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VERTIC BRIEF • 10 • DECEMBER 2009

B R I E F

Putting the CTBT into practice

Malcolm Coxhead and David Jepsen

VERTIC

Introduction

For much of the last fifty five years the idea of a comprehensive ban on nuclear weapons tests was just that; an idea. In 1996 the idea was given legal form in a treaty: the Comprehensive Nuclear-Test-Ban Treaty (CTBT). The political challenge of achieving the 44 ratifications required for the CTBT to enter into force is yet to be completed; however prospects are looking better than in recent years.

Effective verification is universally regarded as necessary for the CTBT, and work to develop concepts and infrastructure has been underway for quite some time. While building the CTBT's verification infrastructure commenced soon after 1996, research on remote monitoring of nuclear tests started many years before. Today more than 80% of a functioning International Monitoring System (IMS) is in provisional operation, and planning for other verification elements, such as on-site inspection (OSI), is well underway.

If the idea of a comprehensive test ban is soon to become a legally binding reality, the task is at hand of actually implementing all that has been planned for and developed over the years to verify that ban. How will CTBT verification work in practice, and how can we get the best out of the legal framework and the technical infrastructure assembled for it?

In this paper we examine the infrastructure that is being set up to support verification of the CTBT, and consider how States Parties can work to fulfill their responsibility of judging compliance with the Treaty.

The verification concept

The verifiability of the CTBT benefits from the fact that it bans just one type of activity: a nuclear explosion. It benefits also from the fact that, as a rule, nuclear explosions generate large physical effects. The probability that such effects will be detectable at a distance, and will leave lasting local impacts, is high.

The CTBT establishes a network of over 300 stations (the IMS) to monitor for the physical effects of any nuclear explosion. Acoustic signals from any terrestrial explosion are monitored in the earth, in the oceans and in the atmosphere. Radioactive particulates and gases generated by the nuclear reaction are monitored in the atmosphere. Data from these stations must be analysed to pick out events from the background noise. An International Data Centre (IDC) set up by the CTBT identifies events and provides details in the form of bulletins to States Parties. States Parties may also obtain the raw data from IMS stations. States, in turn, operate national data centres (NDCs) to identify and further analyse events that are of interest and possible concern to them.

If a state has serious concerns about a possible nuclear explosion it may request that an OSI is conducted by the CTBT Organization (CTBTO). An OSI would gather information on local impacts of an event, to clarify whether a nuclear explosion has occurred. The report of an inspection team would be made available to all States Parties. The Treaty provides that the CTBTO's Executive Council will address the issue of compliance after reviewing the report of the inspection.

In verifying the CTBT, States Parties are

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not limited to relying on the aforementioned sources of information. The Treaty specifically allows for data from national technical means to be considered. In this respect, it is important to note that IMS data can usefully be supplemented by data gathered by extensive networks of seismic stations that have been established by national governments and institutions. Data from other sources could be valuable also. Satellite imagery, including from public sources, may assist with locating and/or clarifying the nature of an event of concern.

Without prejudice to the right of any State Party to request an OSI, the CTBT provides that States Parties should make every effort to clarify and resolve compliance concerns among themselves, or with or through the CTBTO. The Treaty provides explicitly that clarification may be requested from another State Party, either directly or through the CTBTO's Executive Council. The concerned state may also ask the CTBTO's Director General to assist, including by providing information in the possession of its Technical Secretariat.

Finally, if at any time a State Party has a concern that a nuclear explosion has occurred, it may raise the concern with the CTBTO through its Executive Council, which may take action in response. The nature of that action is not discussed further here, but could include referral of the issue to the UN Security Council.

The IMS

When completed the IMS will consist of 321 monitoring stations and 16 radionuclide laboratories. The 50 primary seismic, 120 auxiliary seismic, 11 hydroacoustic, 60 infrasound and 80 radionuclide stations are distributed as evenly as possible over the globe. Such coverage was designed to enable the detection of a nuclear explosion at any terrestrial location, including remote ocean areas where an attempt to clandestinely test might be considered by a proliferator. Use of the four technologies in synergy offers benefits both for coverage and sensitivity. For example, hydroacoustic coverage in the Arctic and Mediterranean regions is limited, but effective monitoring is possible through seismic detection of signals coupled from the sea to the land. Conversely, hydroacoustic monitors can offer additional data on some inland events.

The IMS is designed to reliably provide high quality data to the IDC (and thus states) in near real-time. The CTBTO and station operators need to operate and maintain equipment to high standards, and down-time is kept very low. Logistical planning to minimise downtime for stations, and recapitalisation to keep abreast of technology development, are part of this. Data authentication is applied at source to provide assurance against tampering. Assurance that data has not been tampered with to hide an event is reinforced also by overlap in the coverage of many stations.

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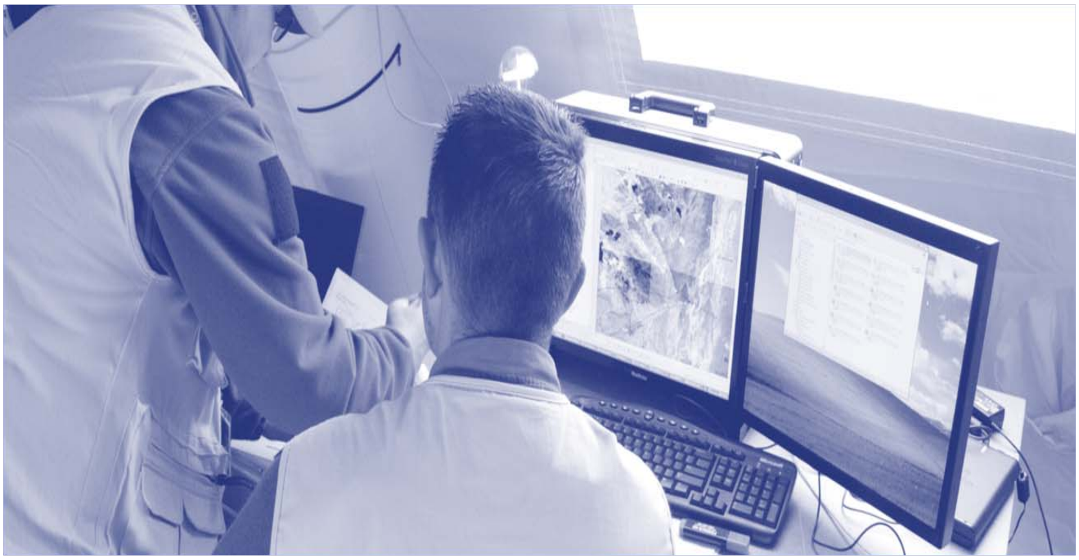

The Field Information Management System, CTBTO on-site inspection exercise, Kazakhstan, 2008

The 2006 event highlighted in particular the value of the noble gas detection as part of the system. Atmospheric modelling has shown that the noble gas capability of the IMS, when fully installed, will enhance the ability to determine whether an explosive event was nuclear in origin.

stations will fill the gaps that do remain. The effectiveness of the IMS has clearly been shown in its ability to detect the North Korean nuclear tests in 2006 and 2009. These events appear to have been quite small when compared to early tests carried out by the *de-jure* Nuclear Weapon States.[1] The 2006 event highlighted in particular the value of the noble gas detection as part of the system. Atmospheric modelling has shown that the noble gas capability of the IMS, when fully installed, will enhance the ability to determine whether an explosive event was nuclear in origin.

The IDC

The IDC analyses all data from IMS stations and provides daily bulletins and associated products to State Signatories on events detected by the IMS. For seismo-acoustic (i.e. seismic, infrasound or hydroacoustic) data automatically calculated solutions can be found in Standard Event Lists that are available to State Signatories one, four and six hours behind real-time. While the accuracy of these lists is inferior to the products that have been fully reviewed by analysts, they provide a view of recent global events in a timely manner. The Reviewed Event Bulletin (REB) product contains a comprehensive list of events and associated features. Evaluation of IDC products for the North Korean tests shows that they contained timely, accurate information that could be used for verification purposes.

Final spectra from radionuclide stations are typically made available to the IDC 48 hours after the end of the measurement day. The IDC runs an automated process on these data to generate radionuclide spectral reports that can be found in the Automated Radionuclide Report (ARR). As with seismo-acoustic data all the spectra are reviewed interactively and the results of these are found in the Reviewed Radionuclid Report (RRR).

A fusion tool to simultaneously view REB and RRR products has been made available to State Signatories. This provides states with the capability to correlate radionuclide spectra of concern with seismo -acoustic events, and so enables them to locate the possible origin of an event of compliance concern.

1. The *de-jure* Nuclear Weapon States are defined in article IX.3 of the 1968 Nuclear Non-Proliferation Treaty, which stipulates 'For the purposes of this Treaty, a nuclear-weapon State is one which has manufactured and exploded a nuclear weapon or other nuclear explosive device prior to January 1, 1967'. These states are: China, France, Russia, the United Kingdom and the United States. Other nuclear weapon armed states are sometimes referred to as *de-facto* nuclear weapon states: the DPRK, India, Israel and Pakistan.

Judgements about compliance following an OSI are formed by States Parties by analysing data provided in reports of the inspection team. Each State would decide for itself how to analyse these data, however it would be logical for many states to maintain the necessary expertise within NDCs.

The IDC also provisionally operates an event screening process. This process, which is mandated in the Treaty, screens out events that are considered to be consistent with natural phenomena or non-nuclear, man-made phenomena. The screening criteria are designed to give high confidence no nuclear explosion would be screened out. The events that are not screened out can be found in the Standard Screened Reviewed Event Bulletin. The radionuclide component of this bulletin contains the Level 4 and Level 5 radionuclide products that may be indicative of a nuclear event.

The role of NDCs

The CTBTO operates the IMS and IDC, and will conduct any OSI, to gather verification data. However the CTBTO is not mandated to form any judgement about treaty compliance. Responsibility for analysing verification data to form judgements about the nature of events, and thus treaty compliance, rests with States Parties.

For this purpose, states operate national data centres (NDCs) to identify and analyse events that are of interest and possible concern to them, and to provide technical assessments to their national authorities. Each state may choose the level of effort that its NDC will put into treaty verification. An NDC may simply examine IDC products, available through subscription or from the IDC secure website or it may set up a capability to examine events of concern itself, or even analyse all raw data itself through a system comparable to that of the IDC.

To help NDCs enhance and/or test their capability, preparedness tests are conducted annually and the results of individual analyses are shared at NDC forums. Other mechanisms to enhance NDC capabilities include collaboration on a bilateral or multilateral basis, and the development of regional data centre arrangements. As we will describe later, strong cooperation among NDCs can make a key contribution to effective verification of the CTBT.

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The approach to verification under the CTBT differs from that under the Chemical Weapons Convention (CWC) or with International Atomic Energy Agency (IAEA) safeguards. In these cases the international agency carries out technical assessment of verification information, and reports to states on treaty compliance.

The CTBT leaves judgements about compliance, and thus on the nature of events detected by the IMS, to States Parties at a technical as well as political level. It calls on States Parties to clarify and resolve matters that may cause concern about non-compliance, either through the CTBTO or among themselves. It refers to NDCs as the places through which states would process and analyse IMS data and IDC products.

Thus NDCs would take on the role of analysing and interpreting verification data that in the case of IAEA safeguards and CWC verification rests with the technical secretariat. This presents both a problem and an opportunity for CTBT States Parties. It means that states need to establish and operate NDCs, and arrange for cooperation among them. It also means that states are free to decide how they should do this. Cooperation among NDCs has been promoted by the CTBTO Preparatory Commission to build national capacity. As entry into force approaches, a focus will also be needed on how the task of verifying the CTBT can be promoted through NDC cooperation.

OSIs

If concerns arise about CTBT compliance, a state may request that an OSI is conducted by the CTBTO to investigate an event. If approved by the Executive Council, the CTBTO would dispatch a team of up to 40 inspectors to gather information in the area that the event took place. The inspection is carried out in a designated area of up to 1000 square kilometres, over a period of up to 130 days. An OSI could be called for any possible nuclear explosion, however the more likely scenario of an underground nuclear explosion is the focus of treaty provisions.

Depending on what information is available to an inspection team on the location and nature of the event that triggered the inspection, initial activities on the ground would include a reconnaissance of the inspection area to identify areas of several square kilometres or less for closer investigation. Visual observation from the ground and air would aim to identify artefacts of an underground nuclear explosion such as equipment or works that may be associated with a test, as well as evidence of ground disturbance such as cracks. Survey of gamma radiation levels, and sampling for radioactive gases or particulates, would also be undertaken. Multispectral imaging could also complement visual observation by identifying anomalous surface features such as ground or vegetation disturbance. It will also be important to begin as soon as possible to monitor for shorter-lived phenomena such as seismic aftershocks. An early priority will be to place seismic monitors to listen for aftershocks, generated by collapse of an explosion cavity. Satellite imagery, including that available from open sources, could be very valuable for focusing inspection activities.

Guided by initial search results, the inspection team can use a range of geophysical techniques (ground penetrating radar, magnetic and gravitational field mapping) to search for and characterise subsurface anomalies. Active seismic techniques and electrical conductivity measurements could be used to identify and image such anomalies, including a deep explosion cavity. Geophysical techniques are potentially powerful, but are not well suited to wide-area searches. Information to closely locate the triggering event, including from national technical means could play an important role.

The detection of radioactive gases and particulates consistent with a nuclear explosion would provide clear evidence of non-compliance. Ideally these would be gathered by drilling to obtain samples from an explosion cavity.

Reports of the inspection, which could include numerous technical findings, would be made available to all States Parties for their analysis. The Executive Council would review the reports, for which purpose Council members would need to be briefed by technical agencies

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such as the National Data Centre.

The range of techniques available to inspectors should find signs of an underground test that has not been fully contained. Any surface expression of a nuclear explosion, such as ground cracking, release of radioactive gases or particulates, or the presence of test-related equipment or works ought to be detectable.

If a violator has succeeded in fully containing a nuclear explosion, and in hiding associated cultural artefacts, the search could be more difficult. However, if additional information, such as satellite imagery, can give an accurate location, a deep cavity could be located with geophysical techniques.

Would OSIs be used?

It has been noted that the CTBT's requirement that an OSI is approved by at least 30 of the 51 members of the Executive Council could present a roadblock to the use of this aspect of the Treaty. It is the case that 'anywhere-anytime' inspection mechanisms under multilateral nonproliferation and disarmament instruments have not been well used. However, issues surrounding a decision on CTBT OSI could be materially different to those affecting other types of 'anywhere-anytime inspection'. In particular, objective verification information from the IMS and IDC would be likely to be available to support a decision. Even if the meaning of such information may be subject to interpretation, the fact of an event of possible concern, and needing investigation, should be clear.

It is likely that any event which could be the trigger for an OSI request would have been detected and located by the IMS and IDC, which are tools of routine verification for the CTBT. Additional information could be offered by States Parties, to support the inspection request, and to help to define the character of the event. This is different to the situation with CWC challenge or IAEA Special Inspection. There, a request is more likely to rely on information primarily from national technical means (and not from routine verification activities) to demonstrate that something of concern exists, and could thus be subject to political controversy.

The IMS is designed to provide verification data that is objective in character. Measurements of the seismic, radionuclide, infrasound or hydroacoustic signals are made by sensors whose location and specifications are subject to multilateral agreement. Authentication signatures are generated for data at its source to provide assurance against tampering. Most events of interest for CTBT would be detected by several IMS stations, usually located in different countries.

If an event of concern is detected by several IMS stations, the fact of the event should not be in dispute, and the risk that a corresponding OSI request is abusive in intent should be small. What may not be settled is how to interpret the available data. Differing explanations might be proffered for an event; however there would be an impetus to find an explanation that is satisfactory. For seismic, infrasound and hydroacoustic data, any differences would revolve around the location (including depth), size and explosive character of the event. If radionuclide data consistent with a nuclear explosion is available, the case for an OSI would be considerably strengthened (if such clarification is still considered necessary).

Detection, clarification and deterrence

Two basic objectives of verification are to detect non-compliance, and to deter possible non-compliance by creating the risk that it will be detected. Under the CTBT detection of non-compliance should be understood as having two parts. The first is the technical function of detecting an event; the second is analysis of the event to clarify its nature. The verifiability of the Treaty is often spoken of in terms of ability to detect a nuclear explosion, especially smaller explosions. However, the day-to-day challenge of CTBT verification is not the ability to detect an event, but the task of identifying an event of concern among the noise of other (mostly natural) events.

Our planet is a seismically active place. Events with a seismic magnitude similar to that of a small nuclear test occur many times each day. To identify a possible nuclear test among these requires effective screening processes to pick out seismo-acoustic events showing characteristics of an explosion, and if possible to relate an event to a detection of particular radionuclides. The frequency of events that form the background noise, whether from natural or man-made sources, increases as their size decreases. Quite small events could be detected by IMS stations in many places, but picking these from the background, and gathering enough information to characterise them, is what sets limits for its capability.

The IMS and the IDC carry out the first step of detecting and screening events to identify those that may require further investigation, and report around 100 such events each day (some states may do this screening also). The step of more closely analysing and forming judgments on the nature of events is the task of NDCs. As has been mentioned, how states choose to

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Inspector on watch, CTBTO on-site inspection exercise, Kazakhstan, 2008

Although no explicit mechanism for it is included in the CTBT, technical cooperation among NDCs to clarify the nature of the many detection events that occur each day should be an important way for States Parties to fulfill their verification role.

do this analysis is up to them. In most cases the analysis would be a straightforward technical procedure, but for some events additional efforts may be needed to clarify its nature. This could include use of the consultation and clarification provisions in the CTBT, or even an OSI.

If the CTBT's verification mechanism is to be effective in deterring non-compliance, the processes of detecting and screening to identify events of possible concern, and then of clarifying their nature need to work well. Infrastructure for detecting and screening events, in the form of the IMS and the IDC, is well on its way to completion and is performing well. Ongoing work to clarify the nature of events is what will be needed after entry into force of the Treaty to make the system work. Mostly this work will be done by States Parties through their NDCs, but should also include appropriate use of consultation and clarification and of OSI.

Exercising the Treaty

If data from the IMS and IDC clearly indicates that an event with the characteristics of a nuclear explosion has taken place, and locate it in a particular State Party, the international community might, in principle, conclude that the state has acted contrary to Treaty obligations. However such a conclusion would probably require additional evidence.

As mentioned, the CTBT's consultation and clarification, and the OSI mechanisms provide ways to obtain additional information. However, there is a risk that use of these mechanisms could be eschewed due to political sensitivities. Related provisions under the Chemical Weapons Convention have not been used. It is important however for the effective verification of the CTBT that their potential is able to be realised.

Ongoing and collegiate activity by NDCs to analyse ambiguous events would help to establish as normal the objective of clarifying the nature of events, and lead naturally to the use, where appropriate, of the clarification mechanisms that are explicit in the Treaty. Such activity could also help to establish a sound, and widely accepted technical case for use of Treaty mechanisms such as OSI. This could be contrasted with a situation where NDCs work largely alone, and where concerns about an event may appear to arise “out of the blue”.

The use of the CTBT’s clarification provisions, most likely on a bilateral basis, could also help to address concerns that have sometimes been raised about so called low-yield tests. Measures could be developed between concerned states to give confidence that nuclear experiments have not resulted in a nuclear explosion. While the CTBT’s OSI mechanism could, in principle, be invoked to investigate such concerns, states may be more comfortable with bilateral arrangements.

NDC cooperation

Effective implementation of the injunction in Article IV of the CTBT that States Parties should make every effort to clarify and resolve compliance concerns among themselves will be at the heart of day-to-day verification of the Treaty. Although no explicit mechanism for it is included in the CTBT, technical cooperation among NDCs to clarify the nature of the many detection events that occur each day should be an important way for States Parties to fulfill their verification role.

As has been mentioned, events with some of the attributes of a nuclear explosion are detected by the IMS and IDC quite frequently. Often it would be easy for States Parties, through their NDC, to determine the likely nature of an event – and thus dismiss it as not relevant to CTBT compliance. At other times additional views or information might be needed. Such assistance could, at one end of the scale, be afforded through cooperation among NDCs. Use of Treaty mandated clarification procedures would be a further option. At the other end of the scale an OSI may be judged necessary.

As entry into force approaches, CTBT States Parties, working through their NDCs, should develop processes of cooperative engagement to examine events of possible concern that are detected by the IMS (or by other means), as well as processes for studying the nature of such events in general. Such cooperation among NDCs should not constrain the ability of any CTBT State Party to exercise its rights (or obligations) as it sees fit. But by working together the effectiveness of CTBT verification would certainly be enhanced. Routine interaction should help to maintain the capacity of NDCs, and allow a coordinated and technically sound response if an event of serious concern is detected.

The risk that a detected event poses might be assessed from two factors: to what extent the event possesses characteristics similar to a nuclear explosion; and the availability of an alternative explanation for the event. If an event is assessed as presenting some risk, but not enough to warrant some action under treaty provisions, States Parties could cooperate through NDCs to study it. The results of such studies would help NDCs to build models against which future events could be assessed. If the risk is assessed as higher, States Parties could (individually or in cooperation) use the consultation and clarification provisions of the CTBT to seek more information. Again, the results could be examined cooperatively by NDCs. If States Parties consider that the risk posed by an event may warrant the request for an OSI the existence of cooperative arrangements among NDCs could help to ensure the request has a sound technical basis.

Effective implementation of the injunction in Article IV of the CTBT that States Parties should make every effort to clarify and resolve compliance concerns among themselves will be at the heart of day-to-day verification of the Treaty.

Conclusions

The CTBT presents a model for verification that is unlike other multilateral arms control instruments. As preparations have been made for the Treaty's entry into force, focus has naturally fallen on the development of verification infrastructure such as the IMS, IDC and OSI. National Data Centre capacity has also been encouraged. Concepts for the integrated use of all these components to verify a CTBT that is in force has been less in focus. The responsibility for effective integration will not lie with the future CTBT Organiza-

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tion, but with its States Parties. As entry into force of the CTBT approaches, states need to consider how they will do this.

The purpose of the IMS and IDC is to gather and screen monitoring data to identify events. Many events are identified each day and notified to states. The key role of NDCs is therefore to sift the events further to find any that might have characteristics of a nuclear explosion. To then go the next step, and clarify the nature of an event may not be easy. The CTBT provides for formal clarification mechanisms, including OSI. But informal mechanisms for states to consult on the nature of detected events are possible also–and their use could strengthen the exercise of the formal mechanisms when this may become necessary.

Glossary

AAR	Automated Radionuclide Report
CTBT	Comprehensive Nuclear-Test-Ban Treaty
CTBTO	Comprehensive Nuclear-Test-Ban Treaty Organization
CWC	Chemical Weapons Convention
IAEA	International Atomic Energy Agency
IDC	International Data Centre
IMS	International Monitoring System
NDC	National Data Centre
OSI	On-Site Inspection
REB	Reviewed Event Bulletin
RRR	Reviewed Radionuclide Report

Editor, design & production
Andreas Persbo

Printing and distribution
Electronic distribution only. May be printed on demand. Best viewed on double side print in full colour.

Parts of this paper were contributed by Malcolm Coxhead to, and appear in, the International Commission on Nuclear Non-proliferation and Disarmament Report, 'Eliminating Nuclear Threats: A Practical Agenda for Global Policymakers', available at www.icnnd.org

About this paper

This brief examines the practical application of the various elements of the CTBT verification regime, their interplay, and suggests a model for technical interaction among States Parties to facilitate verification.

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FUNDERS, *as of 1 December 2009*
Chatham House
Ford Foundation
Netherlands Ministry of Foreign Affairs
Norwegian Ministry of Foreign Affairs
Ploughshares Foundation
Sandia National Laboratories
UK Foreign & Commonwealth Office
US State Department

ISSN 0966-9221.