COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION (CTBTO): VERIFICATION REGIME

Established: 19 November 1996
Duration: Indefinite
Number of Signatories: 183
Number of Ratifications: 164

The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO Preparatory Commission) is an international organization established at a meeting of States Signatories to the Treaty on 19 November 1996.

The Verification Regime: In accordance with the provisions of the Comprehensive Nuclear-Test-Ban Treaty (CTBT), a global verification regime must be operational at entry into force to monitor compliance with the Treaty. The verification regime must have the capacity to detect nuclear explosions in all environments – underground, underwater, and in the atmosphere. The main activity of the CTBTO Preparatory Commission is to establish this global nuclear explosion alarm system.

The global verification regime comprises the International Monitoring System (IMS) and a consultation process to clarify and redress violations of the Treaty. If a State Party suspects a violation has occurred, that State has the right to request an on-site inspection to clarify whether a nuclear explosion has in fact been carried out. The consultation and clarification process also involves the use of confidence-building measures that serve the dual purpose of assisting in the calibration of IMS stations as well as aiding in the resolution of any compliance concerns arising from a State's possible misinterpretation of verification data relating to chemical explosions, such as large mining explosions.

The International Monitoring System (IMS): When completed**,** the International Monitoring System (IMS) will comprise a network of 337 monitoring stations and 16 radionuclide laboratories that monitor the earth for evidence of nuclear explosions in all environments. This network of monitoring sensors search for, detect, and provide evidence of nuclear test explosions. The system uses four verification methods that employ the most modern technology available. Information collected by IMS stations is sent in real time to the International Data Center (IDC) in Vienna for further analysis. Once the data is analyzed, the IDC distributes data products to Member States.

Evidence of a nuclear explosion**:** Two basic phenomena occur when a nuclear device is detonated: the release of energy and the creation of physical products. Energy released from the explosion interacts with the environment and propagates through the earth as sound vibrations. The physical products created by the nuclear explosion are released into the surrounding medium and can escape into the atmosphere from underground or underwater. The radioactive particles and gases released during a nuclear explosion mostly decay within seconds to months, but some last much longer.

Monitoring technologies: Seismic, hydroacoustic, radionuclide and infrasound stations are employed to monitor the underground, underwater, and atmosphere environments, respectively. These stations use wave technologies to detect the transient signals created when energy released from a nuclear explosion propagates through the earth as sound vibrations. The data collected from these stations, in digital waveforms or timeseries, provide diagnostic information to detect, locate, and characterize the energy source.

In order to determine whether an event registered by an IMS station is the result of a nuclear explosion, radionuclide technology is used to collect and analyze air samples for the physical products created and carried by the winds. Radionuclide stations can detect radioactive debris released from atmospheric explosions or vented by underground or underwater nuclear explosions. Radionuclide monitoring is achieved through the collection and analysis of air samples containing atmospheric particulate matter deposited on collection filters. Evidence collected by the radionuclide facilities can confirm the occurrence of a nuclear explosion.

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Seismology: Composed of 50 primary stations and 120 auxiliary stations, the seismological component of the IMS detects and locates seismic events. The primary stations send their data to the IDC in real time, while auxiliary stations make their data available upon request from the IDC. Seismic stations in the IMS collect data used to distinguish between underground nuclear explosions and naturally occurring earthquakes.

The seismic network consists of two types of seismic stations; three-component stations and seismic array stations. With sensors placed at one site, three-component stations measure the three components of the waves (up-down, east-west, and north-south) caused by seismic events, such as earthquakes and explosions. Array stations are composed of between 9 and 25 geometrically arranged seismic sensors. The enhanced detection capacity of seismic array stations enables independent measurement of the direction and distance to the source of a seismic event.

Hydroacoustic: The IMS employs hydroacoustic technology to detect acoustic waves produced by natural and man-made phenomena propagated through the world's oceans. Comprised of 11 stations, the hydro-acoustic network covers the entirety of the earth's oceans. Because acoustic energy propagates through the ocean in an extremely efficient manner, very few stations are required in the hydroacoustic network.

The hydroacoustic network consists of six hydrophone stations and five T-phase (seismic) stations. Hydrophone stations use underwater microphones (hydrophones) that transmit captured signals via trunk cable to the shore facility. While extremely sensitive and very effective in picking up signals from underwater events at large distances, the installation of such stations is expensive and maintenance can be quite costly. Therefore, the hydroacoustic network also includes five T-phase monitoring stations. Located on oceanic islands, T-phase stations employ seismometers to monitor and record seismic waves that have been converted from acoustic waves upon coming into contact with land.

Infrasound: IMS infrasound stations use microbarometers (acoustic pressure sensors) to monitor low frequency sound waves in the atmosphere. The infrasound network consists of 60 stations located in 35 countries around the world. IMS infrasound stations use arrays of four to eight sensors that are located one to three kilometers apart. The sensors detect changes in atmospheric pressure produced by infrasonic waves. Infrasonic waves are the result of natural and man-made phenomena such as exploding volcanoes, meteorites entering the atmosphere, re-entering space debris, rocket launches, aircraft in supersonic flight, and mining and large chemical explosions.

One of the principle uses of infrasound data is the prompt detection of an event, which enhances the potential for a successful on-site inspection in case of a nuclear explosion. Infrasonic waves are characterized by the ability to travel long distances and get around obstacles with little dissipation.

Radionuclide: The radionuclide network consists of 80 stations that employ air samples to detect the presence of radioactive particles resulting from atmospheric explosions. Half of the radionuclide stations will be equipped with noble gas detection systems. Noble gases, such as xenon-133, leak into the atmosphere during an underground or underwater nuclear explosion. The Provisional Technical Secretariat (PTS) utilizes atmospheric transport modeling technology to determine the source and timeframe of a possible nuclear test by evaluating backtracking calculations, which identify possible source regions for air samples collected by radionuclide stations.

After a very brief high-neutron flux irradiation process, nuclear fission and activation products from a nuclear explosion are released into the atmosphere. Since there is no time for decay, the composition of these radionuclides is different from that of other sources, such as hospitals, nuclear accelerators and reactors. The radionuclide network is the only component of the IMS that can unequivocally identify a nuclear explosion if radionuclides are detected in the atmosphere.

Establishment of a monitoring station: The IMS requires many stations located in remote and inaccessible parts of the globe and thus poses engineering challenges unprecedented in the history of arms control. The 337 IMS stations and 16 radionuclide laboratories in about 250 different locations in nearly 90 countries will provide roughly equal global coverage. International monitoring experts designed the IMS during the CTBT negotiations to have the capability to detect nuclear explosions anywhere in the world with at least a one-kiloton yield, provided the weapons were tested without efforts to hide their yields.

Locations listed in Annex I to the Protocol of the Treaty must be verified by site surveys to ensure that they meet the stringent requirements for establishing or upgrading and operating stations as part of the IMS. During each site survey, experts evaluate the physical and environmental characteristics of the site, the local infrastructure, and available technical personnel. If a station existed prior to its selection for the IMS, officials from the PTS conduct the equivalent of a site survey, gathering information from the operators of the station and requesting necessary upgrades.

The CTBTO Preparatory Commission has approved a set of technical requirements that all IMS stations must meet. The provisions of the Financial Regulations and Rules of the Commission specify procedures for the installation or upgrading of monitoring equipment. Uniform equipment specifications ensure that in case of an upgrade, new equipment will be compatible with existing equipment.

***Certification of IMS stations*:** Once the installation and testing period of a station is completed, a certification process will determine whether it can become part of the IMS. The certification process ensures that the site is acceptable and that the equipment meets IMS station requirements and communications specifications. Certification criteria require that the station interface to the Global Communication Infrastructure (GCI) works properly, and that operational practices are consistent with IMS standards. Data availability and timeliness must also be within a predetermined range.

The certification process occurs in three phases. First, all data regarding the station's technical characteristics, operating environments, and performance history must be gathered. Next, the PTS sends out a certification team to inspect the station and discuss any potential issues with the managers and operators of the station. Finally, the certification team evaluates all the necessary information and informs the Certification Group at the IDC of its recommendations. Chaired by the Director of the respective IMS Division, the Certification Group makes the final decision on whether a station can be certified. The Group then sends the notification of certification to the host or responsible State and reports the information to Working Group B.

Upon completing the certification process, all monitoring stations are operated by local institutions under contract with the CTBTO Preparatory Commission. As of April 2015, 42 primary seismic stations, 107 auxiliary seismic stations, 48 infrasound stations, 10 hydroacoustic stations, 63 radionuclide stations, and 11 radionuclide laboratories have been fully certified. As of August 2015, there are 281 certified monitoring stations, out of 337, and another 20 are currently in the testing phase. Construction is underway on another 18 stations, many of them in remote locations. An additional 18 monitoring stations are planned. As of 2015, the CTBTO Preparatory Commission has 85% of the IMS network installed.

The International Data Centre (IDC)

Located at the seat of the CTBTO Preparatory Commission in Vienna, the International Data Center (IDC) supports the verification responsibilities of the IMS by providing objective products and services to ensure effective monitoring worldwide. These data products are developed based upon information collected by IMS stations. The raw data and data products are then transmitted to States Parties for their final assessment, which may be used to request clarification on an event or an on-site inspection. The GCI provides the means with which to distribute data and products between Member States and the IDC.

Computer infrastructure and support: The IDC is responsible for receiving, collecting, processing, analyzing, reporting on, and archiving IMS station data, including analysis completed at certified IMS radionuclide laboratories. The IDC manages the computer infrastructure that allows the PTS to effectively execute its mission.

The IDC uses a relational database management system for information management, and has also created full network redundancy to ensure uninterrupted operations. The IDC possesses a 125 terabyte mass data storage system that provides an archiving capacity for over 10 years of verification data. The United States provided much of the software developed specifically for CTBT monitoring purposes on a cost-free basis. Significant contributions were also provided by IDC staff, other international monitoring experts, and through IDC-funded contracts.

Data products and services: IMS stations transmit collected monitoring data in real time to the IDC for analysis. Upon transmission to the IDC, these data are processed immediately and the first automated products are distributed to Member States within two hours of the arrival of the raw data. The data products comprise data collected on seismological events, acoustic events, and radionuclides that have been detected by IMS stations. After receiving raw data from IMS facilities, IDC analysts review these lists in order to prepare quality-controlled bulletins.

Standard products: As stipulated by the CTBT, the IDC processes raw data to produce and archive standard IDC products on behalf of all States Parties cost-free. These data products are currently distributed to over 1200 users in 120 countries. These products include integrated lists of all signals detected by the IMS, standard event lists and bulletins, executive summaries of the various IDC products as well as the performance and operational status of the IMS and IDC.

Services to States Parties: The CTBT guarantees to all States Parties open, equal, timely, and convenient access to all IMS data, raw or processed, all IDC products, and all other IMS data in the archive of the IDC. The methods for supporting data access and the provision of data include automatic and regular forwarding of IMS data and IDC products, as well as the provision to individual States Parties of expert technical analysis of IMS data and other relevant data to help identify the source of a specific event.

Technical assistance: The IDC will provide technical assistance to individual States Parties in formulating their requirements for selection and screening of data and products, installing computer algorithms or software to compute new signal and event parameters at no cost, as well as assisting with the development of processing and analysis capabilities for IMS data at national data centers.

Transmission of data to States Signatories: Since February 2000, the IDC has been providing IMS data and IDC products to States Signatories on a test basis. Approximately 120 secure signature accounts have been established, which allow States Signatories to access these data and products.

The Global Communications Infrastructure (GCI)

Monitoring data from IMS facilities is transmitted in near-real time to the IDC in Vienna for processing and analysis through the Global Communications Infrastructure (GCI). States Parties also receive raw data, IDC products, and reports relevant to Treaty verification. Digital signatures and keys are used to ensure the authenticity of the data and prevent tampering with IDC products and data.

Transmission of data to the IDC: Over 200 stations are already transmitting data to the IDC, many of them continuously. The GCI, which receives and distributes data through a network of six satellites, ensures global coverage. The GCI became functional in mid-1999.

Very Small Aperture Terminal (VSAT) technology: The GCI network is based on Very Small Aperture Terminal (VSAT) technology, and is the first global communications network of its kind. VSAT technology is a two way satellite ground station with a dish antenna that is smaller than three meters in diameter. VSATs access satellites in geosynchronous orbit to relay data from small remote earth stations to other terminals and master earth station hubs.

VSAT technology enables IMS facilities and States Parties in all but near-polar areas of the world to exchange data via their local VSAT earth stations through one of six geosynchronous satellites. Transmissions are routed through the satellites to hubs on the ground, and then to the IDC via terrestrial links. A State hosting IMS stations may request that its data be routed through national communication nodes before being routed into the GCI.

Design and status: With the objective of providing data within seconds from origin to final destination, the GCI is designed to be cost-effective and operate with 99.5% availability. The GCI transmits data at a rate nearly six times faster than the internet. Installed and operational since 1999, the five GCI hubs are located in the United States, Italy, Germany, Australia, and Japan. To date, GCI terminals have been set up at approximately 260 IMS stations, national data centers, and development sites. The GCI hubs are connected via terrestrial links to the IDC in Vienna.

On-Site Inspections (OSIs)

Concerns about possible non-compliance with the Treaty, should an event occur, may be addressed through a consultation and clarification process. States Parties also can request an on-site inspection (OSI), which is the final verification measure under the CTBT and can be invoked only after the Treaty has entered into force.

Procedures: An OSI is a means to gather facts that might assist in clarifying whether a nuclear weapon test or any other nuclear explosion has been carried out in violation of the Treaty. Verification procedures shall be based on objective information, limited to the subject matter of the CTBT, and carried out with full respect for the sovereignty of States Parties. All necessary measures shall be taken to protect the confidentiality of any information related to civil and military activities and facilities obtained during an inspection.

Request: A State Party may request an on-site inspection in the event that a possible nuclear explosion is detected by the IMS or by national technical means of verification in a manner consistent with principles of international law. The requesting State Party shall be obligated to keep the OSI request within the scope of the Treaty and shall refrain from unfounded or abusive inspection requests.

Specific information, including the location of the event triggering the request, the State Party or States Parties to be inspected, the probable environment of the triggering event, and the estimated time of the event, and all data upon which the request is based must be included in the OSI request. The request should also include a record of the consultation and clarification process preceding to the OSI request or an explanation as to why such a process has not taken place.

The requesting State Party shall present the OSI request to the Executive Council and the Director-General of the Technical Secretariat of the CTBTO at the same time. If the Executive Council finds that a frivolous or abusive request has been made, it can decide to implement measures set out in the Treaty to redress the situation.

Follow-up to a request: The Executive Council immediately begins its consideration upon receipt of an OSI request. After receiving the request, the Director-General acknowledges its receipt to the requesting State Party within six hours, and communicates the request to the State Party sought to be inspected within six hours. The Executive Council and all States Parties are notified within 24 hours of the request by the Director-General.

Upon receipt of an OSI request, the Director-General immediately contacts the State Party that is the subject of the request to clarify and resolve the concerns expressed in the request. Within 72 hours, that State Party must provide the Director-General with an explanation and any other pertinent information. Any additional information available from the IMS or provided by any other State Party, as well as any relevant information from within the Technical Secretariat on the event specified in the request shall be transmitted to the Executive Council by the Director-General. The Executive Council shall decide whether to approve an OSI unless the requesting State Party considers the concerns expressed in the OSI request to be resolved and withdraws the request.

Executive Council decisions: The Executive Council shall decide whether an OSI is warranted within 96 hours of receiving the inspection request. The decision to approve the OSI shall be made by at least 30 affirmative votes of members of the 51-member Executive Council. During the deliberations of the Executive Council, the requesting State Party and the State Party sought to be inspected may participate without voting. The Director-General shall notify all States Parties within 24 hours about the Council's decision and any reports, proposals, requests, and recommendations.

Follow-up after Executive Council approval: An inspection team designated by the Director-General and in accordance with the provisions of the CTBT and the Protocol shall conduct an OSI following an approval by the Executive Council. An inspection mandate for the OSI, issued by the Director-General, shall contain specified information including the location and boundaries of the inspection area, the planned types of activity of the inspection team, and the list of equipment to be used in the inspection area. Within 24 hours of the expected arrival of the designated inspection team, the Director-General shall notify the inspected State Party of the planned inspection.

Conduct of an OSI: In accordance with the Treaty, a State Party must permit an OSI on its territory or any place under its jurisdiction or control. However, no State Party shall have to accept simultaneous on-site inspections.

The Inspected State Party has the right and obligation to demonstrate its compliance with the Treaty and enable the inspection team to fulfill its mandate while retaining the right to take the necessary measures to protect national security interests and prevent the disclosure of information unrelated to the OSI. Appropriate access within the given inspection area for the purpose of determining facts relevant to the OSI mandate must be granted to the inspection team and the Inspected State Party must not obstruct the OSI process by invoking its rights under the Treaty to conceal any violation of its obligations under Article I.

As specified in the Treaty, on-site inspections shall be conducted in the least intrusive manner possible, consistent with the efficient and timely accomplishment of the inspection mandate. Wherever possible, the inspection team shall begin with the least intrusive procedures and then, only if necessary, progress to more intrusive procedures in order to collect sufficient information. An inspection teams must collect only the information and data required to complete its mandate.

The Inspected State Party is obligated to assist the inspection team throughout the OSI, as well as provide for or arrange amenities necessary for the inspection team. These may include means of communication, interpretation services, transportation, working space, lodging, meals, and medical care. The CTBTO will reimburse the Inspected State Party for all expenses related to the stay and the functional activities of the inspection team.

Observers: The requesting State Party may send a representative observer along with the inspection team. The Inspected State Party shall notify the Director-General of its acceptance or non-acceptance of the observer within 12 hours of the Executive Council's approval of the inspection. There shall be no more than three observers from an aggregate of requesting States Parties.

Reports of an OSI: On-site inspection reports shall include a description of the activities conducted by the inspection team as well as the factual findings of the inspection team relevant to the purpose of the inspection. The report shall also contain an account of the cooperation granted by the Inspected State Party during the inspection, as well as a factual description of the extent of the access granted.

Within 48 hours of the inspection, the Inspected State Party has the right to provide the Director-General with comments on the draft inspection report or identify any data that, in its view, are not related to the purpose of the inspection. Comments and explanations provided by the Inspected State Party to the report shall be annexed to the inspection report.

The Director-General shall promptly transmit the results of the inspection to the requesting State Party, the Inspected State Party, the Executive Council, and all other States Parties. The results may include the report, any results of sample analysis in designated laboratories, relevant data from the IMS, assessments of the requesting and Inspected States Parties, as well as any other information deemed relevant by the Director-General.

In keeping with its powers and functions, the Executive Council shall respond appropriately in accordance with Article V of the Treaty if it reaches the conclusion that further action may be necessary. Article V specifies measures, including sanctions, for redressing a situation and ensuring compliance.

Operational manual: The Provisional Technical Secretariat is in the process of developing an OSI Operational Manual to guide the actions of the inspection team. Some of the issues that need to be addressed include procedures for overflights during an OSI for the purpose of providing the inspection team with a general orientation of the inspection area, narrowing down and optimizing the locations for ground-based inspections, communications between the inspection team and the Director-General, provisions regarding the health and safety of team members. Measures for preventing the disclosure of confidential information must also be addressed.

The manual will also contain a list of core and auxiliary inspection equipment, as well as procedures for calibrating, checking, and protecting such equipment.

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