. In addition to verifying the accuracy of declared data, inspectors also will initiate the process of negotiating "facility attachments." These agreements, between the Convention's administering body and the inspected nation, will determine the procedures for future inspections at individual facilities.²³

For most types of facilities, initial inspections must take place within 60 days of the Convention's entry into force; negotiation of facility attachments must be concluded within six months of entry into force.²⁴ In the interim, inspectors may remain continuously on-site if they believe there is some reason to do so.

b. Monitoring TLI-related Facilities

As shown in Table III-1, all treaties require nations to declare those types of facilities that form the infrastructure surrounding TLI during their operational lifetimes. Under INF and START, these facilities include operating bases, storage facilities, TLI maintenance and repair facilities, test ranges, and training facilities. The same is true for CFE, although a single OOV may incorporate one or all of these things.

²² See footnote #2 to Table III-1 for an brief explanation of the different schedules of chemicals under the CWC.

²³ The CWC is the only treaty that does not specify uniform inspection and monitoring procedures for all facilities of a given type. Instead, the Convention as now drafted simply states that verification activities can include either inspections, continuous instrument monitoring, permanent inspector presence, or some combination of all three. The actual form that verification activities will take will be negotiated and codified in individual facility attachments, and thus may vary a great deal by facility.

²⁴ These timelines have not been specified for all types of declared facilities; different timelines may ultimately be defined. The conduct of initial inspections and the negotiation of facility attachments would undoubtedly be easier for the International Organization if these timelines were uniform for all types of facilities.

The CWC is somewhat different. Any facility where chemical weapons are located, for whatever reason, is defined as a CW storage facility. As a result, the infrastructure surrounding TLI in this case consists solely of storage facilities.²⁵

INF

The INF verification regime includes two different inspections of this general type. First, both nations were required to destroy certain support structures and equipment at declared sites. Once all TLI had been removed from a declared site, and all associated support structures destroyed, that site was considered "eliminated" under the treaty. Closeout inspections subsequently were conducted at eliminated facilities to verify that required elimination of support equipment and removal of TLI had indeed taken place.

Second, INF allows each nation to conduct a limited number of quota inspections per year at declared missile operating bases, missile support facilities, and eliminated facilities. The purpose of these inspections is, in a broad sense, to verify that the status of the inspected facility, including the number and type of TLI present, is what would be expected from the declared data. At eliminated facilities, this means making sure that the facility is not resurrected to support illegal activities. Each nation was allowed to conduct 20 quota inspections per year during the first three years of INF implementation, and will be allowed to conduct 15 inspections per year during the five following years and 10 inspections per year during the final five years of the treaty.

START

Inspections at declared sites are more varied under START. The treaty allows 15 data update inspections per year at declared sites; these are similar in purpose and scope to quota inspections under INF, the only difference being that eliminated facilities are not included.

While START does not require nations to eliminate facilities, they may choose to do so. A one-time closeout inspection will take place at every eliminated facility to verify that

²⁵ While this seems to be a departure from other treaties, in fact it is not inconsistent considering the nature of the TLI. Were CFE to limit conventional munitions, or INF and START to limit nuclear warheads, the approach might be similar. Munitions of any type are typically held in storage, whether at operating bases, training facilities, or dedicated storage sites. Most if not all nations maintain chemical weapons in carefully controlled storage at all times. Yet even if nations were to, say, train with live CW munitions, as many nations do with conventional munitions, the facilities where they were doing so would be captured by the treaty definition of a storage facility, since chemical weapons would be located there.

all TLI have been removed and support structures destroyed. Nations may subsequently conduct up to three formerly declared facility inspections per year at eliminated facilities, with the proviso that no facility need receive more than two inspections in any given year.

Nations may also choose to deploy new systems or open new facilities under START. In the first case, the treaty requires one-time new system exhibitions; these will be conducted in the same manner as the initial technical exhibitions of TLI. Every new facility will likewise receive a one-time new facility inspection, after which it will be added to the list of declared sites and subject to declared site inspections.

In addition, both signatories will be allowed to conduct 10 reentry vehicle on-site inspections (RV-OSI) per year. Inspectors will travel to an ICBM or SLBM operating base and designate a particular missile for inspection. The warhead section of that missile will then be opened so that inspectors can confirm that the number of warheads loaded onto the missile is no more than that declared for missiles of that type.

Finally, START generally restricts the movement of mobile missiles in and around their operating bases; it does, however, allow them to be dispersed in exercises no more than twice every two years. Following these exercises, post-dispersal inspections may take place at 40 percent of the facilities involved, or one such facility, whichever is the larger number.²⁶ Since the United States does not plan to deploy mobile missiles at present, only Soviet facilities will be affected by this provision.

CFE

Declared site inspections will continue under CFE after the baseline validation period is concluded. The percentage of OOVs that may be inspected in any given year, however, will vary. The baseline validation phase is followed by a three-year reduction period, during which time 10 percent of OOVs may be inspected per year. This in turn will be followed by a 120-day residual validation period, similar to the baseline period, during which 20 percent of remaining OOVs will be inspected. Finally, during the remaining years of the treaty, 15 percent of OOVs will be inspected each year.

²⁶ Although the treaty language is awkward, negotiators were apparently concerned that, if only one or two facilities were involved in an exercise, "40 percent of the facilities involved" would be less than one, and the resulting inspection would either be restricted or denied.

CWC

After initial inspections and the conclusion of facility attachments, routine inspections will be conducted at CW storage facilities as long as chemical weapons are stored there. The frequency and duration of these inspections at individual facilities will be determined in the facility attachments. While these inspections will most likely be of the standard form, they may, as noted above, be supplemented or replaced by continuous instrument monitoring or a permanent inspector presence, depending on the outcome of facility attachment negotiations.

c. Monitoring TLI Elimination

All four treaties take virtually the same approach to monitoring TLI elimination. Inspectors are allowed to continuously monitor certain elimination activities in person,²⁷ whether they occur intermittently or continuously during the treaties' elimination periods.

For the most part, TLI destruction and conversion are not subtle processes. Visual observation will usually be sufficient to confirm that elimination has taken place in the prescribed manner. Chemical weapons destruction is the only exception. For safety reasons, inspectors cannot be physically present in the chambers where the destruction process is underway. Moreover, there may be no obvious physical difference between chemical agent and the benign products of the destruction process. Under the CWC, therefore, all destruction facilities must incorporate monitoring instruments to assist inspectors in determining that destruction occurs as required.

d. Monitoring TLI Production Facilities

The verification regimes of the four treaties begin to differ significantly with their approaches to this general type of inspection. The CFE treaty does not allow monitoring of TLI production facilities at all. INF allows monitoring at only one facility, and then only under certain circumstances. START also limits monitoring of TLI production facilities to those that produce mobile ICBMs. The CWC mandates extensive monitoring of all CW production facilities, but in a manner much more akin to the standard form of inspection than either INF or START.

²⁷ Exceptions are the conversion of certain types of helicopters under CFE, the conversion of heavy bombers under START, and certain eliminations, such as the destruction of fixed ICBM silos, that will be confirmed through NTM. Inspectors will be able to verify that conversion or elimination has taken place as required, but only after the fact. They will not be allowed to observe the conversion process itself.

INF

INF is the only treaty that preferentially monitors potential production facilities over actual TLI production facilities. Monitoring is allowed at any missile assembly facility using missile stages that are outwardly similar to stages of the ballistic missiles banned under the treaty. For reasons of reciprocity, only if a nation does not possess any facilities of this type will one of its actual TLI production facilities be monitored. Negotiators were concerned that, since production of TLI is banned under the treaty, cheating would be just as easy, and less likely to be noticed, at facilities that are actively producing nearly identical missiles.

The United States does not possess any potential production facilities meeting the required criteria. As a result, the Soviets currently are monitoring the Hercules missile production facility at Magna, Utah, which produced the banned Pershing II missile.

Under INF, this general type of inspection takes the specific form of permanent continuous monitoring (PCM)²⁸. This involves the erection of a fence or other barrier around the perimeter of the monitored facility and the establishment of a limited number of portal exits. Both the portals and the perimeter are then monitored continuously by inspectors permanently based at the site to make sure that illegal TLI do not leave the site. To this end, the inspectors also will be allowed to examine any vehicle large enough to contain a TLI that exits through the portals.

Since inspectors are not allowed access to the interior of the facility, they will not be able to detect any illegal production or storage of illegal TLI that may be underway. They can, however, ensure that no illegal TLI produced or stored at the monitored facility will be stored or deployed elsewhere as long as the treaty is in effect.

While this appears to compromise the objectives of verification, in fact it may be better than the alternative. To have a high degree of confidence that no illegal activities, including production and temporary storage of TLI, are taking place at a missile production facility, nations would have to inspect the interior of the facility several times a year. But inspections can be a two-edged sword. Missile production facilities tend to be highly sensitive; inspections would risk the loss of a great deal of information the inspected nation would clearly prefer to keep secret and/or the producer would prefer to keep proprietary.

²⁸ Permanent continuous monitoring (PCM) has become a colloquial term for this type of monitoring activity, used generally here when inspectors are permanently stationed at the exit point of an enclosed facility.

Perhaps more importantly, missile production is a dangerous and time-consuming activity. Inspections could significantly delay or disrupt the production process. Depending on their frequency, inspections could result in cost overruns, delays in system deployment, or even in the facility being unable to produce legal systems at all. PCM, by contrast, has virtually no impact at all on facility operations.

START

Under the START verification regime, monitoring will take place at all mobile ICBM production facilities. The Thiokol Peacekeeper Stage Final Assembly Facility at Promontory, Utah, the Votkinsk Machine Building Plant at Votkinsk, Russia,²⁹ and the Pavlograd Machine Plant at Pavlograd, Ukraine are in this category. Other TLI production facilities will not be monitored as such,³⁰ since production of any type of TLI is not itself illegal, and only for mobile ICBMs are there limits on the number that can be retained in storage.

These facilities will be subject to PCM in lieu of inspection of their interiors. The purpose is much the same as well--to ensure that mobile ICBMs in excess of treaty storage and deployment limits do not leave the monitored facilities.

CWC

The CWC differs from all other treaties in that it requires nations to destroy CW production facilities, as well as certain specialized equipment contained therein. Operation of these facilities must cease immediately when the treaty enters into force. Within the next 90 days, measures must be taken to close the facility, by which the CWC means rendering it inoperable. Initial inspections at production facilities will confirm that operations have ceased. These will be followed by closure inspections to confirm that appropriate measures have indeed been taken to ensure that production cannot be easily resumed. These inspections will most likely be of the standard form, involving short-term visits to production facilities by teams of inspectors.

Nations must submit plans for the destruction of their CW production facilities and equipment. Until this destruction is completed, routine inspections will take place to verify

²⁹ This facility is also subject to PPCM under INF as a potential production facility.

³⁰ Some TLI production facilities may be monitored because they are capable of producing the mobile missiles limited by the treaty. This will be discussed in the next section.

that the facilities remain closed and that the destruction is proceeding as planned. Again, the number, duration, and form of these inspections will be determined by the facility attachments negotiated between the International Organization and the inspected nation.

e. Monitoring Potential Production Facilities

Three treaties--INF, START, and the CWC--incorporate inspections of this type, while the CFE verification regime does not include monitoring of production facilities at all. They differ a great deal, however, not only in the approach they take to these inspections, but in how they determine which facilities will be inspected. INF and START both focus very narrowly on those facilities producing systems that are virtually identical to TLI. The CWC, on the other hand, broadens its focus to include both facilities that are producing very small quantities of chemical agent for permitted purposes and those that produce chemicals that are one step away from chemical agent in the production process.

INF

As noted above, INF allows monitoring of all missile final assembly facilities that use stages physically similar to those banned under the treaty. The only facility that meets the necessary criteria in either the former Soviet Union or the United States is the Votkinsk Machine Building Plant at Votkinsk, Russia. This facility assembles the START-limited SS-25 mobile missile,³¹ the first stage of which is outwardly similar to that of the INF-banned SS-20 missile.

Like the Hercules facility in the United States, the Votkinsk Plant is subject to PCM. In addition to visual monitoring of the portals there, inspectors have installed a Cargoscan imaging device that allows them to determine that launch canisters purportedly exiting with SS-25 missiles do not in fact contain SS-20s.

START

In addition to facilities that actually produce mobile ICBMs, the START verification regime also incorporates inspections at all facilities that produce ICBMs or SLBMs that are as large or larger than the mobile missiles deployed by the inspected nation. There are three such facilities in the United States and three in the former Soviet Union.

³¹ And is therefore included on the list of facilities subject to portal monitoring under START as well.

Inspections at these facilities are termed mandatory suspect-site inspections. They are more disruptive than PCM, in that they will provide inspectors with access to the interior of the inspected facility. No more than two inspections per year may be conducted at any one facility, however, thus limiting the extent of disruption somewhat. Moreover, there is a penalty associated with these inspections in that they count against the quota of 15 data update inspections allowed per year. For every mandatory suspect-site inspection a nation conducts, it will be allowed one fewer inspection of another declared site. It is therefore likely that one or both nations will choose to forego some of these inspections over the course of the treaty.

CWC

Routine inspections will be conducted at Schedule 1 chemical facilities, in accordance with their facility attachments. Although these facilities are not CW production facilities, they do produce and/or use chemical agent, albeit for peaceful purposes. The goal of these inspections is therefore to verify that the amount of agent produced is within the limits set by the Convention and that it is not being illegally diverted.

The CWC verification regime also includes routine inspections at Schedule 2 production facilities. These inspections will be conducted to verify that the inspected facility is not producing Schedule 1 chemicals, that the amount of Schedule 2 chemicals produced are consistent with that declared, and that Schedule 2 chemicals are not being diverted elsewhere for transformation into chemical agent. As with all CWC inspections, the nature and characteristics of these will be determined by individual facility attachments.

Schedule 3 chemical facilities will not be inspected under the CWC verification regime in its present form. Rather, the International Organization will simply monitor data provided by signatory nations regarding the amount and type of Schedule 3 chemical they produce, use, or export.

f. Monitoring Undeclared Facilities

All five types of inspection described above are based on declared data. Their effectiveness, as a result, depends in the first instance on the willingness of treaty signatories to declare all its TLI and related facilities, as required.

In fact, as previously noted, if a nation does cheat, it will very likely do so at undeclared facilities. For this reason, many treaties include some provision for inspections

at undeclared facilities, should compliance concerns arise. Of the four treaties discussed in this paper, INF is the only one that does not include inspections of this type.

Obviously, the number of undeclared facilities is orders of magnitude greater than the number declared under any treaty. The vast majority are civilian industrial facilities, with no relationship to defense or military production, much less to particular TLI. Some, however, are sensitive defense contractor facilities; others are military installations or government laboratories. Fully compliant nations may have legitimate cause to avoid inspections at facilities like these, for fear of compromising classified or export-controlled information and programs. Even purely civilian facilities may fear the loss of proprietary information and their attendant competitive advantage.

The tension between the desire to access undeclared facilities in other nations when concerns arise and the need to protect sensitive facilities of one's own has made this type of inspection complicated and difficult to negotiate. As a result, the three treaties that do incorporate these inspections also have tried to limit their impact in various ways.

CFE

Under CFE, nations may conduct challenge inspections of "specified areas," which, like objects of verification, may contain one or more distinct facilities. Specified areas are amorphous geographic regions of no more than 65 square kilometers in area, in which no two points may be separated by more than 16 kilometers. The precise coordinates of any specified area are not defined a priori, but will be designated by an inspection team shortly after it reaches the inspected nation's designated point of entry.

Challenge inspections will be conducted in the same manner as declared site inspections. The major difference is that, once the specified area is so designated, the inspected nation may refuse to allow the inspection to take place. If a challenge inspection is refused, the nation involved is obligated to make a good faith effort to resolve concerns about its compliance. Even if the challenge inspection is accepted, the inspected nation may deny inspectors access to particular parts of the specified area, either on the ground or via helicopter overflight. As is the case during declared site inspections, the inspected nation also will be allowed to shroud sensitive equipment and to deny access to sensitive points.

Like mandatory suspect-site inspections under START, CFE challenge inspections will count against quotas of declared site inspections. For every challenge inspection a nation agrees to host, it will be subject to one less declared site inspection. During the baseline validation and residual level validation periods, and during each year of the

reduction period, challenge inspections may comprise no more than 15 percent of the inspections a nation is required to host. During the residual monitoring period, challenge inspections may comprise no more than 23 percent of inspections hosted per year.

START

The right to conduct inspections at undeclared sites is not absolute in the START treaty. The treaty establishes a Joint Compliance and Inspection Commission (JCIC) as a forum for discussing any compliance concerns that may arise between the four signatories. It also specifies a number of means available to the nations to resolve such concerns, including special right of access visits. These visits would not be conducted automatically; rather, they would take place only if agreed upon within the JCIC, and then usually after other means of resolving concerns have been exhausted. Procedures for these visits would have to be negotiated as well.

CWC

The recently-concluded CWC gives the International Organization the right to conduct challenge inspections. These inspections are the most complicated ones conducted under any of the four treaties under discussion.

Challenge inspections are initiated when a nation conveys its compliance concerns to the International Organization. If the Organization believes the concerns have a valid basis, it may authorize the conduct of a challenge inspection. A special challenge inspection team would then travel to the country in question; once the team arrived, the Organization would designate, for both the team and the inspected nation, the facility to be inspected.

The inspection team has the right to ground access of the perimeter of the challenged facility within 36 hours of the team's arrival at the point of entry. The exact location of the perimeter, however, is subject to negotiation between the inspection team and the inspected nation. If agreement has not yet been reached when the inspection team arrives at the facility, the team will be transported to a provisional perimeter, as defined by the inspected nation. Negotiations would then continue; if no agreement is reached after an additional 72 hours, the provisional perimeter would become the final perimeter and negotiations would cease.

At the facility perimeter, the inspection team may collect whatever ground, air, water, or effluent samples it chooses. Within 108 hours of the team's arrival at the point of

entry, the team also must be given some form of access to the interior of the perimeter. The degree and type of access provided, however, and the procedures associated with it, will be subject to negotiation with the inspected nation. A managed access approach will be used to satisfy compliance concerns with the least possible disruption of and intrusion into the inspected facility.

g. Summary

Table III-2 provides a summary listing of the general types of inspections and the specific terms used to refer to them within the INF, CFE, and START treaties and the CWC draft text.

Table III-2. Inspection Types By Treaty

Inspection Type	INF	START	CFE	CWC
Data Declaration and Validation	Baseline	Baseline Validation Technical Exhibitions	Baseline	Initial
TLI-Related Facilities	Quota Closeout	Data Update RV/OSI Close-out Formerly-declared New Facilities New System Exhibitions Post-dispersal	Declared site	Routine
TLI Elimination	Conversion/ Elimination	Conversion/ Elimination	Reduction	Destruction
TLI Production	-	PCM	-	Closure Routine
Potential TLI Production	PCM	Mandatory SSI	-	Routine
Undeclared Facilities	-	Special Right of Access Visits	Challenge	Challenge

C. COSTS OF VARIOUS APPROACHES

Beginning with the INF treaty in 1987, all modern arms control agreements to which the United States is a party have incorporated some sort of cooperative verification

provisions³² to supplement (or substitute for) National Technical Means (NTM). As a result, there has been a commensurate rise in the cost of implementing treaty verification provisions.

Generally, NTM is considered a free good: monitoring is an activity that uses assets already in place and data which would be collected in any case and used for threat assessment, targeting, etc.³³ Analytic assessment of compliance with the SALT treaty, for example, was part of a general assessment of the disposition of Soviet forces. Satellite monitoring for arms control verification is a subset of, rather than an addition to, satellite monitoring for intelligence purposes. As a result, this paper does not include any discussion of NTM costs.³⁴

With the inclusion of cooperative measures such as the inspections, notifications, displays and exhibitions described above, arms control verification in the post-INF era has become a dedicated, specialized activity with a significant dollar cost. The costs of these cooperative measures are described and discussed in the sections that follow.

1. General Cost Factors

Verification monitoring today is first and foremost a manpower-intensive enterprise. The main purpose of on-site inspections, the major feature of the verification regimes discussed here, is to allow humans to verify compliance by counting, examining, or otherwise observing TLI in close physical proximity. This requires a number of people of various types, including inspectors, escorts, linguists, air crews, and support personnel. Training, salaries, per diem, and transportation costs for all of these people account for the majority of costs directly related to inspections.

³² These are defined as activities that cannot take place without the acquiescence of all affected parties to a treaty. On-site inspection is a cooperative verification activity; national technical means is not.

³³ This is certainly the case for arms control agreements limiting systems that have always been high-profile intelligence targets, such as Soviet strategic nuclear systems. We recognize, however, that this is a fortunate coincidence that heavily favors those tasked with estimating the cost of verification, and that may not always exist. Future arms control agreements, for example, may require NTM to monitor less traditional targets, such as Third World ballistic missile deployments or chemical production facilities. Unless there is a similar change in the prioritization of intelligence targets (as may well occur), this is likely to require either a redirection or additional deployment of NTM assets, and will thus have greater associated opportunity or real dollar costs. It would be a daunting task to determine the cost of NTM in this case, given the inaccessibility of needed data.

³⁴ A courageous estimate of the cost of that portion of NTM devoted to arms control is included in *U.S. Costs of Verification and Compliance Under Pending Arms Treaties*, Congressional Budget Office, September 1990.

The equipment used to support verification activities is the second major factor in overall cost. A wide variety of equipment is used for a number of different purposes, ranging from the tape measures and weighing scales carried by INF inspectors, to the DMNS³⁵ data management system that monitors U.S. treaty-limited equipment and generates notifications as required by the CFE treaty.

The relative cost of both manpower and equipment is largely a function of the level of technology or expertise involved. The CWC as now written, for example, will require some inspectors to have a detailed understanding of chemical production facility design and good technical knowledge of chemical processing. Other CWC inspectors must be able to use sophisticated sampling and analytic equipment, and still others must be trained to glean relevant information from facility records. CWC inspection teams will have to include chemists, engineers, and auditors, all of whose skills command expensive salaries.

INF inspectors, on the other hand, have the relatively simple task of counting treaty-limited items (TLI) or, as is now the case, determining the absence thereof. They must be able to recognize a TLI when they see it, with the assistance of tape measures and scales. The vast majority of U.S. INF inspectors have been military personnel, who have most of the requisite training, are familiar with the systems involved, and have the added benefit of being significantly cheaper than are civilians. This is because military salaries, while competitive, do not add to the marginal cost of treaty verification: active duty force levels are determined by other considerations; no military personnel are hired specifically to support verification activities, and those that are assigned to verification tasks would be assigned elsewhere in the absence of arms control. Thus while there is a clear opportunity cost associated with using military personnel as inspectors, there is no real cost in doing so. As a general rule, the more military personnel can be relied upon to perform verification tasks, the cheaper the verification regime will be.³⁶

As may seem obvious from these examples, the level of technology and expertise required by any verification regime is closely related to the type of treaty involved and its

³⁵ Data Management and Notification System (DMNS). DMNS was developed and brought to operational status by the Defense Nuclear Agency.

³⁶ Clearly, however, we recognize that at some point the opportunity cost of using military personnel could become too great to ignore. There would then need to be an assessment of priorities among military missions and, perhaps, an increase in the use of civilians for verification tasks. Such an assessment is, of course, beyond the scope of this analysis. We merely wish to point out the general cost-effectiveness of using military personnel.

overall goals. Within treaties, too, some verification tasks require higher levels of technology than do others.

The CWC is a good example. Inspections at commercial chemical facilities will require chemical processing and engineering expertise and may involve extensive sampling and analysis. Inspections at chemical weapons storage facilities, however, may involve nothing more than opening a sealed bunker and counting the munitions within.

Finally, the impact of a given verification regime on civilian production facilities has a strong influence over its relative cost. Inspections at these facilities may require a great deal of planning and preparation, large-scale personnel readiness training, shrouding of sensitive equipment, and, in some cases, facility shutdown. Costs for all of these activities are generally expressed in terms of civilian manhours and are therefore relatively expensive. Facility shutdown also may require payment of fines or loss of incentives if it results in a failure to meet planned production schedules.

2. INF, CFE, START, and CWC Inspection Costs

Based on assumptions about various cost factors, we developed estimates of the cost of inspections of various types; these are presented in Table III-3 below.³⁷ These estimates draw heavily on the body of verification cost work done by the Institute for Defense Analyses, with reference to other government sources.³⁸ All costs presented are those to the U.S. government only,³⁹ and include both direct inspection costs and an administrative overhead charge.

³⁷ For INF, most of the numbers presented represent actual, not estimated, expenditures. For other treaties, where it was possible to present a range of estimates, the lower cost, or best case, estimate was chosen. This reflects both optimism on the part of the authors and respect for the efficiency with which the INF treaty has been implemented—it has proven significantly cheaper than we had originally expected.

³⁸ Other than the general discussion provided in Section II.C.i, we will refrain from describing the methodology and inputs used to develop the cost estimates provided here. Estimated INF costs are based partly on *Intermediate-Range Nuclear Forces Treaty Implementation*, United States General Accounting Office, *op.cit.* Additional information regarding INF costs as well as costs for the other treaties come from a variety of studies conducted at the Institute for Defense Analyses. Interested readers should contact the authors for information regarding the availability of these papers.

³⁹ For the CWC, this includes both the cost to implement the treaty in the United States and the U.S. contribution to the International Organization charged with implementing the treaty.

Table III-3. U.S. Treaty Verification Costs* (\$M - 1990)

Inspection Type	INF	START	CFE	CWC ²
Data Declaration and Validation	31	25	4	160
TLI-Related Facilities	174	100	41	74
TLI Elimination	53	120	27	290
TLI Production	-	350	-	130
Potential TLI Production	230	36	-	2,500
Undeclared Facilities	-	130	5	37
TOTAL¹	490	760	77	3,200

* Assumes a 15-year lifespan for all treaties except INF, which has an agreed 13-year lifespan. All costs are to the U.S. government only; costs to other nations are excluded.

¹ Totals may not add due to rounding.

² Does not include cost potentially incurred by commercial U.S. facilities for hosting inspections.

Costs not captured include research and development and analytic support, including data management system development and maintenance. As noted earlier, NTM is not included, nor are compliance costs not related to verification, such as TLI destruction costs.

a. The Cost of Monitoring Production

A number of observations can be drawn from these estimates. For the three treaties that incorporate production monitoring, the bulk of inspection costs are incurred at either TLI production facilities, potential production facilities, or undeclared facilities, which are assumed for costing purposes to be production facilities of some kind. These costs comprise 47 percent of total INF inspection costs, 65 percent of START costs, and 83 percent of CWC costs.

Though the INF and START verification regimes only affect a small number of facilities, the per-facility cost of monitoring is very high. Of all forms of inspection, PCM is the single most expensive. Establishing PCM at the Magna and Promontory facilities in the United States has, or will require, enclosure of the facility perimeters, movement and construction of roads around and into the perimeters, and construction of buildings for inspectors and equipment at the entrance to the facility. Under INF, this effort alone cost

almost \$7 million. Maintaining permanent U.S. inspectors and equipment at Soviet PCM facilities is expensive as well, amounting to roughly \$9 million per year at the INF facility at Votkinsk.

In addition, the START mandatory suspect-site inspections will all take place at sensitive, and potentially dangerous, missile production facilities. Extensive inspection planning and preparation must be done to ensure the security of information and the safety of inspectors and escorts. Inspections themselves will entail high costs if the inspected facilities need to delay or disrupt the missile production process.

Finally, any special right-of-access visits that take place are likely to be conducted at either sensitive government facilities, such as national laboratories, or industrial production facilities of some kind. The estimated cost of these inspections assumes that moderate facility preparation and protective measures are required.

The high cost of monitoring production facilities under the CWC is less a function of the type of facilities inspected than of the sheer number of facilities inspected. The number of Schedule 2 facilities worldwide is largely unknown; estimates have ranged from as low as 100 to well over 1,000. The cost estimates in Table III-3 assume 1,000 such facilities, of which some 250 are assumed to be in the United States. If the number of Schedule 2 facilities is ultimately much lower, the estimated cost of these inspections would be reduced substantially, to \$230 million for 100 facilities. Still, the cost of monitoring production facilities would comprise 51 percent of total CWC inspection costs.

Unlike the START case, the estimated cost of CWC inspections at production facilities does not include facility preparation costs for inspections at U.S. facilities. This is because the Chemical Manufacturers Association (CMA), which has actively represented the U.S. chemical industry on arms control issues, has repeatedly taken the position that: 1) very little planning and preparation will be required for U.S. facilities to host inspections, and 2) any costs that do result will be borne by inspected facilities as simply an added cost of doing business. Obviously, if the U.S. government becomes responsible for reimbursing facility costs, its costs would be much higher.

b. Inspections at Undeclared Sites

Under START, inspections at undeclared sites are relatively expensive, comprising 16 percent of the total estimated cost. Had the procedures for these inspections been negotiated differently, however, the cost of the regime would have been substantially greater. In particular, the fact that inspected facilities will have sufficient time to prepare for

inspection means that the cost will be more than 90 percent less than it would have been if inspections were conducted on short notice, or within only a few hours of a nation's request for inspection.

Two contractor production facilities, General Dynamics' Plant 19 and Martin Marietta's Middle River facility, are considered missile support facilities by the INF treaty and thus are subject to baseline and quota inspections. Experience at these facilities has shown that it takes several days, or even weeks, to adequately plan for inspection at a sensitive production facility. If sufficient planning time is *not* available, then inspection planning must take place, and readiness maintained, at *every* facility that both may be inspected *and* has classified or export-controlled information that must, by law, be protected.⁴⁰ Since the treaty does not specifically exclude any facilities from inspection, and since it is impossible to predict, a priori, which undeclared facilities might be chosen, all sensitive facilities would have to be prepared to host an inspection or risk the loss of important information.⁴¹

Earlier IDA work found that some 5,000 U.S. facilities are likely to have some information requiring protection if inspected, of which perhaps 500 are particularly sensitive. Based on the INF experience, we estimated that the 15-year cost of inspection planning, maintaining readiness, and hosting inspections at these facilities would be between \$16 billion and \$44 billion, of which only \$17-83 million would result from actual inspections.⁴²

Clearly, if inspection planning and preparation were required only at those facilities that are actually inspected, the cost of this type of inspection would fall dramatically. For

⁴⁰ Inspected facilities would obviously be very interested in protecting proprietary information as well. Because there is no legal requirement to protect this type of sensitive information, the U.S. government is not likely to be financially responsible for doing so. However, if proprietary information is lost as the result of an inspection, the government may well be required to make some sort of financial restitution to the affected facility.

⁴¹ Assuming that the U.S. would retain the right to deny any request for inspection, it is possible that it would do so at the most highly sensitive facilities; these facilities may not then be required to prepare for inspection. The disadvantages of this approach are twofold: first, maintaining a list of such facilities and excluding them from inspection preparations may, in itself, compromise certain programs or facilities; second, it is generally in the U.S. interest to allow inspections whenever possible, to avoid both unnecessary conflict with treaty partners and unnecessary attention to the facility in question.

⁴² These figures are for ten inspections per year, or 150 inspections total. The estimated cost of the agreed START provisions for special access visits, shown in Table III-3, assumes a much smaller number of inspections, on average one per year in the United States.

this to be the case, treaty provisions must allow sufficient facility preparation time between an inspection request and the start of the inspection.

To avoid dollar costs of the magnitude described above and, conversely, to legitimately protect sensitive facilities, the U.S. has pushed hard, and in the case of START, successfully, for restrictions on timely access to undeclared facilities. This is also reflected in the current U.S.-sponsored proposal for CWC challenge inspections. Because the outcome of the CWC negotiations are uncertain, however, the costs incurred by U.S. facilities for hosting challenge inspections are excluded from the estimate shown in Table III-3; this estimate includes only the cost of U.S. escorts and the U.S. contribution to the International Organization for conducting challenge inspections.

This is not meant to imply that there would be no costs at U.S. facilities for CWC challenge inspections. While the likelihood of U.S. facilities being challenged cannot be accurately predicted, the U.S. challenge inspection proposal, like the START special access visit provisions, would not exclude facilities from inspection; any facility, not just a chemical production facility, could be challenged. Thus the same universe of sensitive facilities would be affected by both treaties. Moreover, it is uncertain whether a non-chemical facility subject to challenge inspection would take the same attitude as that professed by the chemical industry, via the CMA--i.e. that it would accept the burdens and costs of inspection as simply the cost of doing business, and not seek reimbursement from the U.S. government.

In sum, there will be some costs associated with CWC challenge inspections at U.S. facilities; these may range from the relatively small cost of START special access visits, as now formulated, to the much higher cost of a short-notice regime. Too many variables remain unresolved, however, for an accurate assessment of these costs to be made.

The CFE challenge inspection provisions stand in stark contrast to both START and CWC; although they will be conducted on short notice, they will cost the United States very little. The treaty explicitly provides a brief period of time for facility preparation, limits inspector access to buildings within the specified area, and gives the inspected nation the right to refuse a challenge request. All of these factors may mitigate cost somewhat. For the U.S., however, the reason these inspections are so inexpensive is that the only U.S. facilities that may be subject to challenge inspection are the few undeclared U.S. military facilities, primarily naval facilities, that are located in the Atlantic-to-the-Urals region; the treaty does not allow inspections at any facilities outside this geographic area.

Because U.S. production facilities will not be inspected, and probably very few, if any, U.S. facilities overall, the cost to the U.S. for hosting challenge inspections will be negligible. This may not be the case, however, for nations with territory within the ATTU region.

c. Why is CFE So Inexpensive?

Inspections under CFE will be surprisingly inexpensive for many reasons, in addition to the limited geographic scope of the treaty. First, although the total number of OOVs is several times the number of facilities captured by any other treaty, the CFE quota system limits the number of OOVs that actually will be inspected. Inspections will then be further divided among the individual nations party to the treaty, so that the number ultimately conducted by the U.S. will be limited even further.

Second, monitoring TLI elimination is generally an expensive undertaking, because all four treaties allow a continuous inspector presence during elimination activities. Under CFE, these inspections are significantly cheaper than under any other treaty, even though the treaty requires the destruction of several thousand pieces of equipment. Again, this difference can be accounted for by a division of labor among participant nations. Very likely, these inspections will be conducted by multinational teams, with at most one or two U.S. members. Even if TLI elimination took place continuously over the three-year reduction period, it would require only some 10 to 20 U.S. inspectors on a full-time basis.

Finally, American inspectors and escorts will all be Service personnel, for whom no marginal salary costs are calculated. The technical requirements for CFE inspections of all types are conceivably at their minimum; inspection equipment will be decidedly low-tech. As a result, manpower and equipment costs are very low.

d. Why is CWC So Expensive?

While the CFE treaty takes a minimal-cost approach to verification, the CWC does much the opposite. It is, by far, the most costly treaty, even though the estimates shown in Table III-3 do not include the potential cost of facility impact in the United States. A number of factors contribute to make this so.

As discussed earlier, the mission of CWC inspectors is technically very demanding, requiring sophisticated, expensive equipment. Inspectors will generally be technically-trained civilians who can command relatively high salaries. Average equipment and manpower costs, as a result, will be higher for the CWC than for other treaties.

Far more importantly, however, the CWC monitoring regime captures an enormous number of facilities relative to INF and START. Unlike CFE, it does not incorporate a quota system to limit the number of facilities inspected in a given year, therefore reducing cost. In fact, the draft treaty implies that all facilities for which a facility attachment is negotiated will be inspected one or more times a year, depending on the type of facility.

In even greater contrast to CFE, the draft CWC requires the creation and maintenance of the International Organization charged with implementing the Convention. Should the International Organization follow the pattern of such organizations generally, and the IAEA Nuclear Safeguards Program in particular,⁴³ it will experience administration and overhead costs substantially higher than those typically found in U.S. government agencies, leading to greater overall costs. Although the CFE treaty, like the CWC, is a multilateral agreement, it specifically assigns responsibility for verifying compliance to the signatory nations. Unlike the CWC, it does not establish an independent organization to implement, coordinate, or oversee verification activities. The CFE treaty, as a result, avoids the costs associated with establishing and maintaining such an organization.

D. SUMMARY AND DISCUSSION

The primary difference in the four verification regimes discussed here is where they draw the line between declared and undeclared facilities, and how this affects the ability to detect cheating by various means. The number and types of facilities that fall into the declared category are, clearly, closely related to the types of inspections incorporated into a treaty's verification regime. The types of inspections, and various treaty approaches to them, in turn determine the overall cost of the regime.

The list of declared facilities for all four treaties includes the facilities that make up the infrastructure surrounding TLI--those where TLI are routinely located during their operational lifetimes. Monitoring of these TLI-related facilities, together with declared data, will accomplish the first goal of monitoring: observing other signatories' compliance with the treaty.

The second, arguably more important and clearly more demanding goal of monitoring is to detect cheating if it occurs. If declared data are thoroughly validated and

⁴³ There is a rather large body of literature discussing the pros and cons of using the IAEA as a model for the International Organization established by the CWC. While the analogy is far from perfect, both would be international organizations established in part to verify compliance with a multilateral treaty.

TLI destruction closely observed, nations will have high confidence in the continued accuracy of the body of declared data. Inspections at TLI-related facilities, and comparison of collected and declared data, should then detect any cheating that may occur through the diversion or alteration of declared TLI. Any undeclared TLI located at these facilities is likely to be detected as well.

The heart of the difference between the four treaty monitoring regimes is in the quite different approaches they take to the problem of detecting the production of illegal TLI. The differences here explain most of the variation in verification costs.

It is simply not possible to identify and monitor every facility where TLI could possibly be produced. As a result, verification regimes tend to focus on capturing the most likely production facilities, generally those that have produced actual TLI and/or those that produce items very similar to TLI. Nations usually are required to declare these facilities and allow them to be monitored.

All other possible production facilities, known or unknown, will fall into the category of undeclared facilities. Both the production of illegal TLI and the storage of undeclared TLI can take place at undeclared facilities. Nations will be able to detect activities like these only through NTM and other intelligence assets; on-site inspections may confirm that cheating is taking place, but in and of themselves they provide almost no confidence that cheating can be detected.

The treaties differ in the scope of their requirement to declare and monitor production and potential production facilities. The CFE treaty precludes monitoring of such facilities altogether. Only two are declared and monitored under INF, and only nine under START. The CWC, on the other hand, is much broader in the types of production facilities it captures. All facilities where chemical agent is produced or used in small quantities will be monitored, as will all those producing commercial chemicals that could be transformed into chemical agent with the addition of a single step in the production process. The treaty will require other chemical facilities to report on the amounts of certain chemicals produced there.

The treaties also differ in the way they monitor production facilities. The START and INF treaties include PCM at the facilities where they consider cheating most likely; START also includes suspect-site inspections at a few other likely facilities. Both these types of inspection are very expensive: the former because of the manpower and equipment requirements for inspections themselves, the latter because of the sensitivity of the

inspected facilities and the likelihood that they will experience costly disruptions in their production processes. Inspections under CWC are much more likely to adhere to the standard form of inspection, augmented perhaps by instrument monitoring or continuous inspector presence. These inspections are cheaper on a per unit basis, but the sheer number of them leads to very high costs.

Finally, the approaches to inspection of undeclared facilities varies by treaty. The INF treaty does not include inspections of this type. The START treaty mentions them as one of several means by which compliance concerns can be resolved; the right to conduct an inspection and the procedures for doing so are subject to negotiation. Under CFE, nations have the right to refuse challenge inspections, but if they take place, inspectors will be given access to the inspected area on short notice. Challenge inspections under the CWC may not be refused, but the extent to which inspectors may access the facility in question is subject to negotiation.

What are the implications of these differences for the relative cost of the treaties? The percentage of verification costs resulting from the different types of inspection are shown in Figure III-1 below.

For inspections at undeclared facilities, the difference is slight. All treaties that include such inspections have either consciously taken a low-cost approach (START and CWC), or would not result in significant costs for the United States whatever the approach (CFE).

For all treaties except CFE, the large bulk of costs results from monitoring production facilities. These facilities are the most expensive to monitor because they are usually commercial facilities, because they have production processes that are sensitive to disruption, because they are highly sensitive and require a great deal of preparation, or because there are a large number of facilities involved.

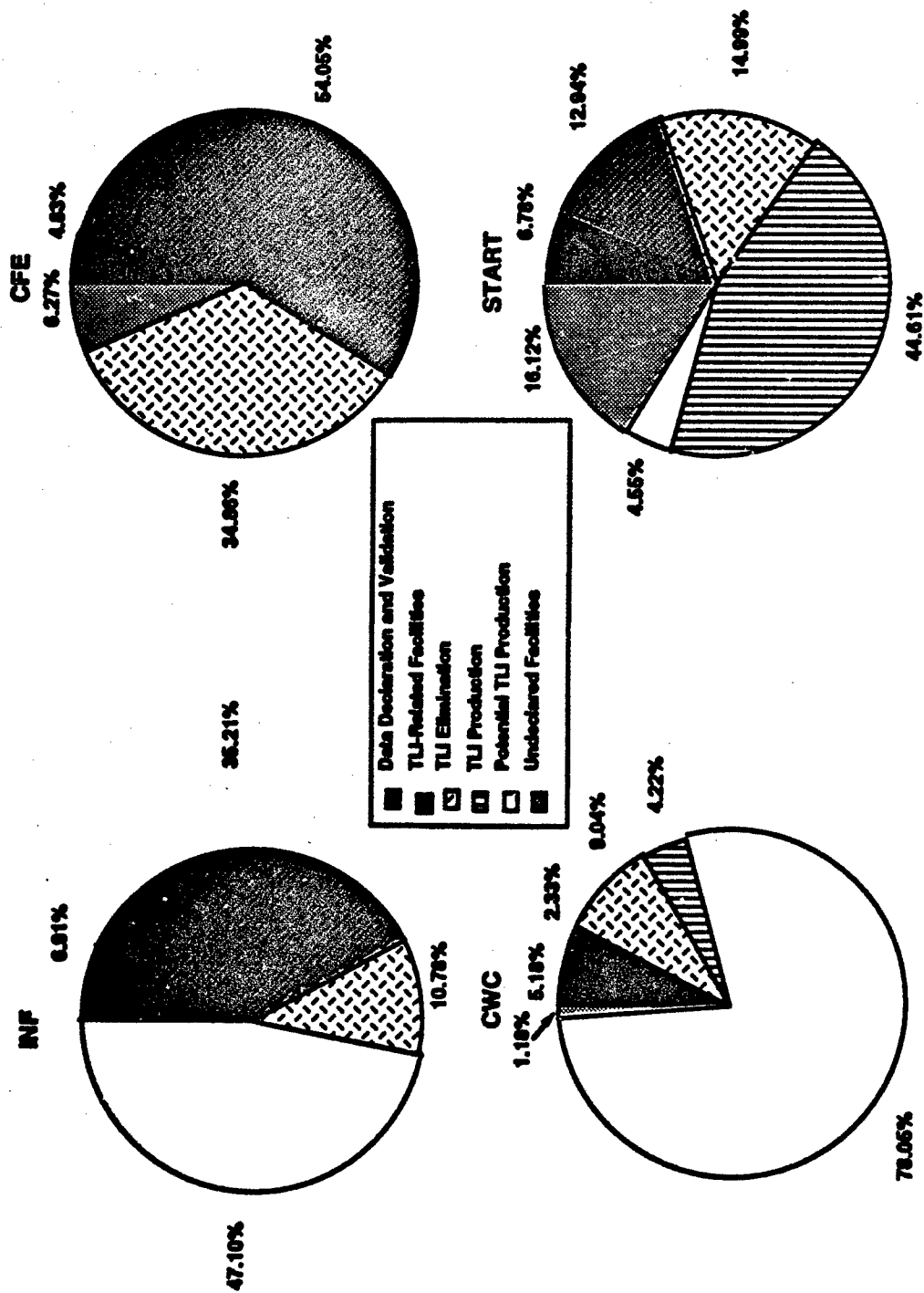


Figure III-1. Percentage of Treaty Verification Costs Devoted to Inspections of Different Types

IV. WAYS TO REDUCE THE COST OF VERIFICATION AND IMPLICATIONS FOR EFFECTIVENESS

After considering all of the factors discussed in the previous two sections, we have concluded that it is indeed possible to significantly reduce the cost of treaty verification without compromising its effectiveness. A proposal for doing so is described below.

While the elements of this proposal generally can be applied to any verification regime, particular attention is given here to the START treaty and the Chemical Weapons Convention. In our view, the CFE verification regime already reflects a minimum-cost approach. The INF treaty, meanwhile, is now in the later phases of implementation; there is probably little benefit in changing its verification regime at this point in time.

A. REDUCING VERIFICATION COSTS

1. Monitoring Declared TLI and the TLI Infrastructure

For data validation, inspections at TLI-related sites, and monitoring of TLI elimination, the only measure that could really be taken to save costs would be to inspect on a quota system, reducing the number of sites that are inspected in a given period of time. This is already done in many cases, including CFE baseline and declared site inspections, INF quota inspections, and START data update inspections. Because of the large numbers of sites involved, the CWC could benefit from placing quotas on routine inspections as well.

To have confidence that cheating will be detected at TLI-related facilities, one must have a high degree of confidence in the continued accuracy of declared data. For this reason, we feel that the resources required for thorough data validation and monitoring of TLI destruction are well-spent. In these cases, it would be better to make inspections more efficient than to reduce their overall number. This could be done in a variety of ways, such as minimizing the number of inspectors involved or conducting inspections in a sequential fashion.

2. Inspections at Undeclared Facilities

As discussed in the previous section, inspections at undeclared facilities can be very costly to the U.S. if they are conducted at U.S. industrial facilities on short notice. Both the START special right-of-access visits and the proposed CWC challenge inspections were designed to limit costs to the U.S. by allowing affected facilities adequate time to prepare for inspection. We believe that these regimes effectively minimize the cost of inspections at undeclared facilities.

3. Monitoring Production Facilities

Clearly, any proposal to reduce the cost of verification must include changes in the monitoring of TLI production facilities and potential production facilities. As shown in Table III-3, these types of inspections account for the majority of the cost of both START and CWC. We recommend that inspections of declared production facilities either be restricted to something like the START mandatory SSI regime, or better yet, eliminated altogether.⁴⁴

B. IMPACT ON EFFECTIVENESS

We have consistently referred to two main goals of verification: to confirm compliance with a treaty, and to detect cheating if it occurs. Nations will conduct compliance activities at TLI-related sites; verifying compliance effectively would require monitoring only at these sites.

Cheating, on the other hand, can occur in a number of different ways and at a broad range of facilities. Declared TLI can be diverted or altered at TLI-related facilities. Illegal TLI can be manufactured at declared TLI production facilities, potential production facilities, or undeclared facilities. Undeclared TLI can be stored or deployed virtually anywhere.

Given the relationships between methods of cheating and types of facilities, a verification regime must meet two basic requirements before it can provide confidence that cheating will be detected. First, it must include inspections at TLI-related facilities to detect

⁴⁴ The only exception we would make to this recommendation for the four treaties discussed here involves monitoring of CW production facilities. Since the CWC requires nations to destroy these facilities along with all chemical weapons, they are essentially considered a type of TLI and should be treated as such. Thus, declarations of these facilities and their subsequent destruction should be thoroughly validated.

the diversion or alteration of declared TLI. Second, it must include inspections at undeclared facilities to confirm the existence of undeclared or illegally produced TLI.

Both storage or deployment of undeclared TLI and illegal TLI production can take place at declared facilities as well. But no matter how much confidence the regime provides that cheating will be detected at these facilities, overall confidence will be lacking if cheating of this kind cannot be detected and confirmed at undeclared facilities.

1. Monitoring Declared TLI and the TLI Infrastructure

Our proposals for reducing verification costs are consistent with meeting the requirements described above. We recommend that all declared data be validated, and any changes to the data, such as that resulting from TLI elimination, be thoroughly monitored as well. If confidence in the declared data is maintained, we feel that inspecting TLI-related facilities on a quota system will provide adequate confidence that any cheating there will be detected. We do not see a need for frequent inspections at every facility.

It can be argued that thorough validation of declared data at the beginning of treaty implementation is unnecessary, since subsequent inspections at declared facilities will ultimately provide the same information, albeit over a much longer period of time. We believe, however, that there are many advantages to conducting baseline inspections at all declared facilities.

First, it provides a complete picture of the TLI-related infrastructure at a defined moment in time. Inspections at declared sites conducted over the lifetime of a treaty will never provide the complete picture that is gained through baseline inspections. Second, we believe that thorough validation of declared data at the beginning of treaty implementation will allow nations to retain high levels of confidence in declared data with fewer inspections over the lifetime of the treaty than would otherwise be the case. Finally, there is a significant psychological benefit in thorough validation of declared data, since it provides immediate confidence in a nation's declaration; the alternative provides confidence only after an extended period of time.

Appendix A examines the quantitative relationship between the coverage of baseline inspections and the validation process.

2. Inspections at Undeclared Facilities

Effective detection of cheating at undeclared facilities depends not on the inspection regime, but on the capability of a nation's NTM and other intelligence assets. The role of inspections is to provide confirmation of illegal activities by other means. The usefulness of these inspections should not be underestimated: even if a nation is willing to publicize intelligence information that points to cheating, the information will always be subject to misinterpretation and doubt. Evidence collected as a result of an inspection is likely to be more clear-cut and less easy to ignore.

To avoid having their illegal activities confirmed, cheating nations may attempt to remove incriminating evidence from the facility in question or destroy it in situ. In many cases, NTM will be able to detect these activities; occasionally it will not. For inspections at undeclared facilities to be effective, they must allow nations to not only collect any evidence of cheating that exists at the facility, but also to detect efforts to remove or destroy evidence in cases where NTM cannot do so.

The way in which inspections at undeclared facilities are conducted, as well as their effectiveness, will depend to a large extent on the nature of the TLI and the capability of NTM. For example, chemical weapons, whether munitions or bulk agent, probably can be moved out of a facility with impunity because they generally are not in containers large enough to be detected by NTM. As a result, the U.S. CWC challenge inspection proposal allows inspectors to monitor the perimeter of a challenged facility on short notice, increasing the likelihood that inspectors would detect any attempt to move incriminating evidence.

On the other hand, if NTM were focussed on a suspect, undeclared facility, it could, in all likelihood, detect the movement of tanks, aircraft, artillery pieces, or the first stage of a ballistic missile out of the facility. For START and CFE, therefore, inspectors would not need immediate access to the perimeter of a challenged facility, since the removal of illegal TLI would probably be detected by NTM.

It would be virtually impossible for a nation to clandestinely destroy TLI in situ at suspect facilities. Controlled burning of ballistic missiles or chemical agent may be observable via NTM. It is also likely to leave traces that can be detected by inspectors, even if several weeks elapse before they are granted access to the facility. Moreover, destruction of these types of TLI is an inherently dangerous process. Attempts to destroy

TLI in a hurry and at facilities not configured to do so will only increase the likelihood of a tell-tale explosion or release of toxic substances.

If cheating nations keep any illegal TLI or other evidence of illegal activities under cover or otherwise hidden at a suspect facility, they probably will not be observed by NTM prior to inspection. But assuming inspectors are ultimately provided sufficient access to the suspect facility, the existence of these illegal TLI is likely to be confirmed.

Popular wisdom now has it that inspections of undeclared facilities will only be effective if they are intrusive and conducted on short notice. This is because it is generally believed that such inspections are capable of detecting cheating in and of themselves. As we have pointed out, however, inspections conducted in the absence of cueing information are simply conducted on a random basis; whether on short notice or not, they will provide very little confidence that cheating will be detected.

The only way short notice inspections can increase the effectiveness of the regime is if they are the sole means by which the movement or destruction of illegal TLI could be detected. This is not the case for any of the four treaties under discussion. Moreover, as noted earlier, short notice inspections would be extremely expensive if conducted in the United States.

In sum, inspections at undeclared sites must meet three criteria to be effective. First, they must provide a means of detecting the removal of TLI from a suspect facility if NTM is unable to do so. Second, they must be able to detect any attempts to destroy TLI in situ that may have been made prior to the inspection. Finally, and most importantly, they must be intrusive enough to ensure that evidence of any illegal activities can be collected.

We believe that the inspections of undeclared facilities included in CFE, START, and the CWC meet these criteria at a minimum cost. Although the INF treaty is clearly lacking in this regard, this will be of less concern once the START treaty enters into force. Because of the similarity of TLI between the two treaties, and because both have the same signatories, any suspected violations of the INF treaty probably can be resolved through the START Joint Compliance and Inspection Commission.

3. Monitoring Production Facilities

We see no clear need for TLI production facilities or potential production facilities to be included in the inspection regime for declared sites. Rather, we suggest that they be

subject to inspection as though they were undeclared sites. Doing so would have only limited consequences and would save a large percentage of the cost of verification.

Most of these facilities will be known to treaty signatories whether or not they are declared; as a result, they will continue to be the focus of ongoing intelligence collection efforts. This makes it much more likely that illegal activities will be detected at production facilities than at other types of undeclared facilities. In addition, cheating could be deterred by occasionally conducting inspection at these facilities, even if no illegal activities are suspected.

This regime may not guarantee that illegal production of TLI would be detected if it took place *at these facilities*. But confidence in detecting such cheating at these particular facilities is meaningless in the absence of sufficient confidence that similar cheating would be detected anywhere else. And if nations can be confident that they can, through NTM, detect cheating at undeclared facilities, then they will have even greater confidence that they can do so at known TLI production facilities and potential production facilities.

In short, the expensive inspections of production facilities now incorporated into START and the CWC add very little to the effectiveness of either treaty. Without the means to detect cheating at undeclared facilities, the effectiveness of both will be very limited. If, on the other hand, these means exist, then inspections of this type are superfluous.

C. SUMMARY AND CONCLUSIONS

We believe any arms control verification regime can be effective at minimum cost if it includes the following key elements:

1. Require the declaration of all facilities that are part of the infrastructure surrounding TLI during the course of its operational lifetime.
2. Validate data at all declared facilities.
3. Inspect TLI-related facilities on a percentage, or quota, basis.
4. Continuously monitor all TLI elimination activities.
5. Incorporate provisions for inspection of undeclared facilities.

As a corollary, we believe it is neither necessary nor, because of the high cost involved, particularly desirable to include the monitoring of TLI production and potential production facilities as part of a verification regime.

Except for the second element, the CFE verification regime could serve as a model of low cost, effective verification. We expect that adapting these elements to the START and CWC verification regimes would have little if any impact on their effectiveness and would result in savings to the United States of nearly \$4 billion over the fifteen-year lifetimes of these treaties.

APPENDIX A
BASELINE INSPECTIONS

BASELINE INSPECTIONS

In the body of this paper, it is argued that it is necessary to inspect fully all declared facilities during baseline inspections in order to build a foundation for future monitoring. This is consistent with current monitoring schemes and is subjectively appealing. Nevertheless, if it could be shown that there was some point at which the marginal returns from baseline inspections began to decrease with the number of inspections, then it might be possible to argue that complete baseline coverage is not necessary. In this appendix, we investigate this issue quantitatively. We will show that, in fact, a useful measure of the effectiveness of baseline inspections displays increasing marginal returns with the number of inspections.

Baseline inspections address what we have characterized as the first objective of monitoring: generally to ensure that compliance activities are carried out properly, which in the particular case of baseline inspections means ensuring that declarations of holdings correspond to what is actually at declared sites. In addition, a validated set of declared data provides a benchmark against which non-compliance can be determined.

One would not expect systematic circumvention of the treaty through invalid representation at declared sites.¹ Such sites are simply under too much scrutiny at the earliest stages of the monitoring process for there to be a conceivable benefit in such an action. What would be more reasonable, on the other hand, are discrepancies at various locations due to administrative error, misinterpretation of treaty provisions, and other unique factors that allow one to treat the occurrence of discrepancies at sites as independent random events. One can then examine the relationship between number of inspections, and the likelihood that all discrepancies will be caught, and presumably corrected, establishing a credible baseline for further monitoring activities. We model this as follows.

¹ Cheating on declarations is far more likely to take the form of omitting sites altogether than of under-reporting holdings at those that are declared. In this case, however, the problem is substantially different from that discussed here. See Appendix C on challenge inspections.

Let p characterize the binomial² probability that there is a discrepancy at a given site. We assume that the same parameter applies to all sites and that errors at different sites are completely independent. Although this is a simplification in that some sites may be more prone to error because of size or complexity, it is reasonably consistent with the notion that errors in declarations are inadvertently created rather than part of a conscious scheme.

Let the total number of declared facilities be N , and the number inspected, n . Let $q(n/N)$ be the probability that all discrepancies have been caught after a fraction n/N of the sites have been inspected. Then

$$q\left(\frac{n}{N}\right) = (1-p)^{N\left(1-\frac{n}{N}\right)}$$

Figure A-1 displays this curve for various values of N and p . What is most significant about this function is that it is convex, signifying increasing marginal returns as n/N increases. Since baseline monitoring costs increase linearly with the number of sites,³ it is apparent that there is no place short of complete inspection where effectiveness (measured by q) divided by cost decreases. Hence there is no standard cost-effectiveness argument that can be made to justify less than complete coverage of declared facilities during baseline inspections. Figure A-1 suggests that in situations where the number of declared facilities is small *and* the probability of discrepancy low, then, as would be expected, the likelihood of undetected error at uninspected facilities is low almost independently of how many facilities are inspected. In this case, however, the costs of inspection are low because of the relatively few facilities, and so the monetary advantages of foregoing baseline inspections are relatively small. Moreover, since the value of p is essentially unknowable a priori, assuming p is low enough for this argument to be valid is difficult to justify.

Even if the baseline inspections were a significant portion of the monitoring budget, which is not generally the case, it would nevertheless be inadvisable, based on the above analysis as well on intuition, to attempt to save money by cutting back on baseline inspections.

² Note that we are not sensitive to the magnitude of a discrepancy at a site or even the number of discrepancies. The holdings at a site are either in total conformance with the corresponding declaration, or they are not.

³ Or perhaps even more slowly than linearly, if learning effects or efficiencies of scale enter into the process.

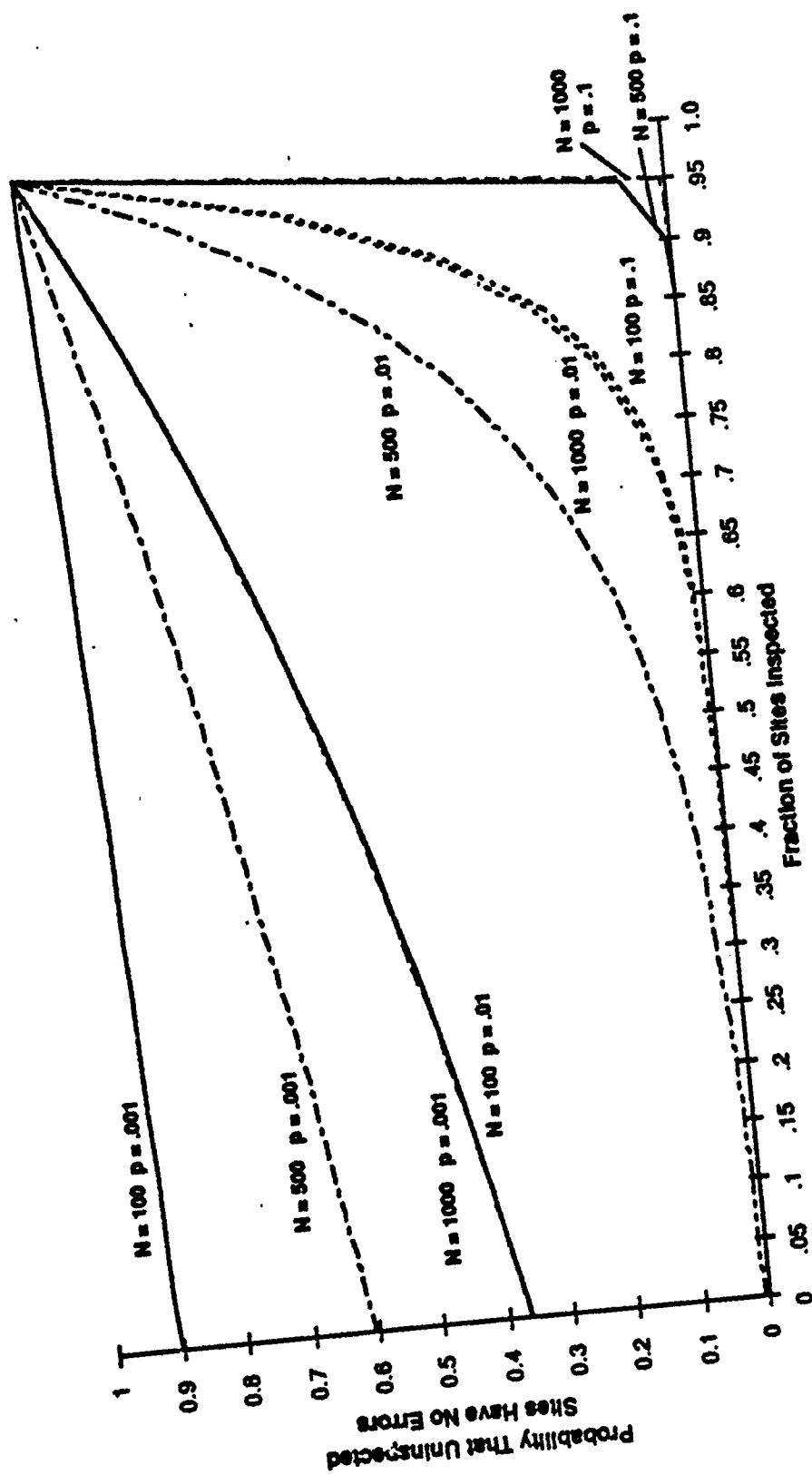


Figure A-1. Baseline Inspection: (a)
Probability of Catching All Discrepancies

APPENDIX B
QUOTA INSPECTIONS

QUOTA INSPECTIONS

A. INTRODUCTION

Regular inspections of facilities associated with treaty-limited items have two functions: to assure that the declared data remain valid and to catch systematic violations should they occur. Although the costs associated with quota inspections at other than production and potential production facilities are not a particularly large component of overall monitoring costs, a question remains as to how to determine what the minimum acceptable level of quota inspection is to determine whether savings can be realized. The two functions, however, need to be analyzed differently.

B. VALIDATING DECLARED DATA

Quota inspections satisfy the first function—to ensure that the numbers of declared items at facilities subject to such inspections remain consistent with original declarations and subsequent notifications. In such a capacity, quota inspections are nothing more than a straightforward sampling mechanism: if the total number of facilities is N , the number of actual discrepancies at those facilities N_1 , and the number of inspections n , then the probability of catching at least one discrepancy (i.e., of identifying that there is a problem with declared holdings, even if the scope of that problem cannot be identified), $s(N_1/N)$, in the course of a year's inspections is given approximately¹ by

$$s\left(\frac{N_1}{N}\right) = 1 - \left(1 - \frac{N_1}{N}\right)^n$$

Figure B-1 displays this function for various values of n . As one might expect, if the number of sites with discrepancies is small, the likelihood of finding at least one is small, suggesting that current quotas have not been set with this objective in mind, since

¹ The formulation given here is approximate in that it presumes *sampling with replacement* instead of *sampling without replacement*, which is probably more appropriate for an annual quota. This approximation is satisfactory when the ratio $n/N < \text{about } 0.1$, which is roughly the situation that obtains for INF, START, and CFE.

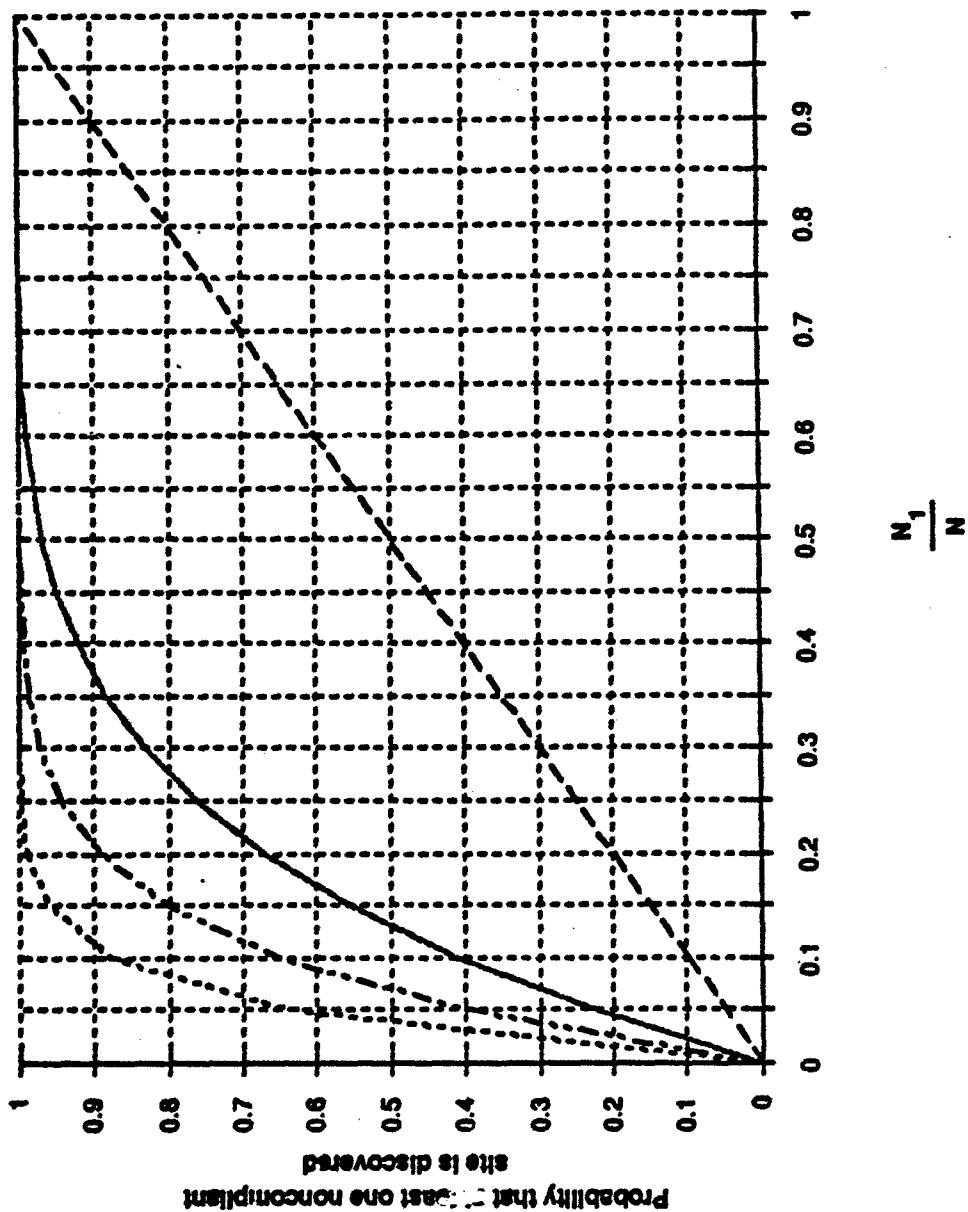


Figure B-1. Quota Inspections:
Probability of Finding a Discrepancy

they are too low to provide much confidence of finding the odd problem with declared information.

C. CATCHING SYSTEMATIC VIOLATIONS

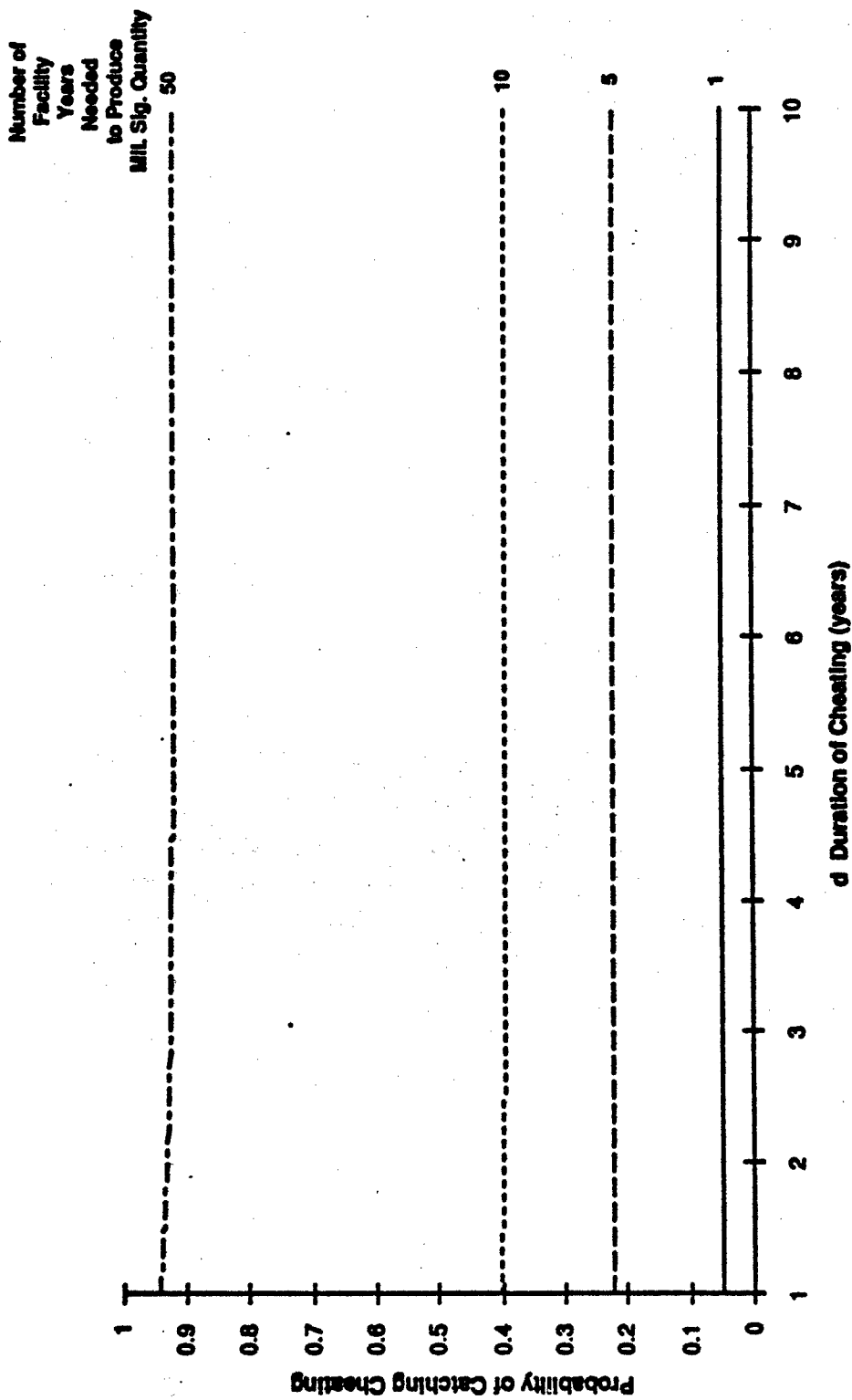
Catching systematic violations is the second objective of quota inspections. When one is looking for inadvertent errors in declared data, it is reasonable to assume that the errors appear randomly, whereas systematic violations involve a number of facilities over a period of time dedicated to, one can assume, producing a militarily significant quantity of treaty-limited items.

We will not endeavor to distinguish types of facilities and how they would need to cooperate to produce a militarily useful threat. In a more detailed analysis, this could, of course, be done. Rather, we will assume a single type of facility, and that systematic circumvention of a treaty in order to produce a militarily significant quantity of treaty-limited items can be characterized by a fixed and known number of facility-years dedicated to such an end. So long as the product is constant, this formulation is independent of whether these facility-years are achieved by many facilities operating over a short period or a smaller number of facilities operating over a longer period. Detecting circumvention requires that at least one of these facilities be found during quota inspections.

Again, let N be the overall number of declared facilities, with the number of facilities participating in illegal activities being N_1 . Let the annual quota of inspections of declared facilities again be n . Let d be the period over which N_1 facilities must operate in a violating mode in order to produce a militarily significant quantity of TLIs, so that $dN_1 = k$, a constant. Now, using a *sampling with replacement* formulation, the probability c of catching at least one cheater during the cheating period is

$$c = 1 - \left(1 - \frac{N_1}{N}\right)^{\frac{nk}{N_1}}$$

Figure B-2 shows the probability of catching a cheater for cases where there are 200 declared facilities, 20 inspections per year, and where there are 1, 5, 10 or 50 facility-years needed to produce a militarily significant amount of treaty-limited items. Note the fact that the probability of detection is approximately independent of whether the violations are effected quickly with many facilities or slowly with only a few. With 200 facilities and 10 years available (in this particular display), 50 facility-years is only a few percent of the



**Figure B-2. Quota Inspections:
Probability of Catching Cheating as a Function of the
Number of Facility Years Required and Duration of Cheating**

N = 200 Facilities

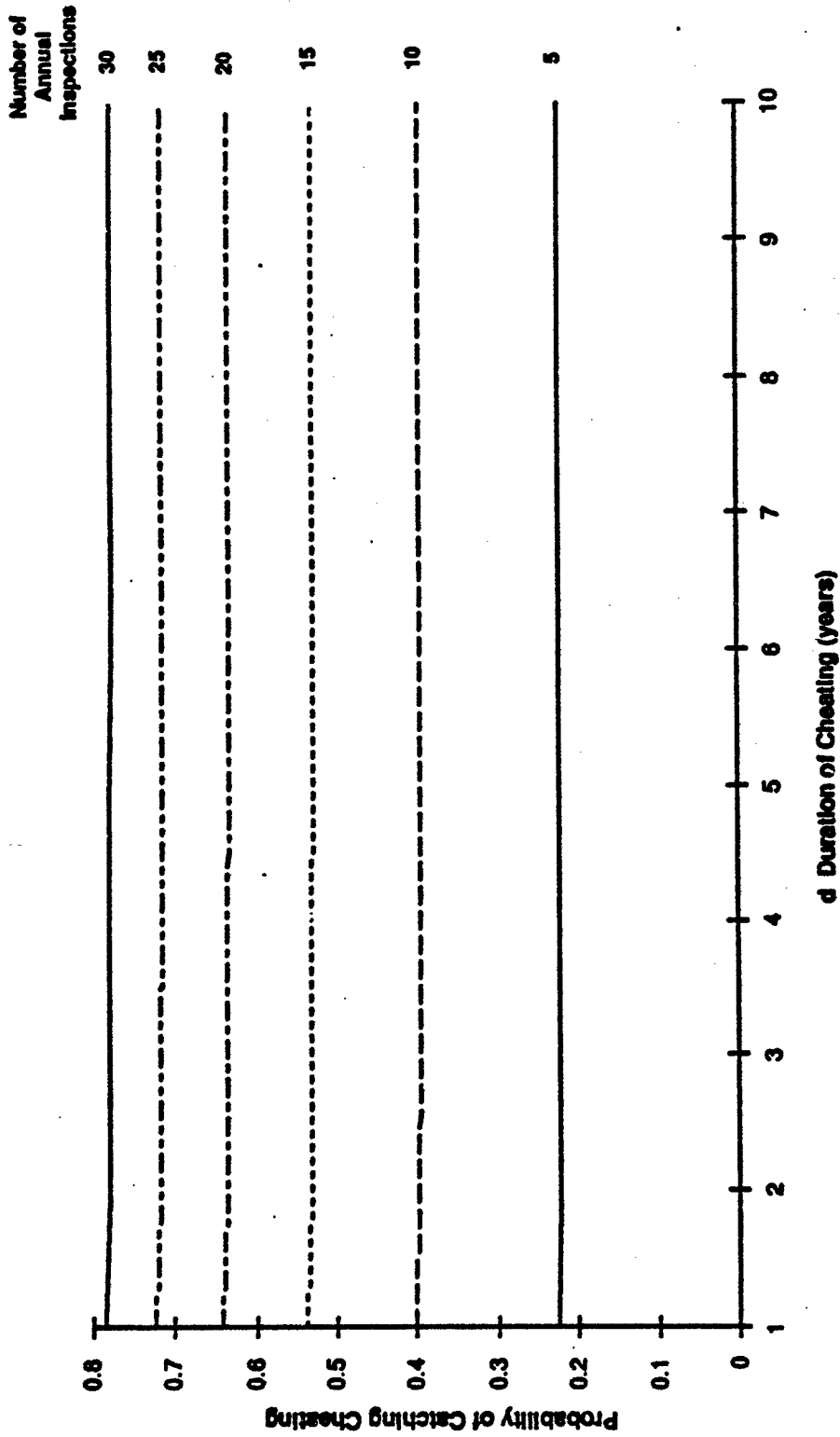
n = 20 inspections per year

Quota Inspection

available capacity. It is not unreasonable to assume that large amounts of excess capacity are not typical of facilities that produce treaty-limited items, so that an inspection regime covering 10 percent of the facilities per year (on a base of a few hundred facilities) yields a good chance of finding violations.

Figure B-3 suggests the sensitivity of detection circumvention as a function of the number of annual inspections. For this example, we again use 200 facilities but restrict ourselves to the case where 10 facility-years is sufficient to produce a militarily significant quantity of cheating. These results also suggest that quota inspections that cover a fraction of the declared facilities are sufficient to generate a reasonable confidence that violations will be detected.

The authors do not know of any analyses that attempt to quantify for any treaty the number of facility-years that are needed to create a serious threat. Qualitatively, however, the foregoing suggests that unless that number is extremely small relative to the number of facility-years available over the lifetime of the treaty, quota levels on the order of what have been implemented in INF, START, and CFE will probably be effective at catching systematic violations at declared facilities.



B-6

N = 200 Facilities

k = 10 Facility years required to
produce a military
significant quantity of TLJ

Figure B-3. Quota Inspections:
Probability of Catching Cheating as a Function of the
Number of Annual Inspections and the Period Over Which Cheating Takes Place

APPENDIX C
CHALLENGE INSPECTIONS

CHALLENGE INSPECTIONS

Challenge inspections differ from those discussed in the previous two appendices in that there is no defined set of facilities to which challenge inspections are restricted. Rather, there is an essentially unlimited set of sites at which concerns could arise. Attempts to limit this set by identifying certain characteristics of challengeable sites generally have been unsuccessful. Further complicating this problem is the fact that, for most treaties, few challenge inspections can be made per year, both because making challenges has political overtones and because challenge invites reciprocal requests for access to what might be sensitive facilities.

The key to successful challenge inspections is not so much the inspection itself--although details such as what levels of access are accorded inspectors are certainly important--as it is the characteristics of the cueing mechanism used to select sites for inspection. We will not discuss what mechanisms are being contemplated by the U.S. government for choosing targets for challenge inspection, but it is clear that unilateral intelligence systems will certainly pinpoint sites that appear to be involved in suspicious activities. Because of the limited number of challenge inspections allowed, a most significant characteristic of these mechanisms, as we will show, is the false alarm rate--the degree to which facilities not actually engaged in circumvention are declared, on the basis of these mechanisms, to warrant challenge inspection.

We can characterize the cueing mechanism with two probabilities¹: f = the probability that, if a site is engaged in circumvention of the treaty, the cueing mechanisms will correctly categorize it as a circumventing site, and g = the probability that, if a site is not engaged in circumvention of the treaty, the cueing mechanisms will categorize it as compliant. Note that we do not allow for a third category, sites that cannot be classified. We can accommodate this by putting such sites in either the compliant or noncompliant baskets. It is also possible to extend the analysis in a relatively straightforward way to accommodate a third category.

¹ This formulation is drawn from Levine, D., *The Costs and Effectiveness of Treaty Verification Regimes*, Institute for Defense Analyses, P-2650, January 1992. The analysis in this section, however, is somewhat less rigorous than that in the cited paper.

The complementary probabilities are also important: $(1-f)$ is the probability of a false negative; i.e., the probability that a cheating site will not be identified as such, and $(1-g)$ is the probability of a false positive--the probability that, if a site is not engaging in illegal activity, it will be characterized as in violation.

Suppose, over the course of a year, the cueing mechanism can view N sites, and suppose, of those sites, only N_1 --a much smaller number--are actually engaged in illicit activities. Then, on the average, we would expect the cueing mechanism to indicate that $fN_1 + (1-g)(N-N_1)$ targets are not in compliance and that $(1-f)N_1 + g(N-N_1)$ are in compliance.

On the basis of this information, there are no grounds for visiting any sites deemed to be in compliance.² Of the sites deemed to be noncompliant, if we pick one at random to visit, the probability of visiting one that is actually noncompliant is approximately³

$$\frac{f N_1}{f N_1 + (1-g)(N - N_1)}$$

This can be rewritten as

$$\frac{1}{1 + \left(\frac{1-g}{f}\right) \left(\frac{N}{N_1} - 1\right)}$$

Inspection of the above expression reveals several important conclusions. First, as it is unlikely that N_1 is close to N , the expression $(N/N_1 - 1)$ is likely to be a large value. If that is the case, then it is necessary that $(1-g)/f$ be as close to zero as possible if the probability of visiting a noncompliant site is to be reasonable. This requires that g be very close to unity. The value of f is less critical.⁴

Consider an example. Let $N=10,000$, $N_1=100$, $f=0.9$, and $g=0.9$. Even with these relatively good performance characteristics for the cueing system, the probability of

² One might choose to visit such a site anyway, in order not to reveal information about the effectiveness of the cueing mechanism, but one should not have a high expectation of finding noncompliance on such a "randomizing" visit, even though the probability of doing so is not identically zero unless $f=1.0$.

³ We are substituting expected values for probability distributions in this section, a practice that is somewhat dubious from the point of rigor but which simplifies the calculations enormously. For the purposes of understanding the importance of the parameters used in the calculations, simplicity of expression outweighs the inexactness of the estimate.

⁴ It may be assumed that $f > 0.5$, since a value of $f = 0.5$ implies that the targeting mechanism, given a noncompliant site, is essentially a coin-toss in specifying whether the site is in violation or not. A targeting mechanism with that characteristic would be of little value.

that a site chosen for a challenge inspection is only 0.08. Increasing the value of g to 0.99 is needed in order to increase the probability of visiting a noncompliant site to as much as 0.5.

We do not know what are actual reasonable values for f and g . They are, however, critical parameters if the effectiveness of challenge inspections are to be estimated. For some treaties, such as the Chemical Warfare Convention, where treaty-limited items and production capability are easily hidden, we suspect that f and g will not be particularly high. Under such circumstances, therefore, challenge inspections may be justifiable more on a political basis than as an effective means of finding noncompliance. For other treaties, such as START, where treaty-limited items have been followed by national technical means for decades, there is more hope of using challenge inspections to find and document noncompliant activities.