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PREPARATORY COMMISSION
preparatory commission for the comprehensive nuclear-test-ban treaty organization

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Basic Facts: Booklet 3

The Global Verification Regime and the International Monitoring System

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Basic Facts:
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International Monitoring System
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Basic Facts 3

The Global Verification Regime and the International Monitoring System

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1 Introduction

Under the terms of the Comprehensive Nuclear-Test-Ban Treaty, a global verification regime to monitor compliance with the Treaty must be operational at entry into force. Such a verification regime must be capable of detecting nuclear explosions in all environments - underground, in water and in the atmosphere. Establishing this regime is the main activity of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization.

Main elements of the verification regime

The verification regime consists of the International Monitoring System (IMS) and a consultation and clarification process to clarify and resolve matters concerning possible non-compliance with the basic obligations of the Treaty. States Parties also have the right to request an on-site inspection to clarify whether a nuclear weapon test or any other nuclear explosion has been carried out in violation of the Treaty, and to gather facts which might assist in identifying any possible violator. Lastly, confidence-building measures serve the dual purpose of helping to resolve any compliance concerns arising from possible misinterpretation of verification data relating to chemical explosions, such as, for example, large mining explosions, and assisting in the calibration of stations that are part of the IMS. The verification regime thus acts as a powerful deterrent to any would-be violators.

The building and operation costs of the monitoring stations (except for auxiliary seismic stations) are paid for by the Organization.

2 The International Monitoring System

The International Monitoring System (IMS) is a network of monitoring sensors which search for, detect and provide evidence of possible nuclear explosions to States Parties for verification of Treaty compliance. It consists of 321 monitoring stations and 16 radionuclide laboratories that monitor the Earth for evidence of a nuclear explosion. The location of stations are set out in Annex 1 to the Protocol of the Treaty. In order to provide uniform coverage of the globe, many stations are in remote and hard-to-reach areas. This poses engineering challenges unprecedented in the history of arms control. The system employs four verification methods, utilizing the most modern technologies available.

MAP OF THE INTERNATIONAL MONITORING SYSTEM, A NETWORK OF 337 MONITORING FACILITIES, AS LAID OUT IN THE TREATY

3 Monitoring Technologies

When a nuclear device is detonated, two basic phenomena occur - energy is released and physical products are created. The energy interacts with the environment and propagates as sound vibrations, through the solid earth, ocean or atmosphere. The physical products created are released into the surrounding medium and can leak into the atmosphere from underground or underwater. The variety of radioactive particles and gases released during an explosion differ in physical and chemical properties. Most are short-lived, decaying within seconds to months, but some last much longer. They are generally the same as those produced by a nuclear power reactor, but occur in different relative abundance.

The IMS uses seismic, hydroacoustic and infrasound monitoring technologies to detect the transient signals created when the energy is released in underground, underwater and atmosphere environments, respectively. Radionuclide monitoring technologies collect and analyze air samples for evidence of the physical products created and carried by the winds. Seismic, hydroacoustic and infrasound, or the wave technologies, all utilize sensors which record signals from explosions and naturally occurring events in the form of digital waveforms. These digital waveforms or timeseries provide diagnostic information to detect, locate and characterize the energy source. Radionuclide technology is based on air samplers which collect and analyse atmospheric particulate matter deposited on collection filters. The analysis of the radionuclide content uniquely confirms the fact of a nuclear explosion.

Seismology

The seismological component of the monitoring system detects and locates seismic events. The seismic network is composed of 50 primary stations, which send their data in real time to the International Data Centre (IDC) in Vienna, and 120 auxiliary stations that make data available upon request from the IDC. The principal use of the seismic data in the verification system is to distinguish between an underground nuclear explosion and the numerous earthquakes that occur around the globe.

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There are two types of seismic stations:

1. Three-component stations have sensors at a single site to measure the three components of the waves (up/down, east/west and north/south) caused by seismic events, including earthquakes and explosions.

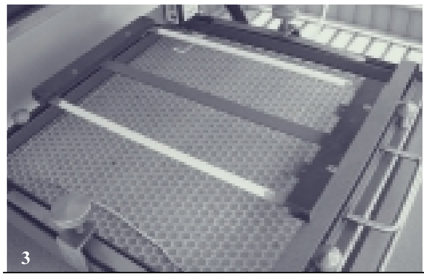
2. Array stations are sets of between 9 and 25 geometrically arranged seismic sensors distributed over an area. Stations built by the CTBTO Preparatory Commission usually have a distribution diameter of three kilometres, but the sensors of older 'legacy' stations incorporated into the IMS can be distributed over an area of up to 500 square kilometres. Seismic array stations have an enhanced detection capacity and can independently measure the direction of and distance to the source of an event.

Hydroacoustics

Hydroacoustic monitoring detects acoustic waves produced by natural and man-made phenomena in the oceans. The hydroacoustic network comprises eleven stations and covers the world's oceans, which make up 70% of the surface area of the earth. Few stations are required because of the very efficient propagation of acoustic energy in the oceans.

The network consists of two kinds of stations: hydrophone stations and T-phase (seismic) stations. The six hydrophone stations use underwater microphones (hydrophones) which capture signals underwater and then transmit them via cable to the shore station. Hydrophone stations are extremely sensitive and can pick up acoustic waves from underwater events, including explosions, occurring very far away. However, such stations are expensive to install and costly to maintain, so the network also includes five T-phase (seismic) stations. These stations are located on oceanic islands and use seismometers to detect the acoustic waves that are converted to seismic waves when they hit the island.

The data from the hydroacoustic stations are used in the verification system to distinguish between underwater explosions and other phenomena, such as submarine volcanoes and earthquakes, which also propagate acoustic energy into the oceans.



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MONITORING TECHNOLOGIES:
1. LAYING CABLE FOR HYDROPHONE STATION
2. NOISE REDUCING ARRAY, INFRASOUND STATION
3. AIR FILTER PAPER, RADIONUCLIDE STATION

Infrasound

The infrasound network of 60 stations uses microbarometers (acoustic pressure sensors) to detect very low-frequency sound waves in the atmosphere produced by natural and man-made events. These stations are arrays of between four to eight sensors which are separated by between one and three kilometres. The IDC uses infrasound data to locate and distinguish between atmospheric explosions, natural phenomena such as meteorites, explosive volcanoes and meteorological events, and man-made phenomena such as re-entering space debris, rocket launches and aircraft in supersonic flight.

Radionuclide

The radionuclide network of 80 stations uses air samplers to detect radioactive particles released from atmospheric explosions or vented from underground and underwater explosions.

The relative abundance of different radionuclides in air samples can distinguish between materials produced by a nuclear reactor and a nuclear explosion. IMS radionuclide laboratories analyse samples that are suspected of containing radionuclide materials that may have been produced by a nuclear explosion. The presence of specific radionuclides provides unambiguous evidence of a nuclear explosion. Half of the stations in the radionuclide network will also have the capacity to detect noble gases. The presence of noble gases is particularly important in detecting releases from underground explosions.

4 Facility Agreements

Facility Agreements are bilateral agreements which grant the Preparatory Commission the legal and administrative authority to work on State territory to establish, upgrade or provisionally operate and maintain monitoring stations. An interim exchange of letters may be concluded as an interim arrangement in lieu of a Facility Agreement which allows the Preparatory Commission to begin work with appropriate local institutions while the Facility Agreement is being finalized.

SITE SURVEY FOR SEISMOLOGICAL STATION, SAUDI ARABIA

5 Establishing a Monitoring Station

Site survey

The locations of the monitoring stations listed in Annex 1 to the Protocol to the Treaty need to be verified by site surveys to ensure that they are suitable for establishing or upgrading and operating stations as part of the International Monitoring System (IMS). The survey looks at the site's physical and environmental characteristics, the availability of infrastructure such as, for example, roads and power, and technical personnel.

In the case of seismological stations, background (seismic) noise such as ground vibrations caused by wind, surf, traffic, industrial activity and so on, is measured to see if a site is quiet enough for a station to be a good detector of seismic events such as earthquakes and explosions. The geological conditions are checked to locate good bedrock for the sensors or to determine the depth to which drilling is necessary to find such good bedrock.

With hydroacoustic stations, the velocity of sound in the ocean is measured as a function of depth to establish the location of the sound fixing and ranging (SOFAR) channel, the low-velocity channel that produces efficient sound propagation. The nature of the seabed is assessed to establish how the cable will be laid to bring the sensor data to the shore facility.

For infrasound station sites, the noise caused by wind turbulence is measured to establish if a site is quiet enough for a station to detect signals from atmospheric explosions. Sites in dense forests are sought, as the trees tend to reduce wind turbulence.

In the case of radionuclide stations, natural and man-made radioactivity at the site is measured to establish the background against which accurate measurements can be made of wind-borne radionuclides. Meteorological conditions are also studied to ensure that the station will be in the direct path of the winds.

If the geographical coordinates listed in Annex 1 to the Protocol to the Treaty are found to be unsuitable for a station, an alternative site will be sought as near as possible to that specified in the Treaty.


Existing stations

For stations that existed prior to their selection for the IMS, the equivalent of a site survey, including upgrade requirements, is undertaken using information available from the operators of these stations. (The survey is known as a Parent Network Station Assessment (PNSA)).

Site preparation

To prepare the site for the installation of equipment, civil works are usually needed, based on the findings of the site survey. Site preparation may include the construction of shelters for instruments, the establishment of a suitable power supply, the erection of antennas or the laying of cables for communicating data from the sensors to the central site, and security fencing.

For seismological stations, site preparation may include the drilling of boreholes to reach solid bedrock. For hydroacoustic stations, it will include any civil work needed for the shore facility, but not for the sensors and cables at sea, for which work will be done during station installation. For radionuclide stations, the housing for the detector systems needs to be built. Site preparation will usually include the preparation of the mounting for installing a special satellite communications antenna.

Equipment procurement

The Commission has approved a set of technical specifications that IMS stations must meet. All equipment for installing or upgrading a station is procured in accordance with the provisions of the Financial Regulations and Rules of the Commission. In principle, the same procurement procedures are followed for the upgrading of existing stations or the building of new IMS stations. In the case of an upgrade, care is taken to ensure that new equipment will be compatible with existing equipment.

Installation

Equipment is usually shipped directly from the manufacturer to the site for installation. It can be installed by the supplier, a knowledgeable local institution that is likely to operate the station, or a third party contracted by the Preparatory Commission. During installation, the manufacturer provides on-site training on equipment maintenance and operation to the designated station operator.

An important aspect of the installation of a station is the testing and evaluation of the equipment to ensure that it functions reliably and produces high-quality data. This task can take several months**.**

EQUIPMENT INSTALLATION SEQUENCE, SEISMOLOGICAL STATION, KAZAKHSTAN

6 Certification Process

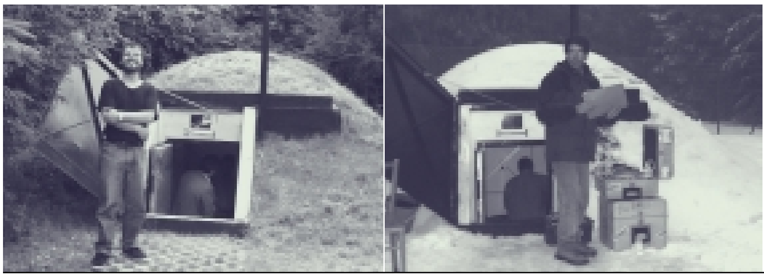
Once a station has been installed and tested, it must be certified before it can become part of the IMS network. Certification criteria ensure that the site is acceptable and that the equipment conforms to IMS station and communications specifications. Certification also ensures that the appropriate data and communications protocols are implemented, and that data authentication devices, including anti-tampering devices, are installed. The station interface to the Global Communications Infrastructure must be demonstrated to work properly, operational practices must be consistent with IMS standards, and data availability must be within an acceptable range. Certification consists of three main phases.

Firstly, all information on the station's technical characteristics, operating environment and performance history must be assembled. For existing stations, this information will be requested from the station operator. For new stations, the performance characteristics will be established during the testing and evaluation phase of the installation.

The certification team then visits the station to inspect it and to have discussions with the managers and operators. The team is composed of two to three Commission staff proficient in the verification technology concerned.

Lastly, the certification team evaluates all the relevant information and forwards its recommendation on certification to the Certification Group, which is chaired by the Director of the IMS Division and composed of senior officers from the IMS and IDC Divisions and other technical experts of the Preparatory Commission as required, for a decision on whether the station can be certified. The notification of certification is sent to the host or responsible State, and reported to Working Group B.

Implicit in the certification process is long-term monitoring and quality control to ensure that a station maintains the standards for which it has been certified.



7 Post-Certification Phase

Once established and certified as meeting all technical requirements, monitoring stations are operated by local institutions under contract with the Preparatory Commission. The post-certification Operation and Maintenance (O&M) contract between the Preparatory Commission and the station operator makes reference to the station operations manual, which will have a station-specific annex defining the standards to be met in station operation. This information will include items such as station inventory, preventive maintenance schedules, procedures for reporting problems, availability of spare parts, list of contacts, etc.

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