Not Quite Ready and Waiting

The CTBT Verification System

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INTRODUCTION

From 6-8 October 1999, those states that have ratified or signed the Comprehensive Nuclear-Test-Ban Treaty (CTBT) meet in Vienna to debate the future of the treaty. The 'Article XIV Special Conference' has been scheduled because three years after it was opened for signature the treaty still cannot enter into force. One hundred and fifty-four states have signed the CTBT, indicating the support of the vast majority of governments for a verified end to nuclear testing. However, Article XIV of the treaty stipulates that ratification by 44 states with an advanced civilian nuclear capability is necessary for it to enter into force.[1] So far, only 21 of these states have ratified. Among them, China, Israel, Russia and the United States have not ratified, while India, Pakistan and North Korea have not even signed.

Meanwhile, the verification system for the CTBT is not yet ready for entry-into-force as the treaty requires. Since the Provisional Technical Secretariat (PTS) of the CTBT Preparatory Commission (PrepCom) was founded in November 1996, and started working in March 1997, steady progress has been made in setting up the International Monitoring System (IMS) which will be responsible for detecting treaty violations. Yet technical, legal, financial and political problems have precluded full implementation.

Three subsidiary bodies are charged with working out the details of the future CTBT verification regime: Working Group A on administrative and budgetary matters, Working Group B on verification issues, and the Advisory Group on financial, budgetary and associated administrative issues. The task of the Working Groups is to make recommendations which the Preparatory Commission can adopt at its plenary sessions. PrepCom and Working Groups meet three times a year and have been working intensely on the many details of the IMS.

However, many difficulties will have to be overcome to make this novel verification system work. Even though entry-into-force may take longer than originally expected, states parties and signatories, together with the PTS, must ensure that the verification system is established as soon as possible with the best possible capability. This will permit the international community to at least unofficially verify compliance with a treaty which, although not in force, is supported by the vast majority of states and which has given legal standing to a norm against nuclear testing that has been gathering momentum for decades. A fully functioning CTBT verification system will also help refute claims by some that the CTBT is unverifiable and that their state should not sign or ratify.

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[1] The 44 states named in Annex 2 are Algeria, Argentina, Australia, Austria, Bangladesh, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Democratic People's Republic of Korea, Egypt, Finland, France, Germany, Hungary, India, Indonesia, Iran, Israel, Italy, Japan, Mexico, Netherlands, Norway, Pakistan, Peru, Poland, Romania, Republic of Korea, Russian Federation, Slovakia, South Africa, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, United States of America, Viet Nam, Zaire.

THE INTERNATIONAL MONITORING SYSTEM (IMS)

The IMS will consist of 321 monitoring facilities and 16 radionuclide laboratories located in some 90 countries. Some of these already exist, while others will have to be constructed. Four types of stations are to be established—seismological, infrasound, hydroacoustic and radionuclide. One hundred and four, about one third of the total planned, are already reporting to the Prototype International Data Centre (PIDC) in Arlington, Virginia. [2] In many cases, IMS stations use existing infrastructure. Existing facilities to monitor seismic activities are upgraded and certified for use by the IMS. While IMS monitoring facilities will be operated by the states on whose territory they are based, the costs of operation and maintenance are shared between states parties.

The Seismic Network

The principal and most mature verification technique for the CTBT is seismology. Fifty primary and 120 auxiliary seismic stations, distributed world-wide, will be used to detect seismic waves generated by earthquakes, explosions or other phenomena. Primary stations will report continuously and in near real time. Many primary stations consist of up to 20 seismometers, spaced up to two kilometres apart. The network of primary stations, once fully implemented, should be able to detect underground nuclear explosions with a yield greater than one kiloton.[3] If additional information is needed to help clarify the nature of suspicious events, the CTBTO can use data from auxiliary stations. The seismic network will be able to determine the location of an event within an area of a few hundred to a few thousand square kilometres. The seismic network is likely to receive the largest capital investment over the next two years ($US 15.6 million). Seventy-four seismic stations, about half the number planned, are already transmitting data to the PIDC.[4] Thirty-six of these are primary, 38 are auxiliary.

Hydroacoustic Network

Eleven underwater hydroacoustic stations are being established to detect explosions under water or in the atmosphere at low altitude. Six of these will use hydrophones, which have three microphones at each end of 100-kilometre fibre-optic cables, located mostly in oceans in the Southern hemisphere. Five so-called T-phase stations are based on islands in oceans in the Northern hemisphere and will be used to detect seismic signals created when hydroacoustic waves hit land. Hydroacoustic stations are more expensive, but more sensitive than seismic stations. The hydroacoustic network is expected to be able to detect underwater explosions below one kiloton. In broad ocean areas, the location of such an explosion can be determined within an area of less than 1,000 square kilometres. Four hydroacoustic stations are currently reporting to the PIDC, three of which are operated by the US.

Infrasound Stations

Sixty land-based infrasound stations will use sonar to detect atmospheric tests. Although at present infrasound is the least developed of all IMS technologies, the broader frequency ranges now available make it potentially very sensitive. A single station will usually consist of three or four microbarographs spaced about one kilometre apart to increase sensitivity and help determine the location of an event. Infrasound stations should be able to detect a one kiloton nuclear explosion within several thousand kilometres. The coverage of the network will be global and the network by itself will be able to determine the location of a nuclear explosion within an area of 1,000 to over 10,000 square kilometres, depending on regional and weather conditions. Only four infrasound stations are currently reporting, three in the US and one in Australia.

Radionuclide Stations

Eighty radionuclide stations will measure radioactive particles in the atmosphere from atmospheric nuclear tests or underground tests which vent. Forty of these will also be capable of detecting relevant noble gases, such as argon-37, xenon-133 and krypton-85. Sixteen radionuclide laboratories will analyse filters from the stations, plus samples taken by inspectors. While the radionuclide network will be able to detect atmospheric nuclear explosions with a yield of less than one kiloton, its capability to detect underground nuclear explosions will largely depend on the degree of venting of nuclear particles. The network's ability to pinpoint the location of an event is relatively uncertain and will depend largely on the ability to model weather conditions before an event was detected. The main task of the network is not the detection and location of small nuclear explosions but helping distinguish between nuclear and non-nuclear events detected by other verification technologies.

Certification will depend largely on the stations' capability for high sensitivity gamma spectroscopy. In analysing samples the CTBTO may co-operate with the International Atomic Energy Agency, which is located in the same complex in Vienna. The agency is developing its radionuclide sampling capabilities as part of its programme to strengthen nuclear safeguards. Twenty-two radionuclide stations are already collecting samples. Radionuclide stations may be upgraded to have the capability to automatically analyse samples taken and report the findings to the International Data Centre (IDC).

The International Data Centre

Integrating data on a large scale from many different sources poses a completely new monitoring and verification challenge, but is likely to result in great synergies. [5] Thus, while seismic and acoustic detection technologies under specific circumstances might not provide enough conclusive data to reveal whether a large conventional explosion or small nuclear test has taken place, radionuclide stations might help clarify the nature of the event by detecting radioactive particles.

The four different technologies operated by the IMS are able to detect tests in different environments. Seismic monitoring is best at detecting underground tests (although it might also be able to detect atmospheric tests conducted at low altitudes), hydroacoustic technology primarily monitors the oceans and infrasound is most efficient at detecting atmospheric tests (although it may also detect some underwater and shallow underground events).

The IDC, which is being progressively commissioned at CTBTO PrepCom headquarters in Vienna, will receive and process data from all the IMS monitoring facilities. In September 1998 a $US 70 million contract was signed with Hughes Olivetti Telecom Ltd to establish the global communications infrastructure (GCI) for the system and to maintain it over the next ten years. The network will use very small aperture terminals (VSATs) to ensure the swift and secure transport of up to 11.4 gigabytes of data between facilities, the IDC and states parties. By September 1999, seven VSATs were being operated by the IDC at seven IMS stations and five National Data Centres. Eight more installations are planned within a short time-period.

Completing the IMS—The Road Ahead

Phase 4: Initial Testing of IDC Hardware and Software	**March 1999–June 2000**
• Release 2 installed and validated. IDC staff trained on operation	August
• Begin to monitor the Global Communications Infrastructure (GCI) operations	July
• Release 2.1 provided (Y2K fixes)	September
• New Signatory Web Site for IDC Products	November
• IDC assumes full responsibility for daily IDC products	January
• IDC assumes responsibility for seismic location calibration	January
• Release 3 Implementation plan prepared	February
• Release 3 Validation Test at the prototype IDC	June
Phase 5: Full-scale Testing of IDC Hardware and Software	**August 2000–March 2001**
• Release 3 installed and validated and IDC staff trained on operation	August
• Release 4 Implementation Plan prepared	December
• Release 4 Validation Test Plan prepared	December
• Release 4 Validation Test at prototype IDC	January
Phase 6: Validation and Acceptance Test	**April 2001–August 2001**
• Release 4 installed. IDC staff trained on operation	April
• Validation and Acceptance Test begun	May
• Acceptance Test completed	August

Source: IDC Milestones and Schedule for the Completion of the Approved IDC Commissioning Plan, adopted from CTBT/PC-9/1/Annex II, p. 49. Many PrepCom documents can be accessed at http://www.ctbto.org/cgi-bin/ctbto_papers.cgi

[2] The current status of stations reporting to the PIDC can be accessed at http://www.pidc.org. An overview over the planned scope of the IMS is given at http://www.ctbto.org/ctbto/verif.shtml.

[3] Provided they are not 'decoupled' by detonating them in existing underground cavities.

[4] Not all of these are certified as IMS stations.

[5] A good summary of synergies between the different IMS components is given in Larry S. Walker, 'A Systems Perspective of Comprehensive Test Ban Treaty Monitoring and Verification', *Sandia Report*, Sandia National Laboratories, Albuquerque, NM, Nov. 1996, SAND96-2740/UC-700.

Three 'hubs', which receive data collected by different IMS stations in a specific region and send it to the IDC, are completed and are now transmitting data from Germany (European hub), Italy (Atlantic and Indian Ocean hubs) and California (Pacific Ocean hub).

The IDC will make both raw and processed data available to all states parties and is scheduled to take full responsibility for collecting and analysing data from IMS stations in January 2000. By then, the IDC will also begin to distribute its different products— daily 'Fused Event Bulletins', ad hoc event bulletins and analyses of data— to member states. Data from seismic and acoustic stations will be collected in near real time and the information made available within a few hours to states parties. Radionuclide reports will be available with a delay of several days because samples have to be collected, transported and analysed. New technologies currently being developed may help solve this problem.

The extent to which the IDC will make judgements about events is unclear. Yet states without significant national technical and analytical means will naturally look to the IDC for more precise information once initial suspicions are aroused. It will be primarily the responsibility of states parties, in the forum of the Executive Council, to decide whether an event is suspicious enough to warrant an on-site inspection.

ON-SITE INSPECTIONS

In parallel to setting up the IMS, the PrepCom is also laying the groundwork for on-site inspections (OSIs). OSIs may be mandated by the Executive Council of the CTBTO to clarify suspicious events detected by the IMS. The CTBTO will not have a standing OSI inspectorate. Personnel will be drawn from a pool of trained inspectors nominated by member states. This pool needs to be geographically representative and large enough to supply a team of up to 40 inspectors within six days. Inspectors will require a diverse range of skills and the ability to work in harsh climates or terrain. One hundred potential candidates from 39 signatory states have participated in introductory courses conducted by the PTS.

OSI teams will be permitted to spend up to 130 days on an inspected state's territory and will therefore require significant in-country support. Substantial amounts of portable equipment will also be needed, including geophysical and radionuclide equipment, drilling equipment, communications equipment and the means to conduct over-flights. An initial list of equipment for testing and training purposes has been drawn up and future OSI equipment has been divided into seven categories: Seismic Aftershock Monitoring System (SAMS); Gamma Search and Identification Tools; High Resolution Gamma Spectrometer; Xenon Sampling; Separation and Measurement Tool; Visual Equipment; Communications Equipment; and Auxiliary Equipment. Procurement has begun with the purchase of radionuclide search and identification equipment. The PTS estimates that roughly $US 1 million will be spent on OSI equipment in the current fiscal year.

Even though international experts have assisted in developing a concept of operations for an OSI operational manual, progress is slow. The PTS is now taking a more active part in the drafting of the operational manual. International experts are also assisting in identifying elements required for an OSI infrastructure, including an Operations Support Centre, information data bank and an equipment storage and maintenance facility.

STATUS OF IMPLEMENTATION

Many political and technical hurdles will have to be overcome before the IMS is completed and functioning properly. According to Article IV of the CTBT, the IMS must be able to meet verification requirements at entry-into-force, six months after all 44 states required have ratified the treaty. Working Group B of the PrepCom on verification issues anticipated in May 1999 that the IDC would have to fully complete its technical preparations by August 2001, when a final 'acceptance test' will be conducted. Among the issues to be resolved are the following.

Completion of station establishment

The setting up of stations has been hampered by several factors, foremost the slow process of signatures and ratifications. For some stations, new sites had to be found because the co-ordinates provided in the treaty described unsuitable locations (e.g. some turned out to be in the sea or in urban areas). In these cases, alternative locations had to be identified. Another impediment to quick completion is the complex certification process for IMS stations. In order to certify a station, the PTS has to be assured that technical specifications are substantially met and data from the stations can be authenticated. Finally, a proper link to the GCI has to be established.

Calibration of IMS stations has also been slow. Working Group B notes that 'Thus far, sufficient calibration data is available for only a few IMS stations notably in North America and Europe'.[6] Kazakhstan is planning to conduct a large underground chemical explosion in October 1999 which the PTS will use to calibrate some IMS stations. The test will also be used for an on-site inspection exercise.

[6] CTBT/PC-9/1/Annex II, p. 10.

Legal frameworks

Certification of stations has to be covered by an agreed legal framework between the PrepCom and states parties. In order to establish the rights and obligations of both sides, 'facility agreements or arrangements' have to be negotiated between the PTS and member states. These agreements must be approved by every state and by the PrepCom if they differ substantially from a model agreement provided by the Secretariat. Questions about the legal status of the PrepCom prior to entry-into-force have necessitated temporary exchanges of letters to allow work to proceed on vital installations.

By September 1999 the PrepCom had negotiated some kind of agreement (exchange of letters, temporary exchange of letters or facility arrangements/ agreements) that enabled it to start work on 226 IMS facilities. One hundred and seven IMS facilities were not covered by any legal arrangement, preventing the PTS from starting work on construction or necessary upgrades. This lack of legal authority especially affects primary seismic stations, the backbone of the IMS.

So far, only three facility agreements have been concluded, with Canada, New Zealand and South Africa. Since 'only the conclusion of facility agreements will provide the Commission with a solid basis for the implementation of its programme and budget',[7] this represents a major problem. All states that are named in the CTBT as potential IMS station hosts have been provided with draft IMS facility agreements and the Executive Secretary of the PTS has urged those governments that have not responded to the Secretariat's proposal for a facility agreement to do so.[8]

There have also been problems with agreements on Privileges and Immunities for the Preparatory Commission and its officials. Working Group A has urged member states 'to ease this situation'[9] and proposed making such agreements part of bilateral facility arrangements, but there has so far been little progress.

Costs

The 1999 PrepCom budget is $US 74.7 million, compared with $US 58.4 million in 1998. The collection rate for assessed contributions to the budget is approximately 97 per cent, 90 per cent and 71.8 per cent for 1997, 1998 and 1999 respectively. This is a good record compared with most international organisations, but one which needs to be maintained.

Originally, the costs for setting up the verification system were estimated to be $US 150 million for equipment and installation. Annual operating and maintenance costs for the system once completed are estimated to be around $US 85 million annually. These early cost estimates were based on the assumption that entry-into-force would occur within two to three years after opening for signature. But delays in entry-into-force and implementation of the IMS, as well as cost overruns, are likely to lead to much higher initial costs as well as higher operating costs.

The prolonged installation period (now expected to last until August 2001) will drive up initial costs: the additional staff required during the implementation period will have to be paid for a longer time. Only after entry-into-force can the Technical Secretariat start lowering the number of employees (201 as of 3 August 1999) and concentrate on operating the IDC.

Delayed entry-into-force might also drive up long-term operating costs because by the time the complete IMS becomes operational, those stations that have been certified first may need upgrading again.

Another factor driving up costs is the delays caused by states' refusal to exempt PTS investments from local taxes. Working Group B has called on states to make tax exemptions part of facility agreements/ arrangements, but without much success so far.

In addition, initial costs for establishing some stations turned out to be higher than planned. For infrasound stations in non-Antarctic areas, Working Group B noted a 25% increase above initial estimates. There has been a 50% increase in costs for establishing radionuclide and hydroacoustic stations. Working Group B warns that 'it is likely that these higher costs will be confirmed as further stations are considered in detail.'[10]

What the PTS spends its money on

The 1999 budget of the PTS was $US 74.7 million. It included:[11]

- $US 35.5 million or 47.6% for establishing or upgrading IMS stations;
- $US 11.9 million (15.9%) for the IDC;
- $US 9.9 million (13.3%) for establishing the global communications infrastructure;
- $US 1.4 million (1.9%) towards developing an on-site inspection capacity.

[7] CTBT/PC-9/1/Annex IV, p. 8.
[8] CTBT/PC-9/1/Annex III, p. 8.
[9] CTBT/PC-9/1/Annex III, p. 12.
[10] CTBT/PC-9/1/Annex II, p. 2.
[11] 'CTBTO Preparatory Commission concludes its Seventh Session, Budget for 1999 Agreed', Press Release, Preparatory

If entry-into-force is substantially delayed, states might even decide to turn off some stations already reporting to the IDC to save costs. At least one state has already threatened to do so. Some states argue that the PTS' proposed verification Programme is too ambitious and advocate a lower budget, while others believe it to be not ambitious enough and consequently favour a higher budget.[12] A static or shrinking PTS budget is hard to reconcile with the investment required to have the verification system fully functioning by entry-into-force. In any case, costs can only be lowered if entry-into-force occurs.

Confidentiality
The precise handling of the 'confidentiality' provisions in the treaty is still under discussion, but access to IMS data and IDC products is likely to be restricted once the IDC takes full responsibility for collecting and disseminating information. The treaty itself provides only that it is the duty of the Technical Secretariat to 'make available all data, both raw and processed, and any reporting products, to all States Parties' (Article IV paragraph 14.e). But it is unclear whether this excludes the possibility of making part of the information available to others. Seismologists might, for example, be interested in receiving data from the IMS to improve their ability to predict earthquakes and other natural phenomena.

Communications
Delays in releases and installation of new communication software and setting up IMS stations has affected the timetable for inauguration of the global telecommunications infrastructure. Because this is at the core of the verification system, these delays have repercussions for the whole IMS. In July and August 1999 the second of four releases of applications software from the prototype IDC in Arlington, Virginia, USA was installed in Vienna and tested. This was after three months' delay while the US government resolved issues related to exporting the software, even though the IDC infrastructure and personnel were fully prepared for delivery.[13]

In addition, the installation of VSAT communication links is behind schedule. The Executive Secretary of the PTS, Ambassador Wolfgang Hoffmann of Germany, stated at the last PrepCom meeting on 1 September that the installation of VSATs at only 25 IMS stations was planned for 1999, while 79 were budgeted for.[14]

Commission for the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO PrepCom), Provisional Technical Secretariat, Vienna, 16 Nov. 1998.
[12] CTBT/PC-9/1/Annex II, p. 4.
[13] CTBT/PC-9/1/Annex III, p. 9.
[14] CTBT/PC-9/1/Annex III, p. 3.

THE ROLE OF NON-IMS NETWORKS IN VERIFYING COMPLIANCE

If entry-into-force of the CTBT cannot be secured in the near future, the question of how to incorporate information collected outside the IMS might become more important. Formally, the Special Conference in October will not be able alter entry-into-force requirements, because Article XIV only mandates it to 'consider and decide by consensus what measures consistent with international law may be undertaken to accelerate the ratification process in order to facilitate the early entry into force'. But states parties might start considering how additional data can strengthen the CTBT verification regime if the IMS is not likely to be operating as envisaged in the near future, particularly if its global coverage is severely circumscribed.

The IMS is not the only international system capable of detecting and identifying nuclear explosions. Global networks of stations built for scientific purposes, to detect and analyse earthquakes and other natural phenomena, have been in place for decades. These consist of many thousands of seismic stations globally which can also be used to detect nuclear test explosions. In fact, many IMS contributing stations are 'dual use', because they fulfil scientific functions while also being used to verify the CTBT.

Data from non-IMS networks can significantly increase the capability of the IMS to detect small nuclear explosions. Currently, the IMS is designed to detect explosions with a yield of one kiloton and above, which roughly translates into an earthquake of the magnitude of 4 on the Richter scale. While the IMS has already proven that it is able to detect smaller explosions under many circumstances, data from the scientific network of seismic stations has been essential in clarifying the nature and size of recent seismic events.

In August 1997, Russia was accused by the US of having conducted a nuclear test explosion at its nuclear testing site at Novaya Zemlya. The combined data from prototype IDC and scientific stations was able to clarify the event and determine that the allegations were wrong. In fact, an earthquake with the magnitude of 3.5 had occurred at least 80 kilometres away from the test site.[15] Data from scientific stations was also important in separating fact from fiction when India

[15] Hans. E. Hartse, 'The August 16 1997 Novaya Zemlya Seismic Event as Viewed From GSN Stations KEV and GBS', *Seismological Research Letters, vol.* 69, no. 3, May/June 1998, pp. 206-215.

and Pakistan conducted nuclear test explosions in May 1998.[16]

Using data from non-IMS stations to strengthen the verification regime of the CTBT does not pose legal hurdles. Article 27 of the CTBT allows states parties to separately establish co-operative arrangements with the CTBTO to make available to the IDC supplementary data from national monitoring stations that are not formally part of the IMS. Thus, any state could supply data from 'national technical means' (information-gathering capabilities operated by governments) or non-governmental sources (such as university seismometers) if it has concluded such agreements. (Even without such agreements states parties will be able to use information from their own sources to raise a non-compliance issue with the Executive Council of the CTBTO).

Three problems exist in incorporating non-IMS data into the CTBT verification system. First, data from non-certified sources can be manipulated. All IMS stations are equipped with anti-tampering devices to ensure that IMS data can be authenticated. If such devices are lacking, a CTBT member state might refute the validity of non-IMS data on grounds that it could have been manipulated. In practice, this is likely to be theoretical: seismological data usually is cross-checked with data from many different stations. Deriving conclusions on the basis of cross-analyses is one of the main methods of work of seismologists. It would therefore take quite a conspiracy to manipulate data from many stations in order to fabricate a false positive.

The problem of timeliness of data transmission is harder to solve: the IDC will analyse data from seismic and acoustic stations in near real-time, which is important for the political decision-making process. But many scientific stations operate on completely different timelines. Since they are interested in thorough (and much less timely) analysis of data, some seismic networks do not start analysing data until long after an event is detected (for example, the International Seismological Centre in the United Kingdom has a two-year waiting period to ensure completeness of data collection). Obviously, a future CTBTO cannot wait weeks or months before it reports on a suspicious event. This problem might be alleviated by the fact that non-IMS data can only play a supplementary role to data collected and analysed under the official verification system. Since more and more seismic stations are being upgraded for digital data transmission, their ability to report in near real time will gradually improve.

Finally, while data from non-IMS stations might be able to increase the capability to *detect* potential nuclear test explosions, this will automatically add to the burden of *identifying* possible treaty violations. This is a problem of numbers: on average, there are about 25 earthquakes a day—more than 9,000 per year—above the IMS 4.0 Richter Scale/1 kiloton threshold. If the detection threshold is lowered, the number of suspicious events will increase considerably. There are about 87,000 earthquakes annually (or 340 daily) with a strength between 3.0 and 4.0 on the Richter scale. The task of sifting through such an amount of data would pose an enormous challenge to the IDC.[17]

WHAT NOW?

Three years after the CTBT was opened for signature, its verification system is nowhere near ready for entry-into-force. Estimates of when a viable system will be up and running range from 2001 to 2004. Clearly the challenge of establishing such a novel and complex system—involving the collection of data from multiple sources, its smooth and rapid communication to an international data centre and its timely analysis and distribution to states parties—was underestimated.

Besides the inevitable technical problems, there have been legal and political difficulties which are less excusable. After many years' experience with establishing international organisations, legal departments in foreign ministries should have ensured that the legal status of the CTBT PrepCom and the Provisional IDC were properly secured, and that the vast amounts of equipment needed for an international system of this kind were exempted from national taxes and export/import regulations. These lacunae have caused the PTS endless and unnecessary difficulties. They have been compounded in some cases by states being pedantic and over-protective of their national prerogatives in response to the difficulties.

To these legal failures must be added national political churlishness. Even strong supporters of the CTBT, as well as nuclear weapon states which have spent millions on nuclear tests, have in some cases been ungenerous in helping overcome difficulties. While the costs of establishing the system were underestimated, in some respects severely, this is a collective

[16] See Gregory van der Vink et al, 'False Accusations, Undetected Test And Implications for the CTB Treaty,' *Arms Control Today*, May 1998. For an argument why the tests in South Asia were not a valid test for the IMS see Trevor Findlay, 'The Indian and Pakistani Tests: Did Verification Fail?,' *Trust & Verify*, no. 80, May 1998, pp. 1-4.

[17] Data from Mark Andrew Tinker, 'Nuclear Weapons Testing Evolution', http://www.geo.arizona.edu/researchers/tinker/research/nuclear/chap1/

responsibility of the states which negotiated and agreed the treaty. Although there has been a comparatively good record of payment of assessed financial contributions, there has been little flexibility by states parties towards genuinely unforeseen costs.

RECOMMENDATIONS

States parties and signatories must invest more political will and resources into bringing the CTBT verification system to reality. This involves at least the following steps:

1) **greater flexibility by states parties and signatories to resolving legal issues between them and the PTS which are delaying the establishment, upgrading, certification and operation of the networks monitoring stations**
2) **greater willingness by states to accept the costs of operating stations prior to the network becoming fully operational (threats by states to turn off their stations are short-sighted and unacceptable)**
3) **greater willingness to fund the establishment of the verification system at the higher levels required prior to entry-into-force**
4) **more resources should be given to the PrepCom to permit it to handle its heavy workload**
5) **faster progress needs to be made in preparing for implementation of the on-site inspection provisions of the treaty; although such provisions cannot be actually used until entry-into-force, valuable experience could be gained with trial inspections, adding to the future deterrent credibility of such measures**
6) **the need for confidentiality needs to be balanced with the transparency and confidence-building benefits from as wide a distribution as possible of IMS data and analyses.**

Ultimately, of course the verification system will work best when the treaty enters into force. Only then can it be legally employed to inform decisions about compliance and non-compliance of states parties. Only then will all states parties be legally obliged to fully participate and comply. Pressure on the 'hold-out' states, both non-signatories and non-ratifiers, should therefore be increased. If entry-into-force is delayed for too much longer, consideration will have to be given to how the treaty might be applied provisionally or brought into force by some alternative means.[18] Otherwise the verification system for the global regime against nuclear tests, established at great cost and effort, will remain in limbo.

[18] For a summary of options available to states parties see George Bunn, Rebecca Johnson and Daryl Kimball, 'Accelerating the Entry Into Force of the Comprehensive Test Ban Treaty: The Article XIV Special Conference', *A Coalition to Reduce Nuclear Dangers Report*, Washington, DC, Coalition to Reduce Nuclear Dangers, May 1999; John V. Parachini and Tom Birmingham, 'The CTBT Special Conference on Entry Into Force', *The Nonproliferation Review*, vol. 6, no. 3, Spring-Summer 1999.

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