Preface

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An effective verification regime, which includes a reliable monitoring system that provides data on which a judgement can be made, is a prerequisite for any arms control or nonproliferation agreement. Verification provisions in arms control accords promote compliance by rendering the risks and costs of evasion unacceptably high, thereby deterring potential violators. Verification also plays a role in international confidence building by reassuring participating states that their interests are being protected. Furthermore, a verification mechanism makes it easier for a party unjustly accused of breaching the terms of a treaty to demonstrate its innocence. By providing evidence that member states are fulfilling their obligations, and by confirming that the prohibited activities have not taken place, verification helps to generate trust in arms control and disarmament initiatives.

Since the 1950s, the nuclear powers have used nuclear testing to develop new types of weapons as well as to assess the reliability of their existing arsenals. A comprehensive test ban was regarded as crucial to preventing spiralling nuclear proliferation. Limited success was achieved with the 1963 Partial Test Ban Treaty (PTBT), which banned nuclear tests in the atmosphere, underwater and in space. However, the PTBT failed to prohibit underground testing due to concern about whether this could be adequately verified. Neither France nor China, both nuclear weapon states, signed the accord. In 1968, the Nuclear Non-Proliferation Treaty (NPT) was opened for signature. In 1974, the Soviet Union and the US signed the Threshold Test Ban Treaty, limiting the yield of underground weapon tests to 150 kilotons. The maximum yield of peaceful nuclear explosions was restricted to 150 kilotons when the same two countries signed the Peaceful Nuclear Explosions Treaty (PNET) in 1976.

The adoption of the Comprehensive Nuclear Test Ban Treaty (CTBT) by a special session of the fiftieth United Nations General Assembly on 10 September 1996 was the product of almost four decades of international effort to end nuclear testing. It also signified confidence that the treaty could be verified in all environments.

The CTBT bans any nuclear weapon test explosion or any other nuclear explosion in any environment. Each state party undertakes to 'prohibit and prevent any such nuclear explosion at any place under its jurisdiction or control'. By constraining both the development of nuclear weapons by states that have not previously possessed them and the qualitative improvement of nuclear weapons by states that already have them, the treaty plays an important role in preventing horizontal and vertical proliferation. It also fosters nuclear disarmament, which is still one of the international community's key objectives.

The number of signatures and ratifications continues to increase. Mauritania became the one-hundredth state to ratify the CTBT on 5 May 2003, representing a notable milestone on the road to universality. As of 11 November 2003, 108 states had ratified the treaty. More are expected to follow suit prior to and during the Conference on Facilitating the Entry into Force of the CTBT in Vienna, Austria, from 3–5 September 2003. The accord has been signed by 170 states, indicating the support of the vast majority of governments for a verifiable end to nuclear test explosions.

Since monitoring is crucial to an effective and credible test ban, the CTBT provides for a global verification regime. This includes: an International Monitoring System (IMS) to provide data on possible nuclear explosions and ambiguous events; a consultation and clarification process; on-site inspections (OSIs); and confidence-building initiatives. The Preparatory Commission for the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) has been established in Vienna to prepare for implementation of these verification measures.

The IMS consists of a global network of 337 monitoring facilities (170 seismic stations, 11 hydroacoustic stations, 60 infrasound stations, 80 radionuclide stations and 16 radionuclide laboratories). Many of the stations are located in remote areas in order to provide global coverage, presenting logistical and engineering challenges unprecedented in the history of arms control. Areas that are particularly demanding include Antarctica and the remoter oceanic islands. Of the 13 IMS stations that will exist in Antarctica by the time the CTBT enters into force, several are already operational and transmitting data to the International Data Centre (IDC) in Vienna. IMS facilities have also been established in many other isolated places, such as the Crozet Islands, sub-Antarctic rocks in the South Indian Ocean, which are uninhabited except for scientific personnel, and the Juan Fernandez Island, better known as Robinson Crusoe Island, over 600 kilometres off the coast of Chile.

The IMS employs four verification methods (seismology, hydroacoustics, infrasound and radionuclide monitoring) and uses the most modern technologies available. The seismological component senses and locates seismic events. New seismic signal processing techniques can detect very small explosions and can differentiate them from earthquakes. Hydroacoustic monitoring identifies acoustic waves produced by natural and man-made phenomena in the world's oceans. The infrasound network uses micro-barometers to distinguish very low frequency sound waves in the atmosphere produced by natural and man-made events. Finally, the radionuclide network uses air samplers to detect radioactive particles and gases released from atmospheric explosions or vented from underground or underwater explosions.

Establishing an IMS station is a lengthy process. After the conclusion of an agreement with the host state, site surveys must be conducted to ensure that the proposed location is suitable for treaty monitoring. Site preparation normally includes the construction of shelters for instruments, the establishment of a power supply, the erection of antennae or the laying of cables for communicating data from sensors to the central site, and the assembling of security fencing. The next stage involves acquiring and installing the equipment. Transporting the hardware to remote places often entails prolonged, expensive ship journeys.

Since the CTBT was opened for signature in 1996, significant progress has been made in establishing the IMS. Site surveys for 88 percent of the stations have been completed. One hundred and fifty stations have been built or substantially meet specifications. Of these, 55 have been certified as satisfying all technical requirements for them to become part of the IMS. An additional 80 stations are currently under construction or subject to contract negotiations. Some 80 facilities are already contributing data to the IDC, where it is processed and, together with IDC 'products', released to states signatories for further analysis.

Once the treaty enters into force, a state party which suspects that a nuclear explosion has been carried out in violation of the treaty may request an OSI. Prior to doing so, though, the treaty encourages states parties to try to resolve, either among themselves or with the CTBTO's assistance, any matters that may indicate possible non-compliance with the basic obligations of the CTBT. A state party must provide clarification of an ambiguous event within 48 hours of receiving a request to do so. If the requesting state party considers the clarification to be unsatisfactory, measures to redress the situation, including sanctions, may be contemplated in accordance with Article V of the treaty.

The verification regime also provides for confidence-building measures, which serve a dual purpose:

- they may contribute to the prompt resolution of compliance concerns relating to conventional (chemical) explosions; and
- they may assist in the calibration of IMS stations by improving knowledge of how vibrations propagate through the earth's structure, thus enhancing the accuracy of assessments of the location of seismic events.

The effectiveness of the CTBT verification regime could be measured by whether, and to what extent, a state could successfully conduct a nuclear test and evade detection. The IMS, with its associated communications infrastructure and the IDC, is capable of identifying nuclear explosions of very low yield in any environment. Nuclear tests below the system's detection level would add little, if anything, to the nuclear capabilities of advanced nuclear states. It is unlikely that less advanced nuclear states or potential newcomers would be able to carry out low-level tests undetected. Furthermore, the fact that development of new nuclear weapons requires multiple tests means that the chances of detection by the IMS are greatly increased.

Potential evasion scenarios include cavity decoupling and masking via conventional mining explosions, although there are no credible examples of the latter. Without substantial experience of underground nuclear testing, however, a state attempting to use large underground cavities to decouple explosions from the surrounding geological media would be unlikely to succeed. Moreover, the process would be costly and would require substantial technical and human resources. The seismic signal generated would have to be significantly reduced so as to avoid detection by the IMS and other seismic networks. In addition, all radioactive particles and noble gases produced by the explosion would have to be contained within the cavity.

With regard to masking, chemical explosions in mines tend to be ripple-fired and, therefore, less efficient at generating seismic signals than single explosions of the same total yield. A very high yield, single-fired chemical explosion could mask a nuclear explosion with a similar yield, but the event would undoubtedly arouse suspicion, since these kinds of chemical explosions are very unusual. In order to mask a nuclear yield of one kiloton in a mine, for instance, a combination of cavity decoupling and masking techniques would be required, increasing the likelihood of detection.

In addition to its monitoring network, OSIs will reduce even further the prospect of testing going undetected. The purpose of an OSI is to clarify whether a nuclear weapon test explosion or any other nuclear explosion has been conducted in violation of the treaty, and to gather facts, to the extent possible, that might assist in identifying any possible violator. An OSI thus serves as a last resort verification measure for the CTBT.

In 1999, the Preparatory Commission's Provisional Technical Secretariat (PTS) conducted an extensive field experiment in Kazakhstan to develop further inspection procedures and the technical and logistical aspects of an inspection. Twenty-one IMS stations around the world detected the simulated nuclear test of 0.1 kilotons. Following more than a year of intensive planning and building on lessons learned during a successful field experiment in Slovakia in October 2001, the PTS carried out another large-scale field experiment in Kazakhstan between September and October 2002. More than 25 surrogate inspectors spent three weeks in a remote part of the country engaging in activities similar to those that a real inspection team would perform. The experiment provided valuable data and insights for the development of the OSI Operational Manual.

Installation of the IMS is progressing at a steady pace. New research, improved communications technology and more sophisticated methods of data analysis are strengthening its monitoring capabilities. As provided for in the CTBT, national technical means of verification offer an additional source of data that can be used to identify nuclear explosions or to support an OSI request. Together, these capabilities serve as a powerful deterrent to any potential treaty violator. The possibility of an OSI, and the high political costs of detection, will make attempts to evade the treaty extremely difficult and increasingly unlikely.

As an independent non-governmental organisation (NGO) concerned with effective and efficient verification, the Verification Research, Training and Information Centre (VERTIC) plays a significant role in promoting the early implementation of the CTBT and its verification system. VERTIC has organised several seminars related to CTBT verification in coordination with the Preparatory Commission, raising awareness of the treaty and highlighting the importance of international cooperation in ridding the world of weapons of mass destruction. Along with other VERTIC publications, the *Verification Yearbook* is an important tool in disseminating information on, and analysis of, not just the CTBT's verification regime, but also nuclear verification issues generally. In 2000, VERTIC initiated and published the Final Report of the Independent Commission on the Verifiability of the CTBT. This document lauded the agreement's verification system, concluding, *inter alia*, that its global capabilities 'constitute a complex and constantly evolving verification gauntlet, which any potential violator will have to confront'. By verifiably banning nuclear weapon test explosions and all other nuclear explosions in any environment, the CTBT helps to prevent further nuclear proliferation, facilitates movement towards the elimination of nuclear weapons and promotes global peace and security.

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