Policy Forum

Verification and Arms Control

Verification of arms control agreements has become a matter of widespread interest in the scientific community; the methods used by signatories to ensure compliance and the past record of compliance by the United States and the Soviet Union are being vigorously debated. *Science* has asked two experts in arms control, Manfred Eimer* and Sidney Drell,† to respond to questions about the means of verification, the current verifiability of agreements, and the future outlook.

A. Verification Methods, Capabilities, and Requirements

1. Which methods of verification today give high confidence for monitoring treaty compliance, and what agreements can they verify?

Dr. Eimer:

We refer to the principal methods now used by individual parties to monitor treaty compliance as the "national technical means" (NTM) of verification. These include photographic, radar, and electronic surveillance systems, seismic instrumentation to supply information on the location and magnitude of underground nuclear explosions, and atmospheric sampling of radionuclides.

Arms control agreements impose a variety of restrictions, some of which are more easily verifiable than others. A ban on deployment of all mobile missiles, for example, would be easier to verify than a limit on the number that may be deployed, since observation of a single missile would be sufficient evidence that the ban had been violated. Weapons that are not constrained by an agreement, but that share certain characteristics with weapons that are constrained, also pose a problem for verification, since they can serve to mask violations. Large or stationary objects tend to be easier to count and keep track of than objects that are small or mobile.

The process of determining whether an agreement is effectively verifiable has two phases. The first phase is a technical evaluation that weighs the present and planned U.S. data collection, processing, analysis, and reporting capabilities against the constraints proposed in the agreement. This analysis must take into account credible cheating scenarios and the high standard of evidence required within the U.S. government for decisions about noncompliance.

The second phase addresses whether verification is good enough—whether verification is effective. This assessment couples the results of the technical evaluation with other factors including (i) the degree to which undetectable violations would pose a risk to U.S. national security; (ii) the past compliance record of the treaty party; (iii) the specific incentives that a party might have to violate an agreement; (iv) the ease and speed with which it would be possible for the United States to deny the benefits gained from noncompliance (and likely perceptions about that); and (v) the general impact, on arms control and bilateral relations, of potentially unresolvable compliance concerns derived from limitations in technical verification capabilities.

Each of these factors affects our understanding of the possibility and risk of noncompliance. With a fewer number of permitted weapons, for example, violations typically become more significant. The current pattern of Soviet noncompliance places an even greater emphasis on our verification needs because of the uncertainty engendered by violations. The size and mobility of the systems in question—as well as Soviet concealment, deception, and data denial—create a situation that greatly challenges our current collection capabilities. For example, in both the Strategic Arms Reduction Talks (START) and the Intermediate Nuclear Forces (INF) negotiations, we will have to verify numerical limits for weapon systems that are inherently difficult to detect. Future agreements will, in some cases, require cooperative measures, including on-site inspection; but whether and to what degree on-site inspection or other cooperative measures can improve verification will depend on treaty limitations and the details of the verification regime.

Dr. Drell:

The United States monitors compliance with the Antiballistic Missile (ABM) Treaty negotiated in the first round of strategic arms limitation talks (SALT I) primarily by NTM. These means are essential to ensure compliance with treaty limits on the deployment and testing of ABM interceptors, launchers, and radars, and to ensure that air defense systems are not tested in an ABM mode. They are also essential for monitoring SALT I and II limits on the numbers of deployed strategic offensive missiles plus bombers. These limits include strategic nuclear delivery vehicles (SNDV) together with specified limits on "heavy" ballistic missiles (such as the Soviet SS-18) and subaggregate limits on missiles with multiple independently targetable reentry vehicles (MIRVs) missile launchers. In addition, there are limits on the maximum number of deployed MIRVs as determined by counting the greatest number of MIRVs released, simulated or actual, during missile test firings.

Experience extending over more than two decades in the analysis and interpretation of Soviet activities adds to U.S. confidence in assessing Soviet compliance with the SALT I and II treaties. For instance, we know that the Soviets are complying with the numerical restraints of SALT I and II on offensive forces. (*1*).

Current data from NTM provide assurance of Soviet compliance (*2*) with the Limited Test Ban Treaty of 1963 (permitting only underground testing of nuclear weapons), the Outer Space Treaty of 1967, and the Antarctic Treaty of 1961. The existing worldwide network of seismic sensors can verify with reasonable accuracy compliance with the unratified Threshold Test Ban Treaty of 1974, which limits underground nuclear testing to a maximum yield of 150 kilotons. There is no persuasive evidence for Soviet violations.

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The threshold for detecting and identifying underground nuclear explosions could be reduced below the 150-kiloton limit by one to two orders of magnitude with the present network. If this network were supplemented by unmanned seismic detectors located in the Soviet Union and the United States, the verification threshold would drop to 1 kiloton or less.

An agreement to ban the testing of antisatellite (ASAT) systems capable of destroying satellites in high earth orbits (altitudes greater than a few thousand miles) could be monitored with current NTM. However, a ban on tests and deployments of ASATs that are only capable of intercepting satellites at lower altitudes (less than 1000 miles) would require cooperative measures including, for example, inspection of suspicious large facilities (large, high-power optics for a ground-based laser, for example), based on specific triggers that would need to be identified and negotiated. Verification of limits on the production of weapons-grade fissionable material and prevention of the diversion of fissionable material from commercial to military use would also require on-site inspection. Such inspection is now practiced by the International Atomic Energy Agency with both U.S. and Soviet cooperation.

2. What standards of evidence should be used to determine whether an adversary has violated an agreement?

Dr. Drell:

The substantive question here is what are the required standards of compliance. Of primary importance in judging compliance is whether activities that are ambiguous or appear to be treaty violations can constitute a threat to U.S. national security. This is a very difficult, multifaceted issue of intelligence gathering and analysis. In addition to an assessment of the military and security significance of a potential Soviet violation, three principles are important for guiding a U.S. response:

First, confirmed violations should not be simply ignored or accepted. Resolution of these issues should be sought by persistent discussion through existing channels or in the appropriate forum created for monitoring compliance of the treaty provisions. Premature public accusations can make this task more difficult.

Second, in the presence of ambiguity, it is useful for us to enter into direct discussion with the Soviet Union, maintaining an open and balanced view rather than making an immediate presumption of guilt.

Third, in response to a Soviet violation, the United States must of course protect its security interests, taking whatever measures are required. The appropriate response may differ from abrogating a treaty or imitating the Soviet violation.

Dr. Eimer:

The standard of evidence we use affects the likelihood, timeliness, and credibility of noncompliance charges, and the degree of verifiability required for future agreements. Use of a low standard of evidence could lead to the possibility of false charges and an inability to garner public support for charges of noncompliance. Use of excessively stringent standards of evidence places a large burden on verification, a burden which could cause a pervasive pattern of noncompliance to go unchallenged or, in the extreme, could lead to the conclusion that no significant treaty is effectively verifiable.

President Reagan has required a very high standard of evidence before concluding that the U.S.S.R. has violated agreements. For example, even though the nature of the Krasnoyarsk radar was clear soon after details of its construction were observed, the initial finding was only that the radar was "almost certainly" a violation. Since the ABM Treaty permits deployment of new, large phased-array radars in restricted locations and for restricted purposes, other plausible explanations were eliminated before the United States concluded that the Krasnoyarsk radar was a clear violation. However, only after data from an additional year of observation confirmed earlier assessments did the President decide to formally charge the Soviets with a violation.

3. Is military significance the only criterion for determining arms control violations? Are other criteria important? Why, and what are they?

Dr. Eimer:

Actions taken contrary to legal obligations or political commitments are violations—whether they are militarily significant or not. Military significance is not, and should not be, a criterion for compliance. It is one of the means we use to assess the severity of the violations.

The verification process actually has three purposes:

Warning. Verification should provide timely warning that treaty breakout, or a threat to national security, is imminent. (Treaty breakout would occur if a treaty partner took a number of actions in a short period of time that defeated the object and purpose of the agreement.) A violation of potential military significance should, therefore, be detected well before it becomes a threat to national security so that the violated party is able to respond. In the early stages, such violations may not be deemed "militarily significant." They are nevertheless a cause for extreme concern because they demonstrate Soviet willingness to cheat.

Deterrence of violations. The deterrence function of verification depends on the fear by the parties to the treaty of some cost associated with being detected in violation. Violations, especially a pattern of violations, signal that the deterrence function of verification has failed—indicating that the violator does not fear the penalties of detection. If the deterrence function fails for one provision or agreement, it may fail for others. Violations of other provisions or other treaties may therefore be occurring.

Confidence. Violations, even violations that are not militarily significant, erode confidence in the ability of arms control to enhance security and stability. For example, the negotiators of the ABM Treaty recognized that large phased-array radars (LPAR) were one of the most critical, long lead-time components for a prohibited territorial defense. Therefore, their deployment was appropriately restricted, with the expectation that illegal LPAR deployment would act as a "tripwire" to signal ABM Treaty breakout. We have detected construction by the Soviet Union of just such an LPAR, the Krasnoyarsk radar, deployed in a location and with an orientation prohibited by treaty. Given the immense size of the radar and its facilities, the Soviets could have had no doubt that we would detect its construction. The Krasnoyarsk radar is an example of the detection of a violation that erodes our confidence in the agreement.

Dr. Drell:

No to the first question. Military significance is of greatest immediate importance, but a confirmed violation of a treaty is serious because it is a violation of a legal commitment. Well-documented violations should not be ignored or overlooked. Whether large or small, they raise concerns about a government's values and intentions and call into question whether negotiated agreements can serve as a basis for further progress toward better relations. Our recent inability to resolve real and alleged Soviet violations has had a negative effect on the prospects for future arms control agreements—even if the specific Soviet activities in question have at most a marginal effect on U.S. national security.

Similarly, the U.S. decision to no longer abide by provisions of SALT II—and the implementation of this decision by the deploy-

ment of an additional bomber to carry cruise missiles—or U.S. activities which would constitute violations of the ABM Treaty as a result of the development and testing of system components under the Strategic Defense Initiative (SDI), as projected for the future by the Reagan Administration, will undoubtedly have a chilling effect on arms control efforts and on U.S.-U.S.S.R. relations in general.

4. *Do differences in U.S. and Soviet attitudes toward secrecy and the flow of information affect the U.S. ability to verify Soviet compliance with arms control agreements and Soviet ability to verify our compliance?*

Dr. Drell:

Yes. Because of Soviet secrecy, the United States generally learns of new Russian weapons only after they are further along in the development process; consequently, the United States has a shorter time to respond to newly emerging military threats. In contrast, the Soviet Union can get a first glimpse of our advances in weapons as they are discussed during open authorization and appropriation debates in the Congress. There is an important compensating advantage to the United States for openness in research: Our technical programs benefit from a vigorous exchange of information; the merits and limitations of proposed new systems are openly debated. This openness has been, and continues to be, a vital component of our advanced technical progress.

Another asymmetry between the United States and the Soviet Union has a major effect on the arms control process. Because of Soviet secrecy, the United States has insisted on working out the compliance regime in detail before we negotiate the provisions of a treaty. The Soviet Union, dealing with the open U.S. society, has traditionally given priority to negotiating the treaty before resolving compliance issues. This situation calls for mutual accommodation.

Dr. Eimer:

In open societies, such as the United States, information on military forces is readily available. As a closed society, the Soviet Union is capable of restricting much of this information, and the scope of Soviet concealment and deception continues to increase. These activities might be carried out on a more extensive and rigorous basis than usual whenever arms control violations are committed. As a result, intensive U.S. intelligence collection is required to verify Soviet compliance with arms limitation agreements.

Not only do Soviet information-gathering efforts benefit from our inherently open society, but Soviet verification of U.S. compliance is simplified by our own efforts to comply with our international obligations. There are three major U.S. institutional and legal procedures for ensuring that U.S. plans and programs remain consistent with our obligations. These procedures include internal Department of Defense controls, separate evaluations by the U.S. Arms Control and Disarmament Agency, and congressional oversight. The publications of these agencies, together with the vast quantity of information in the media, are likely to provide the Soviets with most of the information they need to verify U.S. arms control compliance beyond all reasonable doubt.

5. *What are the trade-offs between revealing sources and methods of verification and releasing information about the compliance behavior of an adversary? When should political leaders "go public" with charges of arms control violations?*

Dr. Eimer:

There is a critical tension between the need to make information about compliance public and the need to protect sensitive sources and methods of monitoring. Unfortunately, much information relevant to compliance is of a sensitive nature and cannot be released. When U.S. verification techniques are revealed to the Soviets, the Soviets can tailor their concealment programs to deny such information to the United States. In addition, the details of our negotiations with the Soviets and of the discussions with the Soviets in the Standing Consultative Commission (SCC), which was established for the purpose of discussing questions of compliance, are confidential.

In free societies, a government has an obligation to keep the public informed on issues of national security and arms control. Much has been done to meet this obligation, and in all cases of Soviet violations a large amount of information has been released.

Annual reports to the Congress, classified and unclassified (to the degree that sources and methods can be protected), on Soviet noncompliance with arms control agreements are mandated by U.S. law. The option not to "go public" with charges of Soviet arms control violations is thus not an option at all.

Dr. Drell:

Our future ability to gather information can be impaired if we compromise sources and methods. In addition, the negotiation process can unnecessarily be made more difficult if compliance issues are debated in public before avenues for resolving ambiguities have been exhausted. The credibility of U.S. charges of Soviet violations has been harmed by public overstatements of the violations, followed by backtracking or continued overstatement. One example is the U.S. allegation of Soviet violation of the unratified Threshold Test Ban Treaty (TTBT). Previous U.S. allegations of Soviet violations have now been contradicted by many informed scientists both in and out of government. The Central Intelligence Agency has recently changed its procedures for estimating the yield of large Soviet tests (*3*), lowering previous explosive yield estimates by 20 percent, despite alleged objections from some Defense Department officials. I conclude, based on the best physical evidence, namely, seismic data, that Soviet tests are consistent with the TTBT within the statistical uncertainties that are inherent in any such analysis.

In general, we should go public with allegations of treaty violation only as a last resort, if and when the SCC—which was created especially to deal with ambiguous activities and apparent violations—has reached an impasse. When allegations are made public, information about violations should be placed in the context of the overall compliance record.

6. *Have consultative mechanisms such as the SCC served adequately to resolve disputes related to treaty compliance? Where has the SCC succeeded and failed, and what are its prospects for the future? Should its role be altered?*

Dr. Drell:

Before 1981, the answer to the first question was yes. For 8 years, after its inception in 1972, the SCC was endorsed as an effective mechanism by U.S. government officials at the highest levels, both military and civilian. It is disturbing to note, however, that since 1981 some senior officials in the Reagan Administration have discounted these prior judgments as unsound and politically motivated.

Before 1981, the SCC was able to resolve many ambiguities and alleged violations to the satisfaction of the United States and the Soviet Union. SCC successes include the resolution of issues such as alleged Soviet testing of radars in conjunction with concurrent testing of strategic ballistic missile reentry vehicles at test ranges in violation of the ABM Treaty, and the U.S. use of environmental covers as protection for workers at missile silos, a practice that impeded verification by Soviet NTM. It has been reported that in

the spring of 1985 the SCC further clarified the ban on air defenses being tested in an ABM mode by changing the words in the prior clarification from "concurrent testing" to "concurrent operations" and that a common understanding was achieved to preclude the operation of Soviet air-defense radars during the flight tests of strategic missile reentry vehicles (*4*). This is the only documented example of an SCC success during the Reagan Administration.

The SCC has failed to resolve three U.S. allegations of Soviet violations: the encryption of telemetry from missile test flights that impedes SALT verification in violation of SALT II; the construction of an LPAR near Krasnoyarsk in Siberia in violation of the ABM Treaty; and the development of a second "new" intercontinental ballistic missile (ICBM), the mobile single warhead SS-25 in violation of the SALT II limitation to one new type of ICBM. (See question B3 for details.)

As to whether the SCC should be altered, I believe we will always need such a forum. It is a useful tool for implementing negotiated agreements. In view of its past record of success, I do not believe that the recent problems in resolving compliance issues suggest any fundamental structural problems in the SCC. Several SCCs might need to be created as new treaties are negotiated if the burden on one commission becomes excessive.

Dr. Eimer:

Every effort has been made to use the traditional consultative process in which strategic arms compliance questions are discussed with the Soviets. Every issue discussed in each edition of the unclassified "Report to Congress on Soviet noncompliance" was first raised with the Soviets in the SCC or through other diplomatic channels. Soviet responses in most cases did not alleviate, and in some cases exacerbated, our concerns. In general, the Soviets have merely denied our charges or offered alternative explanations; after close examination, we have judged that their explanations are implausible. The question in such cases is whether to accept false denials, raise the issues privately, or make the charges public and respond appropriately and proportionately.

The confidential consultative process may be useful in cases of unintentional noncompliance. It has also proved useful for determining specific procedures for dismantlement of systems and the exchange of data—tasks that were assigned to the SCC by SALT I and II. Intentional noncompliance is another matter. It is unreasonable to expect the SCC to resolve such cases, and this was noted in the treaties themselves. For example, Article XIII of the ABM Treaty (*5*, p. 137) provides that the SCC will "consider questions concerning compliance which may be ambiguous," will "provide on a voluntary basis such information as either party considers necessary to assure confidence in compliance," and will "consider questions involving unintended interference with NTM." No mention is made of the "resolution" of cases of intentional noncompliance.

In sum, the consultative process has not proved sufficient to settle the numerous cases of Soviet noncompliance. It could not unless the Soviets were willing to reverse their noncompliance. But if mere talk could cause the Soviet Union to undo its violations, it seems unlikely that the Soviets would have intentionally violated their obligations in the first place.

B. Verification of Present and Future Arms Control Agreements

1. Are existing arms control agreements verifiable with the use of currently available technology? Which agreements or provisions of agreements are inadequately verifiable? What are the consequences?

Dr. Eimer:

The degree to which existing arms control obligations can be verified varies widely. It is possible that, in a number of cases where U.S. verification is weak, the Soviets either have not violated an agreement or have taken great care not to be detected in violation. However, with respect to some provisions of agreements for which, in our judgment, the degree of verifiability is low, the Soviets have not taken steps to avoid detection. A case in point is the Biological Weapons Convention (BWC) of 1972. The Soviet Union has maintained an offensive biological warfare program in violation of its legal obligation and for many years has carried out that program without apparent regard for its detection and without taking the apparently simple steps to avoid such detection.

In most instances in President Reagan's three Reports to the Congress on Soviet Noncompliance, where findings of violation were qualified, the uncertainties were due to some shortcomings in the observational data. A critical consequence of these shortcomings has been an often divisive debate concerning the accurate portrayal of Soviet noncompliance.

Dr. Drell:

The ABM Treaty of SALT I is verifiable with currently available technology. We monitor the limits on deployments of interceptor missiles, launchers, and engagement radars; LPARs for early warning; and testing limits. We also know, for instance, that one such LPAR is being built by the Soviet Union deep within eastern Siberia in violation of the treaty.

The SALT I and II limits on numbers of deployed offensive strategic weapons are also verifiable. The systems constrained by the treaty are large and their deployment can be counted by NTM. In particular, the treaty specifies that strategic bombers will be modified with functionally related observable differences (FRODs) when they are equipped to carry air-launched cruise missiles (ALCMs). These FRODs contribute to the ability to monitor the limitations on loadings of ALCMs on such bombers. There are, as yet, no parallel means of counting sea-launched cruise missiles (SLCMs), which in addition may be armed with nuclear warheads or may be altered to fly to shorter ranges with conventional, nonnuclear warheads. Such SLCM deployments are not limited by SALT.

The TTBT, which limits underground nuclear weapons tests to yields of up to 150 kilotons, is adequately verifiable in the judgment of most scientists knowledgeable about existing seismic detection technology. As with any physical measurement, the verification of a specific quantity such as explosive yield will have a "probable error." An exchange of data about the geology of the test sites would occur under the provisions of this 1974 treaty, if the treaty were ratified by the U.S. Senate. Such an exchange would add to U.S. confidence in monitoring treaty compliance by making possible a more precise determination of Soviet yields.

The BWC is not verifiable through technical provisions but has procedures designed to resolve ambiguities. Some of the provisions limit uses of biological agents but do not designate allowed quantities. In the absence of means of verification, this treaty has led to significant and unresolved allegations of Soviet violations. The Soviets are accused of producing weapons involving anthrax organisms at Sverdlovsk; of using toxins in Afghanistan; and of using or providing mycotoxins ("yellow rain") to client states in Southeast Asia. These unresolved charges by the United States are contested by the Soviet Union, which has also not conformed to the specified procedures in BWC. This situation has harmed the prospects for arms control by casting doubt on the reliability of the Soviets as a negotiating partner. For humanitarian reasons and for progress toward future arms control agreements, a way must be found to resolve these questions about Soviet behavior.

2. *Verification capabilities are often assumed to deter noncompliance by the other side. Are there cases where less than optimum verification capabilities have encouraged noncompliance?*

Dr. Drell:

In BWC, the absence of provisions for verification has led to charges of noncompliance as discussed in question B1. There is no evidence, however, that this circumstance has encouraged noncompliance. Our experience has shown that the Soviets push to the very limit of treaty provisions. One example of such Soviet behavior was their replacement during the 1970s of old SS-11 missiles by much larger but formally treaty-consistent SS-19s, which are much more potent. This Soviet approach toward treaties has been demonstrated repeatedly; we must consider this in negotiations and take great care in formulating treaty provisions. However, the Soviet tendency to push to the limit should not undermine our confidence in arms control, given the good overall record of Soviet compliance with the terms of past agreements.

Dr. Eimer:

Verification capability is necessary, but not sufficient, to deter violations. A treaty signer must be made to believe that noncompliance will produce circumstances that are undesirable and that this cost will be greater than the benefit. Unfortunately, U.S. actions in response to Soviet violations also carry a budgetary and political cost to the United States that may be greater in the short term than the cost to the Soviets. Thus, only if the long-term benefits of arms control warrant it will the United States pay the price that is required to deter Soviet violations.

Less than optimal verification is the norm rather than the exception. It cannot be proved, however, that deficiencies in verification capabilities have encouraged noncompliance. As pointed out in the case of the BWC and the ABM Treaty, the Soviets have carried out violations even when it must have been clear to them that the violations would be detected.

3. *Are the United States and the U.S.S.R. in compliance today with existing arms control agreements? If not, in what cases, and to what do you attribute this failure? Can you suggest proportionate and appropriate responses in such cases?*

Dr. Eimer:

The United States has observed strict compliance with its arms control obligations and commitments. The U.S. record of compliance is deeply rooted in our own legal system and in the set of fundamental principles and values that govern American attitudes toward arms control and international obligations. These factors—a deep-seated legal tradition, commitments to the objectives of arms control, and the workings of an open society—are basic and enduring. They create powerful incentives to comply with all international agreements, including arms control agreements. The legal and institutional procedures we have established to ensure compliance reflect the seriousness with which these obligations are taken by the United States.

The Soviet Union, on the other hand, is pursuing a pattern of noncompliance. The Soviet Union has violated its legal obligation or political commitment to the ABM Treaty, the SALT I Interim Agreement, the SALT II Agreement, the Limited Test Ban Treaty (LTBT) of 1963, the BWC, the Geneva Protocol on Chemical Weapons, and the Helsinki Final Act. In addition, the U.S.S.R. has likely violated provisions of the TTBT.

The Soviets have not been deterred from violating agreements. In some cases, such as the SS-25 missile and the Krasnoyarsk radar, the violations provide the Soviets with clear military benefits. In other cases, such as their numerous violations of the venting prohibitions of the LTBT, the only benefit seems to be the saving of a few rubles. The reasons for this are speculative, but Soviet violations indicate a disregard for political obligations and legal commitments, and perhaps a belief that no unacceptable cost is associated with this disregard.

Responses to Soviet violations must demonstrate to the Soviets that they cannot violate with impunity. Our responses should support U.S. goals for national security including maintaining strategic and crisis stability, helping to deter future Soviet violations, providing a precedent for future responses, and demonstrating U.S. will and resolve. In response to Soviet conduct, President Reagan announced on 27 May 1986 that, in the future, the United States must base decisions regarding its strategic force structure on the threat posed by Soviet strategic forces and not on standards contained in the SALT structure, which has been undermined by Soviet noncompliance. Since the United States retired and dismantled two Poseidon submarines in the summer of 1986, the United States remained in technical compliance with the agreement until the United States equipped its 131st heavy bomber for cruise missile carriage. President Reagan superseded the U.S. political commitment to SALT II with a new political commitment: assuming no significant change in the threat we face, as we implement the strategic modernization program, the United States will not deploy more strategic nuclear delivery vehicles or strategic ballistic missile warheads than does the U.S.S.R. These actions were taken in the legally prescribed manner.

Dr. Drell:

Yes, the overall pattern is one of compliance. There have been genuine ambiguities and violations but they are the exception, not the rule. With respect to the ABM Treaty of SALT I, the Soviets are complying with the restrictions on R&D and with all of the numerical limits on engagement radars and interceptors at the one allowed site. Concerning negotiated limits on their offensive missile forces, the Soviets have destroyed or dismantled more than 1200 older ballistic missiles as well as 20 submarines armed with nuclear-tipped missiles in order to stay within the numerical limits of the SALT I and II agreements. There is also strong evidence that the Soviets are in compliance with the LTBT, the Nonproliferation Treaty (NPT), TTBT, and other arms control agreements.

As previously noted, some outstanding compliance issues remain. In addition to several "legal" radars that have been built, the Soviets are now constructing one LPAR deep in eastern Siberia near Krasnoyarsk. It completes their early warning screen as allowed by the ABM Treaty but is not on the periphery looking outward, and is therefore a clear technical violation of the treaty (*6*). Presumably the radar construction at Krasnoyarsk is motivated by two factors. First, it would be much harder for the Soviets to build an LPAR on frozen tundra, which is where it would have to be located to comply with the treaty. If properly deployed in accord with the ABM Treaty, the radar site would have required a more distant and difficult transport of construction materials. And second, in its present location a single radar is able to fill the gap in the Soviet early warning screen. If the radar were sited forward at the northeast periphery as required by the ABM Treaty, the Soviet Union might very well have needed to construct two radars so that their fan-shaped beams could fill the gap. (I will suggest an appropriate U.S. response to the Krasnoyarsk radar.)

The Soviets are also in the process of deploying a second new ICBM although the SALT II Treaty limits each nation to one new type of ICBM. In addition, they are encrypting a large amount of the information that is telemetered during missile test firings. The U.S. government has argued that both of these actions are in

violation of the SALT II Treaty. The Soviet government has denied the charge, and some Western experts have argued that these violations are less clear-cut. The Soviets maintain that their second new ICBM, the mobile, single-warhead SS-25 missile, is no more than an allowed modification of an earlier missile, the SS-13. Ambiguity on this issue arises from the treaty language and the fact that U.S. data on the SS-13 are imprecise and are largely based on flight tests that occurred in the mid-1960s.

Concerning the encryption of telemetry from missile test flights, the SALT II Treaty [(*7*), Article XV, paragraph 3] mandates that "neither party shall engage in deliberate denial of telemetric information . . . whenever such denial impedes verification of compliance . . . ." In fact, Soviet encryption has increased since the agreement, and currently the Soviets are heavily encrypting their telemetry, but important ambiguities remain regarding the degree to which this Soviet practice is constraining U.S. verification efforts. In SCC the Soviets have invited the United States to specify what necessary information we are not obtaining so that they might arrange to accommodate us. We have refused to provide a response to the Soviets, stating that it might require the United States to reveal potentially important information about our intelligence sources and methods. New approaches—such as requesting a broader range of data than we need, within which the required data are buried, or asking for all data except that which the Soviets need to protect for legitimate national security reasons—might be useful.

The challenge to the United States is how to respond on the serious issues raised by Soviet actions. The problem is inherent in the treaty language. As a possible way out of this dilemma I propose the following: With regard to the SS-25 missile, the United States is now going forth with the development of a second new type of ICBM, the small, single-warhead, mobile Midgetman, in addition to the MX. I believe that this can represent the "proportionate response" to the Soviet SS-25. Although eroding a treaty by mutual agreement is not neccessarily a good idea—and it may well appear to some like a cynical abuse of the arms control process to legitimize and manage an arms race rather than bringing it to a halt—it can persuasively be argued that small, mobile, single-warhead ICBMs are a sensible way for both countries to modernize their strategic land-based missile forces in order to ensure their survivability and effectiveness for deterrence. Since these missiles carry only single warheads, uncertainties in the numbers of such mobile missiles, which are harder to count than when the missiles are anchored in fixed silos, will not be multiplied by the presence of multiple warheads to strategically threatening levels.

With regard to the encryption of telemetry during missile test firings, I believe the United States should propose the following deal to the Soviets: in exchange for the Soviets agreeing to change SALT II by a new provision banning denial of telemetry (including all such encryption), we should agree to permit the Soviets to retain the Krasnoyarsk radar. The Krasnoyarsk radar by itself presents no military threat to the U.S. deterrent capability. Designed as an LPAR, it could be easily blinded by a high-altitude nuclear explosion (causing absorption and refraction of its signal) and is vulnerable as a large, soft target. It is also not well positioned for use as a battle management radar in an ABM system. By prohibiting encryption in missile test firings, we would make compliance with SALT II much easier to verify. Such a provision would fully serve the U.S. national security requirements and would introduce no restrictions on current U.S. activities. Such a deal of no denial of telemetry in exchange for retaining Krasnoyarsk would resolve both problems and be consistent with the interests of the United States.

Finally, early U.S. allegations of Soviet violations of the TTBT have now been shown to be unfounded, at least to the satisfaction of most technical experts. For many years the United States has alleged that the Soviets were violating the TTBT by carrying out underground nuclear tests above the maximum allowed yield of 150 kilotons. It is now widely accepted by informed scientists (see answer to question A5), on the basis of all available information, and in particular on the basis of a sound statistical interpretation of the seismic data from Soviet underground nuclear tests, that the Soviets are and have been in compliance with the treaty (*8*).

Overall, the U.S. record on compliance in the past has been excellent. Recently, however, U.S. work on SDI has raised questions about the interpretation of the ABM Treaty as applied to "exotic" new technologies such as directed energy weapons. This question about the meaning of treaty provisions has not been presented to the SCC but must eventually be resolved. The United States is also proceeding to develop a second new type of ICBM, the small single-warhead Midgetman ICBM, which would be a violation of the SALT II Treaty. President Reagan's recent action to exceed the SALT II subceilings with the deployment of additional ALCM carriers seriously calls into question prospects for future U.S. and Soviet compliance.

C. Future Needs, Methods, and Technologies

1. What does our experience with U.S. and Soviet arms control compliance during the 1970s and 1980s suggest about the structure of future agreements and the need for new methods and technologies for verification?

Dr. Drell:

We have learned that, when possible, agreements should be formulated as complete rather than partial bans. Partial restrictions are more likely to lead to ambiguities in interpretation that can become the subject of damaging, unresolved disputes. A total ban on the denial of telemetry during missile test firings as proposed above would not permit ambiguity.

To avoid problems of this nature, we may want to develop future agreements, where practicable, on the basis of a limit on the nuclear weapons "level of effort" on each side. This comprehensive limit would cover activities that can be monitored, such as the introduction of new weapons systems, test flights of strategic missiles, and numbers and yields of underground tests, leading ideally to a comprehensive test ban treaty (CTBT). Such limits could be at least a partial brake on the arms competition and more effective than trying to restrict new types of weapons by defining permitted missile parameters in detail. Such a "level of effort" approach would also be useful to establish effective constraints as we develop new technologies that enable nuclear weapons to be more widely deployed on mobile systems that are smaller and may have dual purposes, such as cruise missiles, which can be armed with either nuclear or conventional warheads. Since it is not possible to count the deployment of SLCMs with any confidence, the idea of "level of effort" would need to be extended to the production of weapons-grade fissionable materials, with appropriate means of verification. Nevertheless, we must continue to develop and deploy the best technical means of verification. The costs are very small compared to operational military systems.

Dr. Eimer:

The record of Soviet noncompliance during the 1970s and 1980s suggests that our verification needs include a number of related requirements. First, discussions about verification must be part of treaty drafting and, to the greatest extent possible, provisions should be drafted to minimize dependence on data that the Soviets can conceal or distort. Second, the United States should seek the best

verification technologies. New and exciting technological opportunities should be exploited, but some of them can be very costly. Finally, if the Soviets believe they can violate with impunity, no verification regime—however strong—can deter violations. The Soviets probably undertake some noncompliance both to test our monitoring and to test our will to enforce compliance. But unless it is made clear that compliance is "cheaper" for the Soviets than violations, they will have no incentive to comply.

2. *Will future agreements need to be supported by verification measures beyond NTM? Will the necessary steps include cooperative verification or on-site inspection? How will one distinguish verification of arms control provisions from military intelligence gathering?*

Dr. Eimer:

Future agreements will probably need verification measures that go beyond NTM. In START and INF, for example, exchanges of information might include declaration of missile and launcher facilities, the numbers of missiles and launchers at these facilities, and information on the destruction of missiles and launchers that exceed treaty limits. In the negotiations on Mutual and Balanced Force Reductions (MBFR), we have asked for an annual exchange of information on the structure of forces subject to MBFR limits. At the Stockholm Conference on Confidence and Security-Building Measures and Disarmament in Europe (CDE), we desire an exchange of information both on overall force structures and on specific forces participating in military activities. In chemical weapons arms control we desire, among other things, a preliminary bilateral exchange of data on stockpiles and on production facilities as a confidence-building measure prior to the entry into force of an agreement.

One method for cooperative verification is on-site inspection (OSI). Although OSI may help in some cases, it is not a panacea for verification problems. In combination with NTM, OSI can help deter Soviet violations at declared sites. The utility of OSI depends on its frequency, on the ease with which the action being monitored by OSI can be conducted at other times and places, and on the calculation by the party being monitored of the costs and risks incurred if violations are uncovered during an inspection.

In evaluating the value of inspection measures in future arms control agreements, we must understand what inspections can and cannot do. U.S. inspection teams in the Soviet Union may lack the freedom necessary for discovering or observing serious violations. Despite our best efforts, inspection can be frustrated and obstructed in a variety of ways. The value of OSI may be limited to providing evidence of obstructive activities designed to conceal violations rather than in supplying evidence of the violations themselves. It should properly be seen as a supplement to NTM, not a replacement for it.

Verification differs from military intelligence gathering by focusing strictly on treaty-limited systems. The Soviets have often used charges of intelligence gathering as an excuse to avoid stringent verification of their treaty-limiting actions. The United States is trying to construct monitoring systems that will aid in verifying compliance in as unobtrusive a manner as possible, but that will increase our confidence. The Continuous Reflectometry for Radius versus Time experiment (CORRTEX), an on-site measurement device that would be required for effective verification of nuclear testing thresholds, is an example. President Reagan has offered to demonstrate the operation of this system to the Soviets for possible joint uses.

Dr. Drell:

We are moving into an era where cooperative measures can be helpful in strategic arms control. As weapons become smaller, more widely deployed, and optionally either nuclear or nonnuclear, the restraints that can be verified by national technical means alone are becoming less significant. Limits on "level of effort" together with cooperative verification will become increasingly important. We must negotiate appropriate measures for cooperative verification and define carefully the circumstances under which on-site inspection would be triggered so that these means cannot be abused for gaining military intelligence. Careful drafting will be required to develop provisions that allow specific inspections, and at the same time guard against intelligence "fishing expeditions." It is an encouraging development that the Soviets now seem willing to consider some forms of OSI in monitoring a CTBT and have agreed to measures for monitoring Warsaw Pact military exercises in the recently negotiated agreement by the CDE. It would be wrong, however, to regard OSI as a cure-all for verification problems.

3. *What compliance problems are on the horizon, based on U.S. and Soviet military programs currently under way? How should they be addressed?*

Dr. Drell:

Four impending compliance issues are of importance:

First, the deployment of mobile ICBMs will make limits on strategic ballistic missiles more difficult to verify than present limits on silo-based or submarine-based ballistic missiles. This problem could be addressed by negotiating provisions that limit new mobile ICBMs to be relatively small and loaded only with single reentry vehicles. Cooperative agreements for monitoring "choke points" and limiting deployment areas could also be helpful.

Second, the development of new technologies for antitactical ballistic missiles (ATBM) has blurred the distinction between defenses against strategic ballistic missiles, which are limited by SALT I, and air defenses which are not restricted. The new ATBMs when extensively deployed and internetted together with radars could pose a significant threat of a terminal defense against current strategic warheads. It will be an important but difficult negotiating task to accommodate the defense of military targets and field armies against tactical missiles without compromising limits of the ABM Treaty on defense against strategic missiles.

Third, we must clarify the interpretation of the ABM Treaty limitations on the development and testing of the so-called "exotic" new technologies, such as directed energy weapons. In particular, the United States has now stated its new interpretations of the treaty (Article V and Agreed Statement D) so as to permit the development and testing of new SDI technologies (*9*). Before 1986, however, the accepted interpretation of the ABM Treaty was that the testing, development, and deployment of space-based, air mobile, land mobile, and sea-based ABM components were forbidden by Article V (*10*). There are two questions here: What is the agreed U.S.-Soviet interpretation of the ABM Treaty limits on the new technologies? And what is the definition of a "component" that is limited by the treaty provisions, as distinct from subcomponents and laboratory research that are allowed? Because these ambiguities are leading to self-serving interpretations by both countries, the ABM Treaty may become a relic of past hopes unless they are resolved.

Fourth, dual-purpose weapons that can be deployed with either nuclear or nonnuclear warheads will make it difficult to verify compliance with numerical limits. This problem will be particularly severe if new technology for "clip-in" warheads is pursued, making it possible to arm missiles rapidly with either warhead. The solution will be either a restraint on deployed technology, new cooperative measures, or abandonment of counting rules in arms control treaties. SLCMs pose an especially difficult problem for this reason.

Dr. Eimer:

By law and by policy, the United States will not deliberately violate arms control agreements; no such violations have occurred. The United States is obligated to publicly announce any changes to unilateral U.S. political commitments that might be violations, or will scrupulously follow the appropriate steps prescribed by treaty to affect changes in obligations. This was the case with President Reagan's decision of 27 May 1986 to supersede the U.S. political commitment to continue to observe SALT II; in its place is a political commitment not to exceed the number of Soviet strategic nuclear delivery vehicles or ballistic missile warheads.

Unlike the United States, the Soviets have, in several instances, neither tailored their programs to their obligations nor attempted to change obligations before carrying out programs prohibited by treaty.

The United States must respond to Soviet noncompliance, and President Reagan has stated that the most obvious immediate response must be the full implementation of the U.S. strategic modernization program, continued pursuit of SDI, and acceleration of the advanced cruise missile program. President Reagan is attempting—through the strategic modernization program, negotiations in Geneva, and the Strategic Defense Initiative—to usher in an era of stability such that the Soviets will have a significantly reduced incentive to violate in the future.

4. *Three Soviet programs—the Krasnoyarsk radar, telemetry encryption, and the SS-25 ICBM—have created concern in the United States. Are any or all of these violations of the spirit or letter of agreements? How should these specific problems be addressed by the United States?*

Dr. Eimer:

The Krasnoyarsk radar is a violation of a core provision of the ABM Treaty. Radars like that under construction near Krasnoyarsk were recognized during the ABM Treaty negotiations as being one of the most critical, long lead time components of a prohibited territorial ABM system. Quantitative and qualitative limitations on LPAR deployments were therefore carefully included in the treaty, as discussed in question A2.

Although the Soviets have claimed that the radar is for space tracking and NTM, the claim is not credible because the radar is not designed and oriented to improve the accuracy of the existing system of Soviet satellite tracking radars. The capabilities, location, and orientation of the Krasnoyarsk radar precludes its use in NTM. Further, the radar is of a type previously characterized by the Soviet government as a radar for the early warning of missile attacks.

SALT II prohibits any deliberate concealment that impedes verification of adherence to the treaty provisions by NTM. Although the treaty permits each party to use various methods of transmitting telemetric information during testing, including encryption, deliberate concealment is prohibited if it impedes verification.

Since the SALT I agreement in 1972, Soviet encryption and concealment activities have become more extensive and disturbing. These activities, Soviet responses on these issues, and the Soviet failure to take the corrective actions that the United States has repeatedly requested, are indicative of a Soviet attitude contrary to the fundamentals of sound arms control agreements. Soviet encryption and concealment activities present special obstacles to maintaining existing arms control agreements and undermine the political confidence necessary for concluding new treaties.

The SS-25 missile is a violation of one of the key restrictions of the SALT II Treaty—that only one new type of ICBM could be tested and deployed. The violation is irreversible because the information gained from flight testing cannot be nullified.

Thus, all three of these Soviet activities are violations of both the object and purpose and of the letter of the relevant SALT treaties. All of these issues have been raised with the Soviets numerous times. The Soviets have been given every opportunity to resolve our concerns or take corrective action. In June 1985, President Reagan announced that he would provide the Soviets another opportunity to join us in establishing a framework of mutual restraint. The United States dismantled a Poseidon submarine to stay within SALT limits, and thus gave the Soviet Union time to correct their noncompliance. The Soviet Union has not used the past year for this purpose. They have not taken positive, concrete steps to correct their noncompliance and reverse their unparalleled and unwarranted military buildup. Therefore, President Reagan has determined that, in the future, the United States will base decisions about strategic forces on the nature and magnitude of the threat posed by the Soviet Union rather than on expired SALT agreements unilaterally observed by the United States.

Dr. Drell:

These Soviet programs were addressed in question B3.

5. *Are there possibilities for "third-party" verification of arms control agreements, as was proposed by a group of leaders of nonaligned countries in 1986? What agreements would be suited to such third-party verification?*

Dr. Drell:

There is an opportunity for third-party verification of a potential CTBT. The Swedish government, for example, has offered and could be helpful in providing stations to monitor either a CTBT or a TTBT with a threshold much lower than the current one of 150 kilotons. Third parties can only increase the technical power of verification to a limited extent; however, they can add importantly to the moral force in case violations are alleged. Third-party verification could also be useful if there were an agreement on a halt to the production of weapons-grade fissionable material.

Dr. Eimer:

Assistance by third parties can play an important role in achieving effective verifiability of U.S.-Soviet arms control agreements. Third-party assistance could be beneficial for all arms control agreements. Of particular importance is the opportunity for emplacing instruments valuable for treaty monitoring on third-party territory.

But, verification by a third party is unsuitable for any arms control agreement. First, the United States will almost certainly have additional data that it may not be able to share with a third party. The United States must, however, weigh all the available data when it makes its compliance findings. Second, it must be remembered that the verifiability of arms control agreements is not evaluated in black or white terms (except in very special circumstances). The degree of verifiability needed for a judgment that a provision or a treaty is effectively verifiable and the standard of evidence required for compliance findings depend on a number of factors viewed differently by different countries—even within closely knit alliances.

6. *Should the United States have a policy of disinformation about its military programs, to match alleged Soviet deception aimed at U.S. verification capabilities?*

Dr. Eimer: No.

Dr. Drell:

The United States should be very wary of getting involved in such a program. With its controlled media and society, the Soviet Union

can play a game of disinformation much better than we can. In practice, a U.S. policy of disinformation is impossible. Congress cannot be misinformed and at the same time responsibly fulfill its constitutional role of authorizing and appropriating funds for military programs. But if Congress is informed, the public will inevitably know the true facts. In addition, openness in scientific discussion has always proved to be of great value for our scientific work and has contributed to the development of our advanced military technology. It should be preserved.

REFERENCES AND NOTES

1. The Reagan Administration has raised the issue of the conversion of a small number of Bison bombers to tankers by the Soviets, as required to remain under the numerical ceiling.
2. An exception is the occasional venting of Soviet underground tests (and in the past of several U.S. tests), which lead to a release of small but measurable radioactivity outside national boundaries. This prohibition is more of an environmental concern rather than a matter of military significance.
3. M. R. Gordon, *New York Times*, 2 April 1986.
4. R. J. Smith, *Science* **229**, 535 (1985).
5. "Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitations of Antiballistic Missile Systems," in *Arms Control and Disarmament Agreements* (U.S. Arms Control and Disarmament Agency, Washington, DC, 1982).
6. The Soviets maintain that it is for space tracking, which is legal under the ABM Treaty. In view of the radar's inherent capabilities and basic similarity to other LPARs built for early warning, I find this claim unpersuasive.
7. See SALT II, Article XV, paragraph 3, and in particular the Second Common Understanding, in *Arms Control and Disarmament Agreements* (U.S. Arms Control and Disarmament Agency, Washington, DC, 1982), p. 266.
8. In particular, Dr. Roger Batzel, director of the Lawrence Livermore National Laboratory, said in written testimony to the Senate Armed Services Committee (Subcommittee on Strategic and Theater Nuclear Forces) on 14 March 1986: "Based on our assessment of the relationship between yields and seismic magnitudes for the Soviet test site and the pattern of Soviet testing, we have concluded that the Soviets appear to be observing a yield limit. Our best estimate of this limit is consistent with TTBT compliance. However, the seismic data are subject to considerable statistical uncertainty." Professor Lynn Sykes of Columbia University, a seismological expert who was a negotiator of TTBT for the Nixon Administration, and who has served on the panel on estimates of Soviet yields for the Defense Advanced Research Projects Agency, has said (in a television interview on 9 May 1986): "The Treaty itself states that neither country shall test above 150 kilotons, and I have no evidence that indicates the Soviets have done that." In addition to uncertainties in estimating yields based on seismic data, the actual yield of a nuclear explosion may not precisely agree with its design value. This added uncertainty led the United States and the Soviet Union to agree in the transmittal documents that accompanied submission of the TTBT to the U.S. Senate that "one or two" slight breaches of the treaty limit would not be considered a treaty violation.
9. "The ABM Treaty and the SDI Program," *Current Policy Report No. 755* (Department of State, Washington, DC, 1985).
10. G. Smith, letter to the editor, *New York Times*, 23 October 1985.