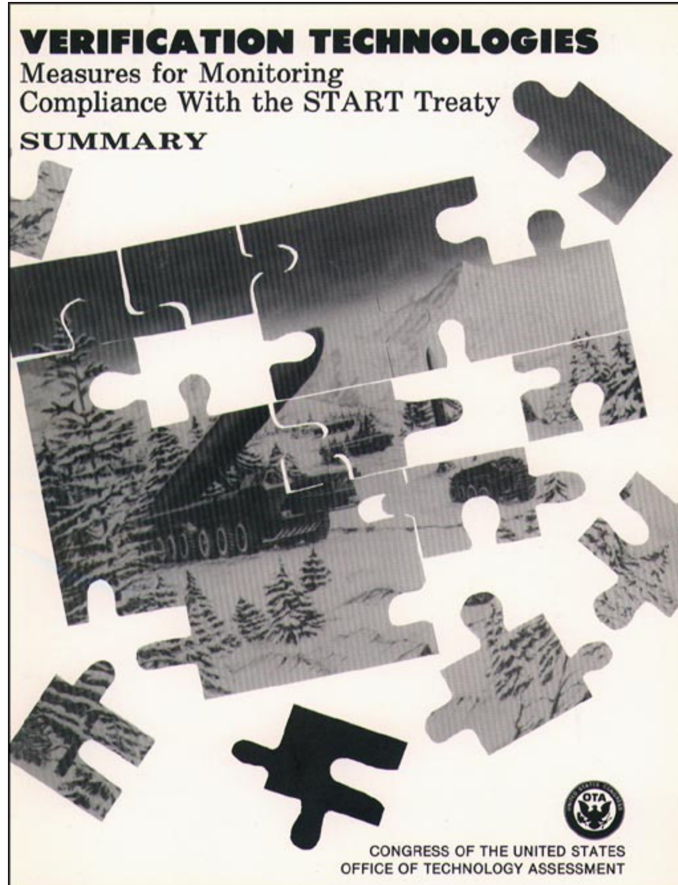
Verification Technologies: Measures for Monitoring Compliance With the START Treaty

December 1990

OTA-ISC-479
NTIS order #PB91-131813



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Foreword

If negotiations continue on track, a Treaty between the United States and the Soviet Union on Strategic Arms Reductions may come before the Senate early in **1991 for its advice and consent. In the coming months and years,** Congress will be faced with various issues related to arms control in areas such as chemical weapons, conventional forces, and perhaps START II. In particular, arms control verification will be an issue of growing importance. Congress will need to reach conclusions about the verifiability of agreements, about the benefits and risks to the United States of increasingly comprehensive verification regimes, about what level of national resources should be devoted to verification activities, and about what directions the development of U.S. and international verification capabilities should take.

The Senate Foreign Relations and House Foreign **Affairs Committees** asked OTA to undertake a study centering on the technologies and techniques of monitoring the Strategic Arms Reduction Treaty, still under negotiation. This is the summary of the first of the reports to be produced by that study. The report describes the role of monitoring in the arms control verification process. It surveys the types of on-site inspection and their costs, risks, and benefits. It also examines the INF Treaty experience for lessons relevant to START. Our general discussions of the monitoring process and on-site inspections are relevant to other types of arms control as well as to START. The report outlines the monitoring tasks specific to START and suggests the cooperative and unilateral measures available for a START monitoring regime. It does not attempt to predict which of the possible cooperative measures will finally be negotiated in the START Treaty. The full, classified report is available to those with appropriate security clearance and "need to know."

In preparing the reports summarized here, OTA sought the assistance of many individuals and organizations (see Acknowledgments). We gratefully acknowledge their contributions. As with all OTA reports, the content remains the sole responsibility of OTA and does not necessarily represent the views of our advisors or reviewers.

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NOTE: **OTA** appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

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Acknowledgments

OTA gratefully acknowledges the assistance of individuals in the following organizations for their help in supplying information or in reviewing drafts of this report (the contents of the report, of course, remains the responsibility of OTA):

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Lawrence Livermore National Laboratory
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Congressional Requests for This Study

Early in 1989 the Senate Foreign Relations Committee requested the Office of Technology Assessment to:

> . . . identify and analyze the monitoring and verification issues raised by the prospective regimes currently under negotiation respecting a START Treaty, including what kind and number of 'anytime, anywhere' inspections might be needed, if any, to resolve concerns about covert inventories or production facilities.

The Committee asked for a classified report, which they received in July 1990. The unclassified summary of that report is published here.

In April 1989, The House Committee on Foreign Affairs added its own request for OTA". . . to assist Congress in understanding the technical issues connected with monitoring compliance with the prospective START Treaty." The request letter outlined the kinds of issues it thought an OTA study might usefully address:

- What kinds of monitoring tasks will be involved in verifying START compliance?
- What kinds of monitoring measures might be included in a START verification regime?
- How would various monitoring measures complement or substitute for one another?
- What would be the relative contributions of various kinds of monitoring measures to the overall verification process?
- What can be learned from the INF Treaty verification experience that might be relevant for START?

In addition, the House Committee letter expressed particular interest in the ". . . newer technologies that can be brought to bear on such cooperative verification measures such as manned on-site inspections, manned perimeter and portal monitoring, and unmanned on-site monitoring, ' saying that "it would be useful to place these technologies in the broader context of verification technologies and methods.

In May 1989, OTA put before the Technology Assessment Board (TAB), and the Board approved, a proposal for a project which would attempt to address the concerns of both the Senate and House request letters. The report summarized here and the projected final report are to be the products of that project.

Project Guidelines

In consultation with the Committees and TAB, OTA determined that it could best serve their wishes by observing the following guidelines:

- the implications for U.S. national interests of on-site inspections of U.S. facilities should also be considered (a point that emerged from consultations with TAB members);
- the report would analyze possibilities for cheating on agreements (a point emphasized strongly during TAB deliberation on the project proposal);
- the report would not offer a detailed critique of the START Treaty, which in any case was likely to remain under negotiation while OTA pursued its research (to provide background for Senate deliberations on START, ideally the interim report would precede by some months the submission of a signed treaty to Senate for ratification);
- the report would not offer a judgment on the verifiability or non-verifiability of the Treaty; instead, it would attempt to provide Congress with background about the monitoring process that would help with that broader judgment; and
- an overall assessment of the strategic implications of the prospective START agreement for U.S. national security would be outside the scope of the OTA study.

Project Reports

The project proposal for this study conceived of an interim and a final report. As external events and the project itself developed, the OTA project staff decided to divide its tasks into two major sets that would address the somewhat differing concerns of the two requesting Committees. This seemed a more productive course than making an interim report that would be merely a preliminary version of the final report.

The initial report focuses on the needs of the Senate Foreign Relations Committee in preparing to deliberate on ratification of the prospective START Treaty. It describes the role of monitoring in the arms control verification process. It surveys the types of on-site inspection and their costs, risks, and benefits. It also examines the INF Treaty experience for lessons relevant to START. The general discussions of the monitoring process and on-site inspections are relevant to other types of arms control as well as to START.

The report outlines the monitoring tasks specific to START and suggests the cooperative and unilateral measures available for a START monitoring regime. Note that not all of the cooperative measures available will necessarily be negotiated into the Treaty. *The Joint Draft Treaty was not directly available to OTA or to the requesting Committees, though information about its contents was. In the* discussion of specific monitoring technologies, the report limits itself to those which may be available (though not necessarily applied) at about the time a START Treaty is ready to be signed and ratified.

The final report of the project is due early in 1991. The bulk of the final report will not focus on the START Treaty as such, although it may contain a section updating the Special Report for the Senate Foreign Relations Committee to use in its START ratification deliberations. Instead, the final report will look beyond the early implementation of a START Treaty to the longer term. It will explore technologies that may not be initially applied in START, but that might later supplement the START verification regime or be applied to other arms control arrangements. It may also review lines of further research on verification technologies that Congress might wish to support.

As the initial report most directly addresses questions posed by the **Senate Foreign Relations Committee, the final report will concentrate on the issues raised in the House Foreign Affairs Committee request letter. Topics for examination in the final report (which may be issued as a series of shorter reports) include:**

- the utility of an Open Skies agreement or other aerial surveillance arrangements for arms control monitoring;
- options for monitoring limits on sea-launched cruise missiles, should such an agreement be considered;
- program options for arms control monitoring technology research; and
- (tentatively) update of initial report in light of further information on Treaty contents.

Introduction

If a Strategic Arms Reduction Talks (START) Treaty is submitted to the U.S. Senate for advice and consent, the question of verification will be a major topic of debate. The report summarized here illuminates the issues, but does not resolve the debate. The preface describes the terms of reference guiding the project of which the full report is a product. Here is a summary of what the report does and does not do:

. the full report *does*
--describe the currently available techniques by which Soviet compliance with a START agreement could be monitored by the United States;
—treat the technology of arms control verification as the application of a set of techniques, not just as the devices which those techniques might employ;
—indicate, for the most part qualitatively, the potential utility, limits, costs, and risks of those techniques;
. the full report *does not*
—*assess* whether the prospective START agreement would be in the U.S. national interest;
—analyze the details of the draft START Treaty under negotiation as the report is being prepared;
—predict which of the verification provisions discussed in the report will actually be included in the treaty;
-describe in detail the characteristics of the devices employed in National Technical Means of verification (NTM);
-discuss all *types* of NTM.

Because of security classification, only the summary of this report will be published. The full report will remain secret but will be available to Congress.

The desirability of a START agreement will depend on whether it offers a net gain in national security **—a judgment that will rest on several factors taken together. Those** factors include the value of mutually reducing or limiting forces, the benefits and costs of the verification regime, the incentives and disincentives for the other party to cheat, the overall efficacy of intelligence about Soviet strategic forces, and the resiliency of the United States' own forces. This report directly addresses only one of those factors, the implications of possible verification measures.

Context for This Report

A START Treaty will be aimed at setting and maintaining mutually agreed ceilings on weapons of certain types. The stated purposes of setting these ceilings include stabilizing the strategic balance and reducing first-strike incentives. Table 1 summarizes the published points of U.S.-Soviet agreement and disagreement on START limits as of July 1990.

To assess verification needs for a START Treaty, it is as important to bear in mind what the agreement probably will *not* limit as well as what it will limit:

- Although the nominal deployed strategic nuclear warhead limit under START will be 6,000, in fact the proposed counting rules will allow the two parties to deploy legally several thousand more warheads in bombs, short-range attack missiles, and air-launched cruise missiles on bombers (although, in practice, they may not choose to do so).
- The production and storage (as opposed to deployment) of the types of Inter-Continental Ballistic Missiles (ICBMs) deployed in fixed, land-based launchers probably will not be limited: these legally produced missiles could conceivably form the basis for a later, overt breakout from treaty constraints.
- Certain types of ballistic missiles probably will be legally deployed with fewer than the actual number of reentry vehicles (RVs) with which they have been tested; in a later, overt treaty breakout, these missiles might be quickly converted to carry more RVs.
- The treaty probably will not limit production and storage of nondeployed Submarine-Launched Ballistic Missiles (SLBMs); conceivably, with the establishment of a clandestine deployment infrastructure, extra SLBMs could be based on land to augment existing ICBM forces.
- Production of submarine-launched cruise missiles probably will not be limited, and they could be used in strategic nuclear roles.

These legal paths to circumvention or preparation for breakout, available to both the Soviets and the

Table 1—U.S. and Soviet Positions on START Treaty Limits (as of July 1990)

	U.S. position	Soviet position
Strategic Nuclear Delivery Vehicles (SNDVs)[a]:	1,600	same
Heavy ICBMs (Inter-continental Ballistic Missiles)	Limit of 154; ban on production, flight-testing, or deployment of new types of heavy ICBMs; limits on flight-testing or modernization of existing types	Same limit; ban on development, testing, and deployment of new types; production, flight-testing, or modernization of existing types permitted.
Other ICBMs, SLBMs (Submarine-Launched Ballistic Missiles), Bombers	No sublimits; an agreed number of heavy bombers may be removed from 1,600 SNDV limit by conversion to conventional-only capability	Same
Non-deployed SNDVs	Numerical limits to be determined only on non-deployed ICBM types that have been flight-tested from a mobile launcher; restrictions on location and movement of other nondeployed ICBMs; ban on rapid reload of ICBM launchers	Same
Long-range nuclear SLCMs (Sea-Launched Cruise Missiles)	Not limited, but (for 5 years) politically binding annual declarations of total numbers deployed, not to exceed 880	same
Ballistic Missile Throw weight:	Aggregate throw weight of Soviet ICBMs and SLBMs reduced to 50% below level existing at a date to be negotiated; neither side to exceed this level	same
Warheads:	6,000	same
Ballistic Missile RVs (Reentry Vehicles)	4,900; For existing types, a quota of on-site inspections to verify that deployed missiles contain no more than the number agreed for each type at the 1987 Washington Summit	Same, but sides not agreed on procedures for future types
ICBM RVs	3,300 or 3,000	If 3,300 sublimit on ICBMs, then must also be 3,300 sublimit on SLBMs
Mobile ICBM RVs	1,100	same
Heavy ICBM warheads (Soviet SS-18)	Cut 50% to 1,540 on 154 ICBMs	same
SLBM sub-ceiling	No sublimit	3,300, if similar limit on ICBMs
Air-launched weapons:	No direct sublimits[b]	same
ALCMs (Long-range nuclear cruise missiles)	ALCMs with range over 600 km; attribute 10 each to the first 150 U.S. heavy bombers and 8 each to the first 210 Soviet heavy bombers; limit actual numbers equipped-for to 20 per U.S. bomber, 12 per Soviet bomber; above the 150- and 210-thresholds, attribute numbers as equipped; no limit on non-nuclear ALCMs deployed on aircraft outside treaty	same
Gravity Bombs and SRAMs (Short-Range Attack Missiles)	Each bomber not equipped for ALCMs counted as having one warhead	same

[a]Restrictions also apply to ICBM and SLBM launchers. Mobile launchers for heavy ICBMs are banned.
[b]However, the number of bombers is limited by the ceiling on strategic nuclear delivery vehicles. In addition, "counting rules" would specify the number of ALCMS each bomber is considered to carry-which might be lees than the actual number the bomber carries.

SOURCE: Adapted from U.S. Arms Control and Disarmament Agency, *Issues Brief—Nuclear and Space Talks: U.S. and soviet Proposals*, July 3, 1990.

United States, need to be taken into account when evaluating both any military advantages that the Soviets might hope to obtain by cheating on a START agreement and the responses available to the United States. The United States also will certainly continue to monitor Soviet production and deployment of weapons whether they are specifically restricted by START or not. It can continue to judge what margins of uncertainty are acceptable and what actions, if any, should be taken to maintain U.S. security. It could decide, for example, to undertake matching military activities not limited by the treaty.

The United States may also choose to maintain specific hedges or safeguards against the possibility of future Soviet departures from treaty limits. Such safeguards might take the form of continued, treaty-compliant research and development on weapons that could be used, if necessary, to counter Soviet treaty-breakout. They might take the form of treaty-compliant maintenance of manufacturing facilities capable of building forces in numbers beyond treaty knits. Or, they might take the form of reducing the payoff to the Soviets of cheating by, for example, deploying mobile missiles resistant to large-scale, first-strike attacks.

The verification and compliance process for START will include:

- monitoring treaty-limited Soviet forces and activities through both National Technical Means (NTM) and onsite inspection (OSI);
- judging whether these forces and activities are in legal compliance with, or are ambiguous with respect to, the terms of the treaty;
- deciding what steps, if any, to take in response to ambiguities or suspected violations; and
- deciding what steps, if any, to take in response to confined violations.

Verification issues should be evaluated in the entire strategic context of the **treaty. The terms of reference of this OTA assessment preclude the report from analyzing that larger context.** At some points, for example, this report calls attention to important issues of Soviet strategic force capabilities and intentions that extend beyond treaty compliance, and that may be important to judging whether a treaty is in the national interest. Nevertheless, the report does not directly address either the larger questions of the risks and benefits of a strategic arms reduction agreement or the entire process of verification. Instead, it focuses on the narrower problem of analyzing various measures that could be applied to the tasks of monitoring compliance with treaty provisions.

Table 2-Current U.S. and Soviet Strategic Nuclear Forces Under START

	Us.	Soviet
Strategic Nuclear Delivery Vehicles	*1,966*	*2,470*
ICBM	1,000	1,373 (240 mobile)
SLBM	656	924
Bombers[a]	310	155
Warheads	*13,292*	11,006
Ballistic missile reentry vehicles	8,146	9,766
ICBM	(2,450)	(6,410)
SLBM	(5,696)	(3,356)
Air-launched weapons (bombs, short-range attack missiles, and ALCMs)	5,146	1,240

[a]Medium bombers not inducted in this table. In START negotiations, the United States has argued that the Soviet Union should make a politically binding declaration on the numbers and capability of its Tupolev 22-M (Backfire) bomber, while the Soviets say the Backfire is not a strategic bomber.

SOURCE: John M. Collins and Dianne E. Rennack, *U.S./Soviet Military Balance:* Statistical *Trends, 1980-1989, As of January 1, 1990* (U.S. Congress, Congressional Research Service, August 6, 1990). The preface to the previous edition of this report points out that this unclassified study ". . . is intended to provide Congress with a starting point for quantitative analyses of the U.S./Soviet military balance and associated issues. Data may differ in detail from classified documents, but patterns portrayed in these pages are dependable. "

Scenarios for Soviet cheating on START need to be evaluated not only in terms of the technical feasibility of the potential violation, but also in terms of the probable cost and difficulty of the required deception, the nature of the military advantage to be expected from successful cheating, and estimates of the Soviet propensity for cheating. This report addresses only the first two issues. There appears to be bipartisan agreement (with some dissent) in the United States that the minimum criterion for a START Treaty verification regime is that it be able to detect militarily significant violations in time to allow corrective action. There is less agreement on how to determine what would constitute a militarily significant violation and whether any plausible verification regime could succeed.

Overview of the Arms Control Monitoring Process

Monitoring measures can collect evidence that would contribute to the following purposes of verification:

- verify baseline data exchanged by the two sides about their forces and facilities,
- verify elimination of weapons,
- verify compliance with limitations on long lead-time capabilities for breakout from treaty ceilings (e.g., conversion of production plants that could add to stockpiles of stored missiles),
- resolve questions about compliance,
- increase the cost of attempting evasion,
- detect signs of intentions to violate or break out from treaty provisions,
- threaten exposure of violations, and
- detect violations.

Arms control monitoring is a process both of detection and of deterrence of cheating. If the potential cheater worries about getting caught, then the requirements for deterring him may be less stringent than those of assuring oneself that cheating is impossible.

Monitoring compliance with a START Treaty will require estimating numbers and a variety of characteristics of several weapon systems (see box A). Arriving at those estimates will involve the identification, compilation, assessment, and analysis of a multiplicity of indicators, or pieces of evidence. Intelligence sources-primarily NTM—will collect most of this evidence, but onsite monitoring and inspections will also collect some.

Arms control monitoring may bethought of as the continuous assembling of many pieces of a puzzle to form a coherent picture. A potential cheater in an arms control agreement might strive to hide some pieces and fake others to cause the monitors to generate a false picture. Creating a coherent, internally consistent, and lasting false picture for vigilant observers is not easy. The monitors can adopt various tactics to make it still more difficult. Because many of the specific methods of monitoring are highly secret, the potential cheater can never be certain which specific pieces of the puzzle are being collected. In addition, the verification provisions of a treaty can be designed to increase the cost or difficulty of cheating. **Monitoring measures that increase the number, variety, and complexity of the false pieces of information that the cheater must create can improve the monitoring process.**

Box A—START Monitoring Tasks

Under the prospective START agreement, the United States will probably need to monitor:

- the number, by type, of deployed, fixed, land-based ICBMs (i.e., those in launch silos) and the number of nondeployed ICBMs that could be either fixed or mobile-based;
- the number, by type, of deployed and nondeployed, road-mobile ICBMs and their launchers;
- the number, by type, of deployed and nondeployed, rail-mobile ICBMs and their launchers;
- the existence of required, authentic tags on certain missiles and launchers;
- the number, by type, of ballistic missile launching submarines and their launchers;
- the number, by type, of deployed submarine-launched ballistic missiles (SLBMs);
- the number of warheads on each type of ballistic and cruise missile;
- the aggregate numbers of warheads carried by such missiles;
- the aggregate throw-weight of the ballistic missiles;
- the number, by type, of deployed heavy bombers that can carry air-launched cruise missiles (ALCMs);
- the number, by type, of deployed heavy bombers that cannot carry ALCMs;
- the number, by type, of deployed ‘‘former’ (previously nuclear-equipped) heavy bombers that do not carry nuclear weapons;
- the number, by type, of any missiles, launchers, or bombers eliminated to reach agreed ceilings for those types.

SOURCE: Office of Technology Assessment, 1990.

Assessing Monitoring Needs and Capabilities

Arms control monitoring, then, is a more complex and sophisticated process than just depending on one source of information to detect one type of objector activity. In most cases, no one technical collection device or cooperative verification measure will by itself monitor compliance with, for example, mobile missile deployments. Instead, the monitoring process will involve piecing together information from a combination of types of sources: previous experience in observing the other side's forces, various kinds of NTM, required declarations about treaty-limited forces, required notifications about activities involving those forces, and various types of OSI.

NTM and OSI (and, possibly, aerial surveillance[1]) can work complementarily to make covert arms control violations more difficult and costly. It is not possible in a report of less than "Top Secret/ Sensitive Compartmented Information" (TS/SCI) levels of security classification to detail the potential and limits of this interaction. **Therefore, the unclassified, and even the classified versions of this report necessarily give an incomplete impression of the monitoring process as a whole.**

Missing at this level of classification, for example, are the range of monitoring technologies available and the precise capabilities and limitations of individual technologies. Most importantly, because it cannot cite specific examples, a report at this level cannot convey the synergism among the various NTM and between NTM and various cooperative monitoring measures, including OSI.[2] Box B cites some open-source literature that discusses NTM.

Arms control monitoring applies a diverse set of techniques and technologies to collect evidence and assemble a picture of Soviet forces and activities. It is not feasible to develop a set of objective, quantitative measures of how likely a given verification regime would be to detect a given level of treaty violation.[3] Instead, the overall confidence the United States should place in a verification regime **will remain a matter of complex qualitative judgment.**

In practice, arms control monitoring capabilities will always fall well short of omnipresence. From the U.S. point of view, developing a verification **regime for START has involved a multidimensional tradeoff among a variety of costs and benefits. These** include:

- the improvements in monitoring confidence that the United States expects to gain from additional expenditures on NTM and on inspection arrangements;
- the resources the United States is willing to spend on such monitoring capabilities;
- the degree to which the United States is willing to risk revealing some monitoring capabilities by confronting the Soviets with evidence of noncompliance;
- the degree to which the United States is willing to expose military, intelligence, scientific, engineering, and industrial sites to Soviet inspection;
- the resources the United States is willing to spend on protecting potential inspection sites from intelligence gathering by Soviet inspectors;
- consistency of inspection arrangements with the Fourth and Fifth Amendments of the Constitution;
- what onsite and other cooperative measures the Soviet Union is willing to accept; and
- the degree to which the United States wishes to preserve some kinds of flexibility for U.S. forces, and therefore take on more difficult monitoring tasks.[4]

Thus, there is no objective or quantifiable answer to the question, "how much verification is enough?" Instead, evaluation of the prospective START verification regime must be a complex economic, political, military, and diplomatic judgment.

The most reliable way to monitor compliance with-and deter violation of—limits on Treaty-Limited Items (TLIs) will be to observe the TLIs (both by NTM and OSI) at several stages of their "life cycles. " The potentially monitorable stages

[1]NATO and Warsaw Pact nations have been engaged in negotiations over an 'Open Skies' agreement for reconnaissance flights over one another's territories. Though not intended for arms control monitoring per se, such flights might contribute to the NTM-OSI complement. And although treaty-related aerial inspections are not under negotiation for START, they could in principle play a role in later START monitoring arrangements or other arms control verification regimes.

[2]A classified appendix t. this report addresses this latter point. It also attempts to indicate the range Of NTM technologies available for START monitoring tasks, but it does not detail the technical limits and capabilities of individual systems.

[3]Nevertheless, it is possible to analyze quantitatively some monitoring measures. For example, if inspectors can repeatedly ex amine randomly selected samples of missiles at declared deployment sites to see if they are "legal" (e.g., not exceeding warhead limits for that type of missile), then quantitative analysis can show the probabilities of given levels of violation over specified periods.

[4]For example, permitting deployment of heavy bombers that no longer carry nuclear weapons, bombers that do not carry Air-Launched Cruise Missiles (ALCMs), and bombers that do carry ALCMs requires distinguishing among these types and monitoring whether significant numbers of one type have been converted to another type.

Box B—National Technical Means of Verification

The U.S. intelligence community has a considerable array of information collecting resources.[a] This array includes, but is not limited to, the so-called ''National Technical Means (NTM) mentioned in previous arms control agreements. President Jimmy Carter publicly identified imaging satellites as a form of NTM. The SALT II Treaty provided that certain telemetry from missile tests should not be encrypted, implying the ability of the treaty parties to collect such signals. A 1983 State Department publication defined National Technical Means as:

> Assets under national control for monitoring compliance with the provisions of an arms control agreement. National technical means include photographic reconnaissance satellites, aircraft-based systems (i.e., radars and optical systems), as well as sea- and ground-based systems such as radars and antennas for collecting telemetry.[b]

There are many other, still classified, NTM. National technical means of collection beyond those specifically allocated to arms control monitoring tasks are also likely to produce useful information.

The Soviet Union also possesses NTM. In an interview in the Soviet military publication *Red Star,* ***Star,*** Soviet Col. General Alexander Maksimov reported:

> Space reconnaissance makes it possible to obtain an image in the visible spectrum with resolution down to 0.2-0.3 meters. This means that from orbit it is possible to see every player on a soccer pitch, to determine whether a bomber of the B-1 type is equipped with missiles . . . radio-technical reconnaissance makes it possible to locate radiation in practically all bands and to determine the source of this radiation , . . space reconnaissance makes it possible to intercept radio conversations . . . with the help of retransmitter satellites, all this information can be obtained in close to real time.[c]

The Senate Select Committee on Intelligence, reporting on the Soviet intelligence threat to U.S. communications, noted:

> Telephone communications, in particular those sent over microwave lines or through a satellite, are extremely vulnerable to interception and provide a lucrative target of opportunity . . . Satellite communications are potentially an extremely valuable source of information as they can simultaneously transmit thousands of telephone, TV, and computer to computer transactions . . . [such vulnerabilities] affect the communications of our national leadership, military and defense industries, tactical military operations, weapons research and development, and economic interests.[d]

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[a]Numerous publications purport to describe U.S. NTM. Some of these are: James Bamford, ***The Puzzle Palace (New York, NY:*** Penguin Books, 1983); William E. Burrows, ***Deep Black: Space Espionage and National Security (New York,*** NY: Random House, 1986); David Hafemeister, "Science and society test IX: Technical means of verification" ***American Journal of Physics 54(8),*** August 1986, pp. 6934599; Jeffrey Richelson, ***The U.S. Intelligence Community (Cambridge, MA: Ballinger, 1989),*** **chs.** 7-10, pp. 145-198, and ***America's Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program (New York, NY:*** Harper & Row, 1990); Richard A. Scribner, Theodore J. Ralston, and William D. Metz, ***The Verification Challenge*** (Boston, MA: Birkhaeuser, 1985), pp. 47-86; Kosta Tsipis et al., eds., ***Arms Control Verification: The Technologies That Make It Possible*** **(Elmsford, NY: Pergamon Press, 1986). Neither OTA nor the Intelligence Community endorses these works as containing accurate information.**

[b]U.S. Department of State, Bureau of Public Affairs, "Security and Arms Control," June 1983

[c]Interview of Maksimov by Col. M. Rebrov, ***Krasnaya Zvezda*****,** July 29, 1989, p. 3, translated by the U.S. Joint Publications Research Service, **JPRS-USP-89-009,** Sept. 22, 1989, pp. 48-50.

[d]U.S. Congress, Senate Select Committee on Intelligence, ***Report, January 1,1983 to December 31, 1984,*** report 98-665.1985, p. 34.

include: design and development, test and evaluation, production, deployment, storage, maintenance and repair, exercise, reliability testing, and elimination

Onsite inspection at some of these stages could force the potential cheater to try to construct secretly and to conceal a separate infrastructure to support any illicit weapon deployments. Such an infrastructure would then be at risk of detection by NTM.

Onsite inspections may also perform an indications and warning function about the other side's intentions toward future treaty compliance. Frequent and unjustifiable obstruction of OSI would suggest a less cooperative attitude and possible intent to depart from treaty provisions. It would likely lead to heightened vigilance through NTM.

Onsite inspections should be seen as a useful supplement to NTM, not as a substitute for them. Except for limited cases, such as the sampling of deployed missiles in a designated deployment area, OTA has not been able to identify a way of determining the "right" number of onsite inspections for a given level of monitoring confidence. All other things being equal, the more inspections, the better: but all other things will never be equal. **The benefits of being able to carry out onsite inspections in the Soviet Union must be weighed against the costs and risks of undergoing Soviet inspections in the United States. This** is an important consideration for any type of inspection, but it bears especially heavily on an assessment of ‘‘anytime, anywhere’ suspect-site inspections (SSI).

The first major potential cost of OSI is loss of sensitive information to Soviet intelligence collection. Allowing Soviet inspectors access to some sites may risk the compromise of classified or propriety information, hardware, or processes. The second major potential cost of OSI is financial. The implementation of an OSI verification regime includes many expenses, both obvious and hidden. Most of these expenditures are intended to reduce the risk of intelligence losses. The Federal Government will bear some of the costs; others, however, will fall on companies whose facilities are to be inspected. A less tangible cost is the burden of intrusive inspection requirements that interfere severely and often with normal industrial or military operations.

The dollar cost of the START verification regime will depend very much on treaty details, The current direct cost of the On-Site Inspection Agency (OSIA) for carrying out Intermediate Nuclear Forces (INF) inspections is about $40 million per year. Adding START inspections would increase that cost in rough proportion to their numbers and types. The major costs come with site preparation. If many hundreds of sites had to be prepared for the possibility of being inspected, the costs could run to tens of billions of dollars. In the more likely event that some tens of sites would have to be prepared, the cost might only run to a few hundred million.

Completely unlimited, ‘‘anytime, anywhere’ **SSI** might help deter Soviet noncompliance with a START Treaty, but such an inspection regime appears impractical because it would maximize the costs cited above. More limited SSIs and other kinds of onsite inspections can still give more confidence in Soviet compliance with START Treaty than could NTM alone. (See table 3. Note that the nomenclature of this table is not intended to replicate START Treaty terminology. For example, the most recent draft treaty refers to PPM as “perimeter and portal continuous monitoring, ’ a term that combines the

Table 3--Types of Onsite Inspection (OSI)

Baseline Inspection:
Inspectors travel to sites designated in the treaty to validate exchanged information and make measurements of all or some treaty-limited items (TLIs). This baseline information serves as the main reference for ail future data comparisons by the signatory countries.

Elimination inspection:
Inspectors observe as TLIs are destroyed completely or in part, or are converted to a function not limited by treaty.

Close-Out Inspection:
Determines that treaty-related activities have ceased at a designated facility and confers a change of status. For example, a heavy bomber manufacturing plant might be converted to building commercial transport planes. An inspection team could be sent to check that the conversion had taken place and then change the status of the site to “formerly designated.” The new status might mean fewer or less intrusive inspections, or it might simply be a confidence-building measure.

Designated-Site Inspection (DSI):
The most general form of inspection is the DSI. During a DSI, an inspection team looks for illegal TLIs at treaty-designated sites. Procedures can be written so that objects that might conceal a TLI are exposed just enough to ensure compliance. Sufficiently frequent and thorough DSIs may drive cheating activity off site, possibly making it more expensive and difficult. DSIs might be conducted routinely or sporadically, with short or longer notice.

Suspect-Site inspection (SSI):
SSI inspection teams search for illegal TLIs at sites not specified in the treaty. When a suspicious activity is detected outside of designated areas, an SSI could be requested. SSIs can in principle be completeiy unrestricted and take place anytime and anywhere, or, as is likely under START, they may be limited by a variety of criteria (e.g., quotas, site specifications, rights of refusal).

Perimeter Portal Monitoring (PPM):
In a PPM system, a team of monitors stand watch over the portals (entrances and exits) and the perimeter of a site, in effect throwing an impenetrable ring of observation around it. The job of these monitors is to detect the illegal movement of TLIs in or out of the site. PPM might be useful at facilities considered too sensitive to allow inspectors prolonged or repeated access to their interior. PPM can be employed alone or in conjunction with inspections of the inside of the facility.

Reentry Vehicle On-Site Inspection (RVOSI):
RVOSIs are specialized inspections that seek to confirm the number or presence of nuclear reentry vehicles on ballistic missiles. Inspection teams can do this visually or with radiation detection equipment. An RVOSI maybe one part of a broader inspection.

Invitational Inspection:
As a means of building confidence, a party might invite its treaty partner to inspect a location, even if the treaty did not require it. For example, a party exercising a treaty right to refuse an SSI might invite inspection of a related site as a good-faith effort to allay suspicions. The inspection could be specifically tailored to display compliance, while revealing as little else as possible.

SOURCE: Office of Technology Assessment, 1990.

Us. “perimeter and portal monitoring” and the Soviet ‘‘continuous monitoring." In the INF Treaty, PPM is called “continuous monitoring. ” The table establishes a framework for all potential types of

OSI, not just those adopted and named under the START Treaty.)

Additional cooperative verification measures can enhance the utility of both NTM and OSI in monitoring arms control compliance. First, **agreements not to interfere with NTM in certain ways (e.g.,** not to encryptor otherwise conceal missile test telemetry) can make NTM technical tasks easier. Second, treaty-required **declarations** about force structures, military facilities, and operational practices can make deception of NTM and OSI more difficult: they can complicate the problem of creating false information that must be kept consistent with what is previously declared and currently observed. Third, treaty-required **notifications of** such activities as missile tests and mobile missile movements can also complicate the problem of deception and, as well, help inspectors choose the best times and places to inspect.

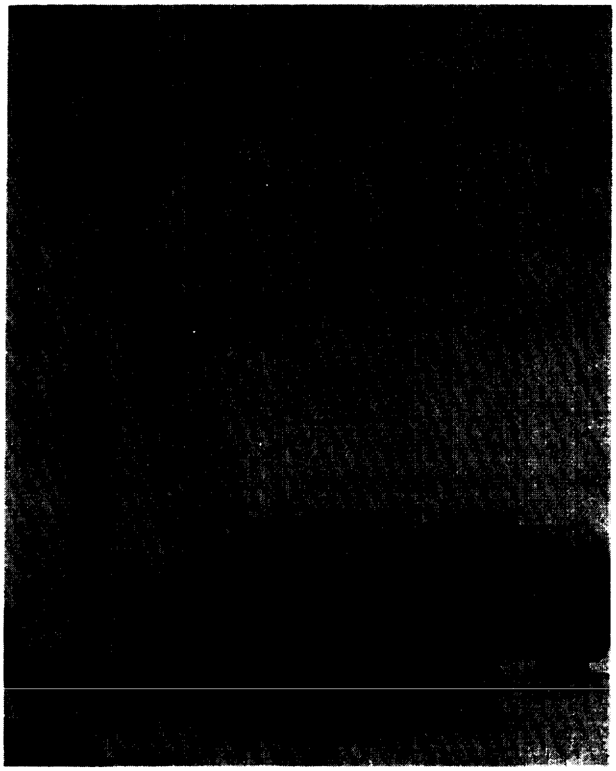
Monitoring Inter-Continental Ballistic Missiles (ICBMs)

Possible violations of START ICBM limits, like those of other START limits, should be evaluated not only in terms of technical feasibility, but in terms of cost and benefit to the cheater. Costs would include the financial burden of building and deploying clandestine weapons as well as the loss of treaty benefits if the violation were discovered. **While analyzing whether militarily significant benefits of cheating are feasible to obtain is beyond the scope of this report, such analyses would be key to an informed debate on the adequacy of a START verification regime. Table 4 illustrates the** issues involved in such analyses.

As table 4 suggests, it is not easy to identify plausible motives for Soviet cheating on START ICBM limits. Nevertheless, assessing verification of compliance with those limits is important. First, judgments of military significance vary: those who are concerned that cheating might lead to important Soviet advantages will want to understand the cheating potential. Second, while desired levels of monitoring confidence may vary with the estimated military significance of the potential violation, the United States would set an imprudent precedent by doing no monitoring at all. Cheating, however uninviting, should not be free. Third, should START II or III lead to deeper force reductions, relatively small levels of cheating could take on much greater **significance.** START I verification procedures may very well set important precedents for future agreements. Understanding the potential and limits of the current options for monitoring compliance with ICBM limits could help guide both future strategic force planning and future arms control policy.

The monitoring of Soviet ICBMs for START compliance will be best accomplished using multiple indicators collected over a span of time. Militarily usable missiles are built and deployed within an industrial, operational, and support infrastructure that is difficult--though not necessarily impossible-to conceal indefinitely. National technical means, OSI, tags, and other cooperative measures can discern traces of clandestine missiles at various stages of the ICBM life-cycle: design and development, test and evaluation, production, deployment, storage, maintenance and repair, exercise, reliability testing, and elimination.

Figure 1-Canisterized SS-18 Being Loaded Into Silo



A crane loads a Soviet SS-18 heavy ICBM, in its canister, into a silo launcher. The SALT agreements limited ICBM launchers; START limits deployments of the missiles themselves.

SOURCE: Department of Defense artist's concept

Table 4-Why Might the Soviets Cheat on START ICBM Limits?

Pro	Con
Gain a disarming first-strike capability against all U.S. nuclear retaliatory forces	Unlikely with U.S. strategic triad at START levels
Acquire first-strike capability against U.S. land-based ICBMs	Calculated capability already high, with or without START, against fixed missiles; extremely difficult if U.S. deployed mobile missiles
Improve overall coverage of time-urgent, hard targets	Ratio of weapons to such targets already high; gains may be marginal
Increase invulnerability of reserve ICBM forces to U.S. attack by concealing their existence	Soviet mobile ICBMs should be sufficiently invulnerable
Prepare to gain exploitable advantage in perceived balance of strategic forces by overt treaty breakout	If this were feasible, storing up *legally* produced ICBMs would be cheaper and easier.

SOURCE: Office of Technology Assessment, 1990.

The SALT (Strategic Arms Limitation Talks) agreements between the United States and the Soviet Union limited numbers of ICBM launchers, as opposed to deployed missiles themselves. Since the ICBMs then limited were designed to be launched from large, fixed silos in the ground, launchers were reasonable indicators of deployed missiles. The advent **of mobile ICBMs complicates the monitoring problem for START.** Mobile missiles are designed to be more difficult for the adversary to locate and destroy in a preemptive nuclear strike.[5] From an arms control monitoring point of view, though, mobile missiles have the disadvantage that they are easier to conceal than freed ICBMs. In addition, mobile missiles are transported in relatively self-sufficient canisters that reduce the size and complexity of their launch facilities; this feature increases the importance of accounting for non-deployed as well as deployed mobile missiles.[6]

The monitoring problem is simplified when entire classes of missiles are banned, as was the case with SS-20s and other missiles in the INF Treaty. In the case of START, strictly from a monitoring point of view, barming a distinctive type (rail or road) of mobile ICBM entirely would be preferable to limiting their numbers. With a total ban, there would be no legal infrastructure for that type of missile. Therefore, there would be no risk that the infrastructure that maintained legal missiles could also service identical clandestine missiles. In addition, there would be a lesser risk that clandestine preparations could lead to an overt breakout in which stored clandestine missiles augmented those in an existing deployment infrastructure.

If an entire class of missiles were to be banned, it might be preferable to choose those with Multiple, Independently targetable Reentry Vehicles (MIRVs), since substantially more single RV missiles than MIRVed missiles would have to be hidden to increase warheads totals by the same amount.

A combination of NTM and OSI might monitor the number of RVs on a type of MIRVed missile. The treaty might require that missile tests would be announced in advance and that their telemetry be unencrypted and intelligibly formatted. National Technical Means could observe tests. Some uncertainties exist about whether such observations will reveal the number of RVs with which a type of missile can be practically deployed.[7] An additional monitoring measure could be to sample deployed missiles periodically by OSI. Such inspections could be carried out on both freed and mobile ICBMs. Then, warhead augmentation would be primarily a concern for overt breakout scenarios as opposed to cheating during a period of presumed treaty compliance.

One means of ICBM monitoring would be to tag major parts, such as first-stage rocket motors, when they came out of the declared factory. These tags might be read on any missile prior to flight-testing. In this way, missile parts (subject to tagging) from an illicit, clandestine factory could not be flight-tested. An important issue is whether the Soviets would be willing to deploy missiles produced at such an unqualified plant. There appears considerable controversy among experts about whether they would or not, with each side asserting that its own position is the consensuse[8] Some would argue,

[5]This feature could also give one's forces some resiliency against potential breakout from START limits by the other side: even hundreds of additional, illicit warheads might not Mice to threaten a robust mobile ICBM force.

[6]The Soviet SS-18 heavy ICBM is also canisterized, but too large and heavy to be considered for mobile deployment. Moreover, unlike the solid-fueled SS-24 and SS-25, it uses a liquid fuel that, while it is storable in the missile, complicates handling.

[7]On the other hand, large difference between tested and deployed numbers of RVs are unlikely.

[8]OTA will attempt to gather more information on this topic; if the information seems helpful, it will be included in a later work.

however, that even if the Soviets required tests, static testing of missile stages on ground stands would suffice to qualify a production line; if so, it would seem to be necessary to monitor tags on static-tested stages as well.

Tagging systems might also be used to monitor either deployed or stored missiles. Deployed missiles could be periodically inspected to assure that illicit missiles had not been introduced into the overt deployment infrastructure. Stored missiles could be sampled to assure that overt storage sites contained only legitimate missiles.

Potential tagging technologies are improving with time, but questions of counterfeitability, transferability, and operational practicality have not all been resolved to the full satisfaction of all U.S. interests. Particularly for the purpose of flight-testing missiles from a clandestine production line, a cheater might be willing to go to great expense to counterfeit a few tags. If this were a concern, however, the monitoring protocol could provide for later attaching supplemental tags to existing tags, thus greatly complicating the counterfeiting task.

Continued research on tagging systems should yield further improvements. To permit application of improved technologies, a START Treaty (or an associated memorandum of understanding) could provide for later upgrading of tagging systems. For example, it may be possible to develop an electronic tag that could be read remotely (from the air or from space, perhaps by host-country-provided local radio relay) and which could be trusted not to compromise the survivability of mobile missiles.

One cheating scenario for rail-mobile or road-mobile ICBMs is for the cheater to produce clandestine missiles and launchers (before or after the treaty had gone into effect), store them, and later overtly break out from treaty constraints by augmenting the existing deployment infrastructure. For operational reasons, this might be most quickly done with rail-mobile systems, in which additional launcher cars could be hitched to trains with existing crews and support cars. **Monitoring missile and launcher production (or final assembly) facilities probably offers the best chance of deterring or detecting this stratagem.**

Another cheating scenario for road-mobile ICBMs utilizes "hot bunking": illicit launchers and their missiles would rotate in and out of legitimate support bases, while observation of the bases would show only a legal number of missiles in garrison at any given time.[9] If this scenario were of concern, two treaty monitoring provisions would make it more difficult to execute. First, a treaty could require prior announcement of missile and launcher departures from their bases, providing a basis for monitoring such announced movements with NTM.[10] Unannounced movement, if detected, would then itself be a violation, as well as indicating the possible presence of undeclared missiles. Second, repeated short-notice reading of tags of in-base missiles or launchers would very likely detect illegal missiles; therefore, tags would help to deter use of the legal infrastructure to deploy illicit missiles. In addition, an Open Skies regime, if agreed on, might help by raising the risk that illicit missiles would be spotted.

Mobile ICBMs may also be limited to designated deployment areas even after leaving base. Counting missiles in these areas would be somewhat easier than if the missiles could travel anywhere in Soviet territory. In addition, confirmed sightings of any undeclared missiles outside the designated areas would be clear evidence of treaty violation.

Monitoring Submarine-Launched Ballistic Missiles (SLBMs)

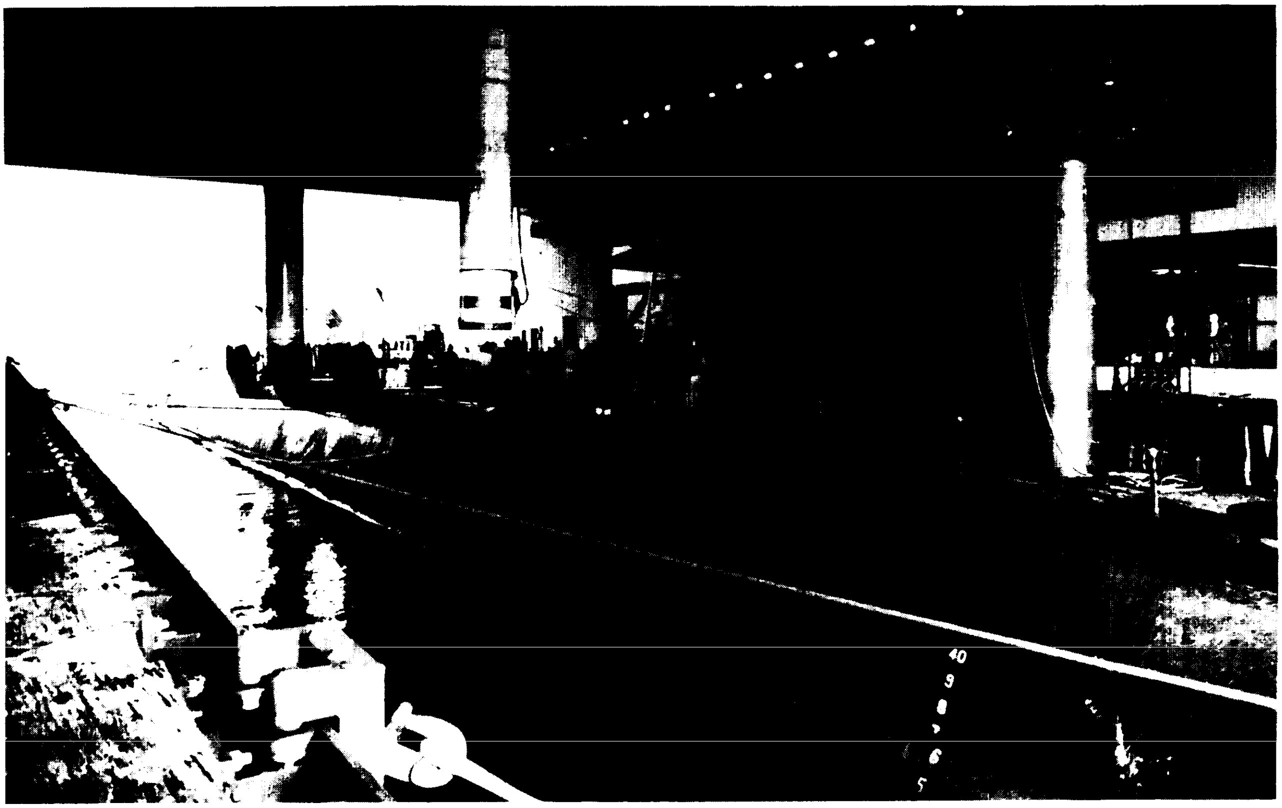
The primary indicator for monitoring submarine-launched ballistic missiles will be the submarine (SSBN) and the number of launch tubes it carries. Such vessels cannot be concealed: they are large and require a highly visible production and support infrastructure. Moreover, under normal Soviet practices, a high percentage of Soviet SSBNs are in port at an given time.

START will generally (but not in every case) restrict SLBMs themselves to carrying no more than the maximurn number of RVs with which they have been tested. The pros and cons of relying on this counting rule and the utility of sampling deployed missiles by OSI are discussed above in the section on ICBMs.

[9] While the term "hot bunking" has mainly been applied to road-mobile missiles, a similar concept could be applied to rail-mobile systems.

[10] The START Treaty, however, will probably not contain this provision. It will, however, require notification before missiles leave their designated deployment areas.

Figure 2-Ohio-Class Strategic Missile Submarine



Above: Trident missile canisters being lowered into their launch tubes on an Ohio-Class (Trident) ballistic missile submarine (SSBN). Below: open launch tubes on the same class of submarine. In START Treaty RV-counting inspections, Soviet observers would be allowed to peer into an open tube to determine that an SLBM did not carry more than its attributed number of warheads. During inspection, missile warheads would be shrouded by a shell that conformed to their shape.

SOURCE: U.S. Department of Defense

Under START, the two sides apparently will agree to permit deployment of some SLBMs with fewer RVs than the maximum with which they had been tested;[11] to keep numbers within the START limits, they could then count the SLBMs as only containing the lower numbers. An OSI regime that regularly sampled deployed missiles could probably deter secret reconversions of the missile loads. There would still be some risk of overt treaty breakout by quick reconversion of deployed missiles, but the payoff from abrogating the treaty for some additional SLBM warheads, as compared to ICBM warheads, may be small.

A missile of concern might be the SS-N-23, which the Soviets have apparently tested with as many as 10 RVs, but which START is to count as carrying only 4. What the military consequences of changing from the 4-RV configuration to the 10-RV configuration would be is another question. It seems likely that, for some purposes, the 10-RV version would be militarily less useful.[12] Still, if these missiles were converted to deliver 10 RVs, each 16-missile submarine carrying them could add up to 96 RVs to its current 64. (In response, the United States might upload its own Trident II missiles from 8 to 12 RVs, adding 96 warheads to each 24-missile submarine.) Note that RV uploading mayor may not be a treaty breakout concern, but with adequate inspections it need not be a treaty cheating concern.

Since the START Treaty will probably not restrict nondeployed SLBMs, it is conceivable that longer range missiles, such as the SS-N-23 or the SS-N-20, could be adapted for clandestine (or overt but rapid) deployment on land. The characteristics of these missiles, however, do not seem to suit them well for this scenario. In addition, many operational barriers would have to be overcome to make this a feasible cheating scenario.

Monitoring Bombers and Air-Launched Cruise Missiles (ALCMs)

Given that START will permit both modernization and expansion of strategic bomber forces, it is difficult to identify incentives to cheat on the agreement's bomber-related provisions.

Heavy bombers of the kind to be limited by START are large, distinctive, and observable objects requiring an extensive production, testing, and support infrastructure. This infrastructure would include:

- assembly buildings scaled to bomber size (a U.S. B1-B bomber is about 150 feet long, with a wingspan of about 136 feet);
- associated warehouses, offices, and engineering space;
- power, transportation, and labor supplies;
- security arrangements (e.g., perimeters and guardhouses);
- a large airstrip and associated support facilities near the assembly plant;
- testing facilities;
- military air bases and associated facilities and security arrangements; and
- storage, transportation, and security arrangements for the nuclear weapons associated with deployed bombers.

Moreover, deployed aircraft need to be operationally tested and maintained.

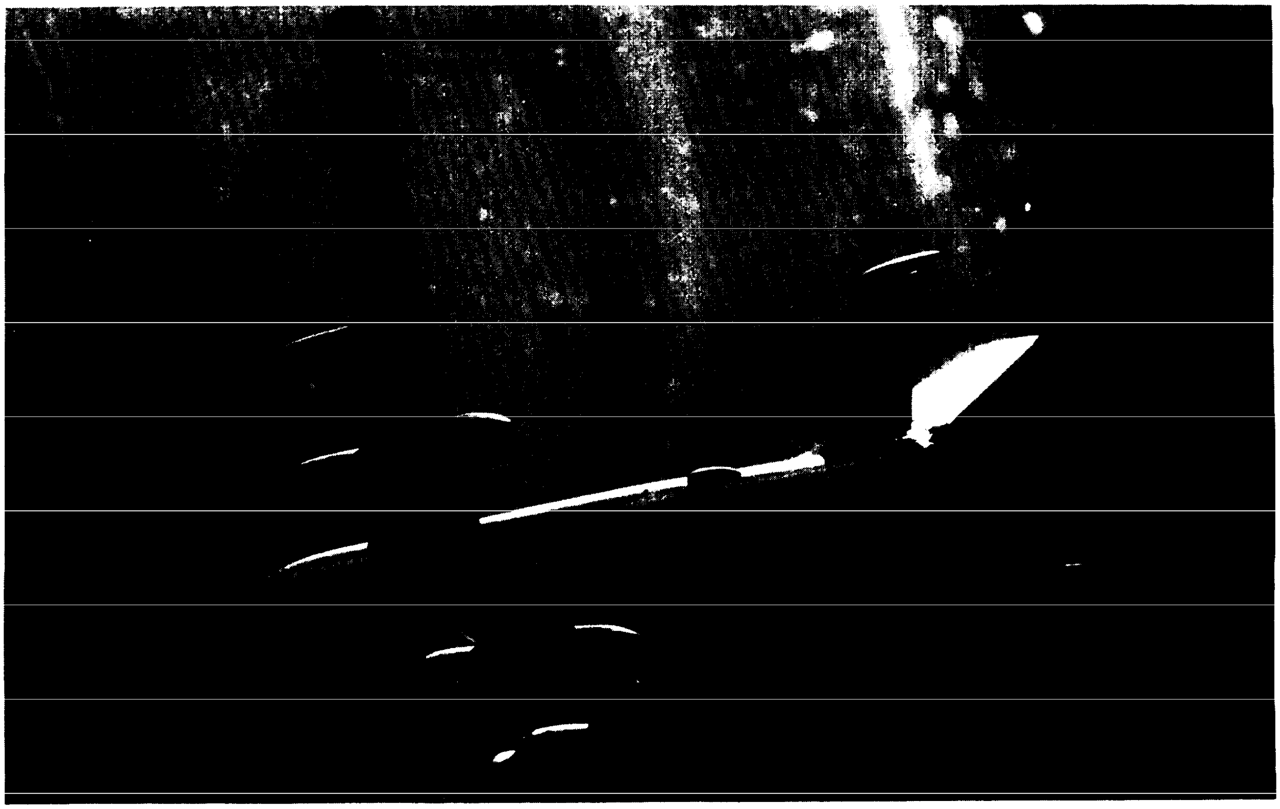
Variations in the configurations of Soviet and U.S. aircraft somewhat complicate the monitoring tasks for bombers. The Soviet Union has deployed some of its bomber airframes as tankers and reconnaissance craft, and it does not wish these to count against the 1,600 Strategic Nuclear Delivery Vehicle (SNDV) ceiling. The United States intends to deploy bombers in different configurations (conventionally armed, armed with long-range nuclear cruise missiles, and armed only with nuclear bombs and short-range attack missiles). It does not wish formerly nuclear, now conventional, bombers to count toward the ceiling. Hardware arrangements that may not be readily observable by NTM determine whether bombers can carry cruise missiles or not, so some form of OSI seems desirable in this case. A further complication would be added if either side were to deploy non-nuclear long-range cruise missiles on bombers other than those counted as equipped for nuclear cruise missiles.

Agreement to base different types of bombers at different locations may ease monitoring of the different configurations. Short-notice inspections

[11] The agreed numbers reflect the operational loadings the two sides say they are planning.

[12] For the same throw-weight, a larger number of RVs will each have a smaller explosive yield, reducing its destructive capability against a given target. The 4-RV version of the SS-N-23 may be step toward a "hard-target killer, " but the 10-RV version is not.

Figure 3—Reconnaissance and Bomber Versions of the Soviet Tu-95 Aircraft



Soviet Tu-95D reconnaissance plane (above), is distinguishable from the Tu-95H "Bear" strategic bomber (below) by the presence of additional radar pods and the absence of bomb bay doors.

SOURCE: U.S. Department of Defense

would then be more useful. In addition, bombers and ALCMs will probably be subject to "counting rules' rather than inspections for numbers of warheads carried. Each bomber not carrying ALCMs will be attributed with only one nuclear warhead counting toward the START limit of 6,000, even though the aircraft will carry several bombs and short-range attack missiles. Each ALCM-loaded bomber will be attributed with a number below its actual carrying capacity. It is expected that the attributed number will be close to the typical loading for such aircraft, but individual bombers carrying more than the attributed number of weapons will not be considered in violation of the treaty .[13] (Note that rules that permit deployment of more warheads than those counting toward START limits preserve U.S. strategic force planning options.)

Some potential would still exist for quickly breaking out of treaty constraints by flying conventional bombers to nuclear bases for conversion. Somewhat more difficult (depending on the bomber type), but still plausible, would be to fly non-ALCM bombers to ALCM bases for conversion. However, given the already liberal allowances for bomber weapon loadings, the incentive to breakout in either of these ways will be small.

Since only nuclear ALCMs with a range beyond 600 km will be limited, another monitoring task for START will be to estimate the maximum range of deployed ALCMs. The difficulty of doing so could result in some ambiguities about whether a long-range bomber will count under START as an ALCM heavy bomber or a heavy bomber with nuclear bombs and short-range attack missiles.

In the future, the deployment of long-range, conventionally armed ALCMs would present particularly difficult monitoring challenges because of the possibility for substitution of nuclear ALCMs.

[13] However, there will be an agreed upper limit on the number that a given type of aircraft may carry.