CTBTO
PREPARATORY COMMISSION

TWENTY-FIVE YEARS

CELEBRATING TOGETHER THROUGH NEW RATIFICATIONS

Annual Report 2021

Published by the Provisional Technical Secretariat of the
Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty
Organization
Vienna International Centre
P.O. Box 1200
1400 Vienna
Austria

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The maps on pages 13-16 show the approximate locations of International Monitoring System facilities based on information in Annex 1 to the Protocol to the Treaty adjusted, as appropriate, in accordance with proposed alternative locations that have been approved by the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization for reporting to the initial session of the Conference of the States Parties following entry into force of the Treaty.

Printed in Austria
September 2022
Based on document CTBT/ES/2021/5 Annual Report 2021

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Annual Report 2021

Message from the Executive Secretary

As the new Executive Secretary of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), taking office on 1 August 2021, I am pleased to present our 2021 Annual Report.

The report offers a summary of salient activities of the Preparatory Commission in the fulfilment of its mandate, namely the promotion of the Comprehensive Nuclear-Test-Ban Treaty (CTBT), as well as completion, sustainment and operation of its verification regime.

2021 marked the 25th anniversary of opening for signature of the Treaty on 24 September 1996, and was a momentous occasion to renew commitment to the Treaty and its noble goal of putting an end to nuclear tests. The international community declared unequivocally 25 years ago that the era of unrestrained nuclear testing had come to an end. Since its opening, the Treaty has created and sustained a norm against nuclear testing so powerful that less than a dozen tests have been conducted in the last 25 years and only one country has violated it this millennium.

The 25th anniversary of the Treaty also coincided with the 30th anniversary of the closure of the former nuclear test site in Semipalatinsk, Kazakhstan and the 25th anniversary of the opening for signature of the African Nuclear-Weapon-Free Zone Treaty (Treaty of Pelindaba).

In 2021, the Preparatory Commission and its States Signatories began holding events to celebrate the remarkable achievements of the Treaty and its Organization.

These events, which will continue in 2022, aim to sharpen the focus on the significant impact of the Treaty as a concrete and practical measure towards nuclear disarmament and non-proliferation in all its aspects, and to encourage further signatures and ratifications.

States Signatories launched the 25th anniversary year of the Treaty with the convening of the 12th biennial Conference on Facilitating the Entry into Force of the Comprehensive Nuclear-Test-Ban Treaty, commonly known as the Article XIV conference. Article XIV conferences aim to rally support for the Treaty and inspire and encourage coordinated action to advance its entry into force and universalization. The conference, convened by the United Nations Secretary-General as the depositary of the Treaty, was held virtually on the margins of the high level segment of the general debate of the seventy-sixth session of the United Nations General Assembly (UNGA) on 23 and 24 September 2021.

The conference was presided over by the Deputy Minister of Foreign Affairs and International Cooperation of Italy, Ms Marina Sereni, acting on behalf of the Minister of Foreign Affairs, and the Minister of International Relations and Cooperation of South Africa, Ms Naledi Pandor, and was attended by around 90 States Signatories.

During the conference, ministers and senior officials from more than sixty countries joined the United Nations Secretary-General, Mr António Guterres (who was represented by the United Nations Under-Secretary-General and High Representative for Disarmament Affairs, Ms Izumi Nakamitsu), the President of the seventy-sixth session of the UNGA,

Mr Abdulla Shahid, and me to express their strong support for the Treaty and the urgent need for its entry into force.

The conference adopted a Final Declaration, which calls for the urgent entry into force of the Treaty and its universalization. It also enumerates a number of concrete actions to be taken towards these ends.

On 27 September 2021, Ireland, as President of the United Nations Security Council for September, organized a briefing to mark the 25th anniversary of the Treaty. The briefing provided the United Nations Security Council with the opportunity to reflect on the significant achievements of the Treaty since its opening for signature and advocate concrete actions to advance its entry into force.

United Nations Security Council members delivered strong statements of support for the Treaty and its verification regime, highlighting the success of the Treaty as a core component of the international nuclear disarmament and non-proliferation regime, and calling for urgent action to bring the Treaty into force. I, together with the United Nations Under-Secretary-General and High Representative for Disarmament Affairs, Ms Izumi Nakamitsu, and a Kenyan member of the CTBTO Youth Group, addressed the United Nations Security Council.

On 8 September, the UNGA convened a high level plenary meeting to commemorate and promote the International Day against Nuclear Tests. Upon the invitation of the President of the seventy-fifth session of the UNGA, I had the honour to deliver a keynote speech calling on all States to do their utmost to advance the entry into force of the Treaty. Participants, recounting the serious impacts of nuclear testing on human health and the environment and international peace and security, unanimously called on the remaining eight Annex 2 States to ratify the Treaty.

With the ratification of the Treaty by Cuba and the Comoros, we reached an important milestone of 185 signatures and 170 ratifications as at 31 December 2021. I remain firm in my belief that our collective efforts to advance the CTBT will strengthen the Treaty and solidify the already powerful international norm against nuclear testing. In this, the 25th anniversary year of the CTBT, we are undertaking strategic and multi-tracked outreach to advance this goal. I have set a target for us to achieve at least five additional ratifications by the end of the anniversary year in September 2022.

Through a series of initiatives the Group of Eminent Persons and the CTBTO Youth Group lent their support to engagements with government officials, technical experts, academics and the media. It is elating to note that our Youth Group has grown to nearly 1 200 members from over 117 countries, including a considerable number from the remaining eight Annex 2 States whose ratifications are required for the entry into force of the Treaty.

Despite continued restrictions caused by the COVID-19 pandemic, the Organization proved its resilience once again and its ability to effectively respond to challenges, including ensuring business continuity. Being able to sustain and operate a very complex global verification network and offer States Signatories uninterrupted data and data products during these difficult times, sets a good example.

In 2021, some International Monitoring System facilities were completed and certified. They include a primary and an auxiliary station in the Russian Federation. After major technological upgrades, several facilities in the Russian Federation, Sweden, France and the United States of America were revalidated. In addition, the underwater environmental survey and cable inspection of hydroacoustic station HA4 was completed. By the end of 2021 out of 337 verification facilities 303 have been certified. The figure represents almost 90% of the network foreseen by the Treaty.

With completion of acceptance testing for SPALAX NG, the development of the next generation of noble gas systems was further advanced. Two other next generation noble gas systems, namely MIKS and Xenon International, continued to undergo acceptance testing.

In 2021, we managed to make substantial progress in International Data Centre (IDC) progressive commissioning as well as implementation of procedures for special studies and expert technical analysis. Enhancement of the technical capabilities of the IDC, including in the quality of automatic bulletins (SEL1, SEL2 and SEL3) and reducing the workload of analysts by tuning the station detection thresholds, also progressed.

Another important area of our activities involved the development of on-site inspection (OSI) capabilities. To that end, a Consultative Group of Experts with selected experts from States Signatories in various OSI fields was established. The objective of the group is to leverage the expertise of States Signatories and obtain guidance and advice on strategic, technical and substantive matters on development and implementation of future OSI exercises.

Subsequently, based on the feedback provided by the group, a draft OSI exercise programme was prepared.

In addition, through the consolidation of the findings of the OSI action plan 2016-2019, the OSI Division finalized the first comprehensive draft list of OSI equipment specifications, which was submitted as Information Paper CTBT/PTS/INF.1573. The document provides for specifications relating to the core equipment for inspection activities and techniques specified in Part II, paragraph 69 of the Protocol to the CTBT, with the exception of drilling (paragraph 69 (h)). It is now offered for in-depth technical discussion with national experts with a view to consolidate the draft list prior to its consideration by States Signatories at subsequent sessions of Working Group B and the Preparatory Commission.

The operation and sustainment of a state of the art verification regime demands ongoing interaction with the scientific and technological community. That is the main driving force behind our biennial international science and technology conferences.

The CTBT: Science and Technology conference was held from 28 June to 2 July 2021. Due to the COVID-19 pandemic it was organized in a hybrid format for the first time. The event brought together a record number of participants. Over 1600 scientists, academics, high level officials and students from every corner of the globe attended the conference. The event reviewed the CTBT verification regime's performance and discussed verification related scientific and technological advances.

The first day featured a hybrid high level opening at the Hofburg palace in Vienna with live video streaming to participants worldwide. The messages delivered underlined the importance of the CTBT and its contribution to global peace and development.

The conference had two important and unique themes: the 25th anniversary of the opening for signature of the CTBT and the COVID-19 pandemic. To mark the 25th anniversary of the CTBT, several invited talks and panel discussions were organized. The events addressed our achievements as well as future challenges and prospects for the Treaty. The programme also included online sessions that explored the latest verification innovations and research supporting the journey to entry into force. A dedicated panel and a series of oral presentations over several sessions reflected on the experience of the COVID-19 pandemic as a stress test for the verification regime and lessons learned.

Despite the significant challenges of the COVID-19 pandemic, we made every effort to maintain our integrated capacity building, education and training activities. Such activities included various courses, workshops and technical meetings, some of which attracted a large number of attendees.

Throughout the year, efforts were made to foster synergies and efficiency gains as well as improvement of administrative and human resources policies, procedures and processes. The success of these endeavours is demonstrated through the allocation of 81.4% of the budget to verification related activities.

I greatly appreciate the unwavering support of States Signatories that helped advance the Treaty and make further progress towards completion of the verification regime as well as its sustainment and operation. I am also grateful to my colleagues who have displayed a considerable level of dedication and commitment in the discharge of their duties.

Robert Floyd
Executive Secretary
CTBTO Preparatory Commission
Vienna, April 2022

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Abbreviations

3 C	three component
3TC	the third training cycle for OSI inspectors
ATM	atmospheric transport modelling
ATG	alpha testers group
BGAN	broadband global area network
BOO	base of operations
BUE	build-up exercise
COPC	CTBTO Operations Centre
CTBT	Comprehensive Nuclear-Test-Ban Treaty
CTBTO	Comprehensive Nuclear-Test-Ban Treaty Organization
ECMWF	European Centre for Medium-Range Weather Forecasts
ECS	Experts Communication System
EIMO	Equipment and Instrumentation Management System for OSI
EU	European Union
GEM	Group of Eminent Persons
GCI	Global Communications Infrastructure
GIMO	Geospatial Information Management for OSI
IDANT	International Day against Nuclear Tests
IDC	International Data Centre
IIA	Institute of Internal Auditors
IMS	International Monitoring System
NDC	National Data Centre
O&M	operation and maintenance
OSI	on-site inspection
PCA	post-certification activity
PKI	public key infrastructure
PRTool	performance reporting tool
PTE	proficiency test exercise
QA/QC	quality assurance and quality control
QMPM	Quality Management and Performance Monitoring (Section)
QMS	Quality Management System
REB	Reviewed Event Bulletin
RFID	radio-frequency identification
SAUNA	Swedish Automatic Unit for Noble Gas Acquisition
SEL	Standard Event List
SHI	seismic, hydroacoustic and infrasound
SPALAX	Système de prélèvement automatique en ligne avec l'analyse des radio xénons
SOH	state of health
SOP	standard operating procedure
SSI	standard station interface
TIP	Test Implementation Plan
UNGA	United Nations General Assembly
VATP	validation and acceptance test plan
VBO	VIC based international organization
VIC	Vienna International Centre
VPN	virtual private network
VSAT	very small aperture terminal
WGA	Working Group A
WGB	Working Group B
WMO	World Meteorological Organization

The Treaty

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) is an international treaty that outlaws all nuclear explosions. By totally banning nuclear testing, the Treaty seeks to constrain the qualitative improvement of nuclear weapons and to end the development of new types of nuclear weapons. It constitutes an effective measure of nuclear disarmament and non-proliferation in all its aspects.

The Treaty was adopted by the United Nations General Assembly and opened for signature in New York on 24 September 1996. On that day, 71 States signed the Treaty. The first State to ratify the Treaty was Fiji on 10 October 1996. The Treaty will enter into force 180 days after it has been ratified by all 44 States listed in its Annex 2.

When the Treaty enters into force, the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) will be established in Vienna, Austria. The mandate of this international organization is to achieve the objective and purpose of the Treaty, to ensure the implementation of its provisions, including those for international verification of compliance with it, and to provide a forum for cooperation and consultation among States Parties.

The Commission

In advance of the entry into force of the Treaty and the establishment of the CTBTO proper, a Preparatory Commission for the Organization was established by the States Signatories on 19 November 1996. The Commission was given the mandate of preparing for entry into force.

The Commission, which is located at the Vienna International Centre in Austria, has two main activities. The first is to make all necessary preparations to ensure that the Treaty verification regime can be brought into operation at entry into force. The second is the promotion of signature and ratification of the Treaty in order to achieve entry into force.

The Commission is made up of a plenary body responsible for directing policy and comprising all States Signatories, and a Provisional Technical Secretariat to assist the Commission in its duties, both technically and substantively, and carry out such functions as the Commission determines. The Secretariat started work in Vienna on 17 March 1997. It is multinational in composition, with staff recruited from States Signatories on as wide a geographical basis as possible.

1 THE INTERNATIONAL MONITORING SYSTEM

Highlights

Maintaining a high level of data availability, despite COVID-19 related travel restrictions

The acceptance process for SPALAX-NG noble gas system was completed

Completion of the underwater environmental survey and cable inspection of HA4

The International Monitoring System (IMS) is a global network of facilities for detecting and providing evidence of possible nuclear explosions.* When completed, the IMS will consist of 321 monitoring stations and 16 radionuclide laboratories at locations around the world designated by the Treaty. Many of these locations are remote and difficult to access, posing major engineering and logistical challenges.

The IMS uses seismic, hydroacoustic and infrasound (SHI) ('waveform') monitoring technologies to detect and locate energy released by an explosion – whether nuclear or non-nuclear – or a natural event that takes place underground, underwater or in the atmosphere.

The IMS uses radionuclide monitoring technologies to collect particles and noble gases from the atmosphere. The acquired samples are analysed for evidence of physical products (radionuclides) that are created by a nuclear explosion and carried through the atmosphere. This analysis can confirm whether an event recorded by the other monitoring technologies was actually a nuclear explosion.

*In this booklet, IMS facilities are referenced using the station codes provided in Annex 1 of the Protocol to the CTBT. Details of each facility can be found at https://www.ctbto.org/fileadmin/content/treaty/treaty_text.pdf.

Profiles of the Monitoring Technologies

SEISMIC STATIONS

120
Auxiliary Seismic
50
Primary Seismic

The objective of seismic monitoring is to detect and locate underground nuclear explosions. Earthquakes and other natural events, as well as anthropogenic events, generate two main types of seismic wave: body waves and surface waves. The faster body waves travel through the interior of the earth, while the slower surface waves travel along its surface. Both types of wave are examined during analysis to collect specific information on a particular event.

Seismic technology is very efficient at detecting a suspected nuclear explosion, as seismic waves travel fast and can be registered within minutes of an event. Data from seismic stations of the IMS provide information on the location of a suspected underground nuclear explosion and help identify the area for an on-site inspection (OSI).

The IMS has primary and auxiliary seismic stations. Primary seismic stations send continuous data in near real time to the International Data Centre (IDC). Auxiliary seismic stations provide data on request from the IDC.

An IMS seismic station typically has three basic parts: a seismometer to measure ground motion, a system to record the data digitally with an accurate time stamp, and a communication system interface.

An IMS seismic station can be either a three component (3-C) station or an array station. A 3-C station records broadband ground motion in three orthogonal directions. An array station generally consists of multiple short period seismometers and 3-C broadband instruments that are separated spatially. The primary seismic network is mostly composed of arrays (30 of 50 stations), while the auxiliary seismic network is mostly composed of 3C stations (112 of 120 stations).

INFRASOUND STATIONS

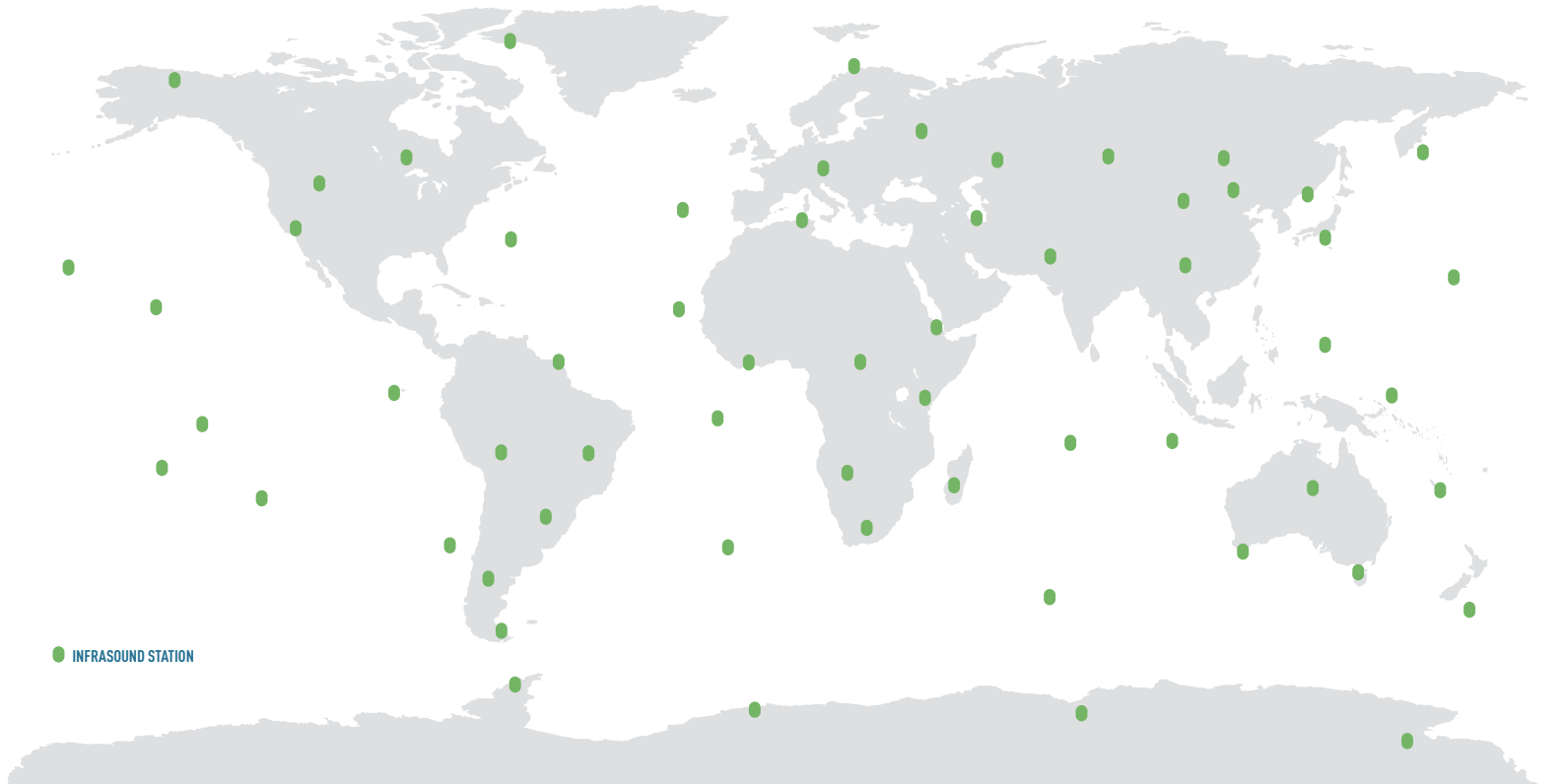
Acoustic waves with very low frequencies, below the frequency band audible to the human ear, are called infrasound. Infrasound is produced by a variety of natural and anthropogenic sources. Atmospheric and shallow underground nuclear explosions can generate infrasound waves that may be detected by the infrasound monitoring network of the IMS.

Infrasound waves cause minute changes in the atmospheric pressure that are measured by microbarometers. Infrasound has the ability to cover long distances with little dissipation, which is why infrasound monitoring is a useful technique for detecting and locating atmospheric nuclear explosions. In addition, since underground nuclear explosions also generate infrasound, the combined use of infrasound and seismic technologies enhances the ability of the IMS to identify possible underground tests.

The IMS infrasound stations exist in a wide variety of environments, ranging from equatorial rainforests to remote windswept islands to polar ice shelves. However, an ideal site for deploying an infrasound station is within a dense forest, where it is protected from prevailing winds, or at a location with the lowest possible background noise in order to improve signal detection.

An IMS infrasound station (also known as an array) typically employs several infrasound array elements arranged in different geometrical patterns, a meteorological station, a system for reducing wind noise, a central processing facility and a communication system for the transmission of data.

60
Stations



HYDROACOUSTIC STATIONS

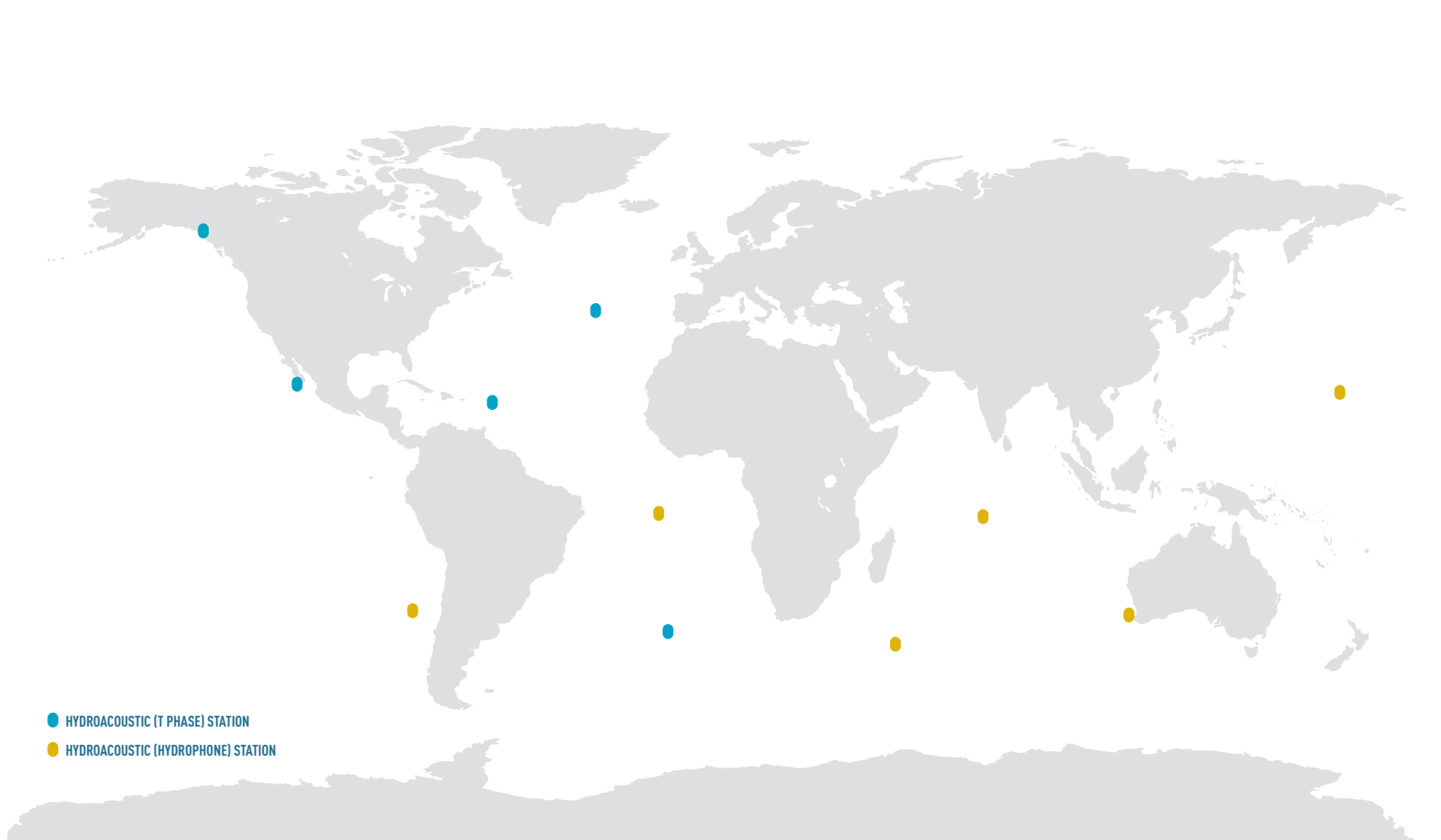
11
Stations

Nuclear explosions underwater, in the atmosphere near the ocean surface or underground near oceanic coasts generate sound waves that can be detected by the IMS hydroacoustic monitoring network.

Hydroacoustic monitoring involves recording signals that show changes in water pressure generated by sound waves in the water. Owing to the efficient transmission of sound through water, even comparatively small signals are detectable at large distances. Therefore 11 stations are sufficient to monitor most of the world's oceans.

There are two types of hydroacoustic stations: underwater hydrophone stations and T phase seismometer stations on islands or on the coast. Underwater hydrophone stations are more effective than T phase stations and are among the most challenging and costly monitoring stations to manufacture and install. They must be designed to function in extremely inhospitable environments and be able to withstand temperatures close to freezing point, huge pressure and saline corrosiveness.

The deployment of the underwater components of a hydrophone station (i.e., accurately placing the hydrophones and laying the cables) is a complex ocean engineering undertaking. It involves the chartering of specialized ships, extensive underwater work and the use of materials and equipment engineered to withstand the challenging underwater environment.



RADIONUCLIDE PARTICULATE STATIONS

Radionuclide monitoring technology complements the three waveform technologies employed in the Treaty verification regime. It is the only technology that is able to confirm whether an explosion detected and located by the waveform methods is indicative of a nuclear test. It provides the means to identify the 'smoking gun', whose existence would be evidence of a possible violation of the Treaty.

Radionuclide stations detect radionuclide particles in the air. Each station contains an air sampler, detection equipment, computers and a communication set-up. At the air sampler, air is forced through a filter, which retains most particles that reach it. The used filters are examined and the gamma radiation spectra resulting from this examination are sent to the IDC in Vienna for analysis.

96
Facilities

16
Laboratories

Noble Gas Detection Systems

The Treaty requires that, by the time it enters into force, 40 of the 80 IMS radionuclide particulate stations also have the capability to detect radioactive forms of noble gases such as xenon and argon. Special detection systems have therefore been developed and are being deployed and tested in the radionuclide monitoring network before they are integrated into routine operations.

Noble gases are inert and rarely react with other chemical elements. Like other elements, noble gases have various naturally occurring isotopes, some of which are unstable and emit radiation. There are also radioactive noble gas isotopes that do not occur naturally, but which can be produced only by nuclear reactions. By virtue of their nuclear properties, four isotopes of the noble gas xenon are particularly relevant to the detection of nuclear explosions. Radioactive xenon from a well contained underground nuclear explosion can seep through layers of rock, escape into the atmosphere and be detected later, thousands of kilometres away.

All of the noble gas detection systems in the IMS work in a similar way. Contaminants of different kinds, such as dust and water vapour are eliminated before the collected air is injected into a processing unit for collection, purification, concentration and quantification of xenon. The resulting sample contains a high concentration of xenon, in both its stable and unstable (i.e., radioactive) forms. The radioactivity of the isolated and concentrated xenon is measured and the data is sent to the IDC for further analysis.

Radionuclide Laboratories

Sixteen radionuclide laboratories, each located in a different State, support the IMS network of radionuclide monitoring stations. These laboratories have an important role in corroborating the results from an IMS station, in particular to confirm the presence of fission products or activation products that could be indicative of a nuclear test. In addition, they contribute to the quality control of station measurements and the assessment of network performance through regular analysis of routine samples from all certified IMS stations. These world class laboratories also analyse other types of samples, such as those collected during a station site survey or certification.

Fourteen radionuclide laboratories are certified under rigid requirements for analysis of particulate samples, and four radionuclide laboratories have been certified for noble gas analysis. The certification process provides assurance that the results provided by a laboratory are accurate and valid. These laboratories also participate in the annual proficiency test exercises (PTEs) organized by the Commission.

Completing the International Monitoring System

Establishment of a station is a general term referring to the building of a station, from its initial stages until its completion. Installation typically refers to all work performed until the station is ready to send data to the International Data Centre (IDC) in Vienna. This includes, for instance, site preparation, construction and equipment installation. A station receives certification when it meets all technical specifications, including requirements for data authentication and transmission through the Global Communications Infrastructure (GCI) link to the IDC. At this point the station is considered an operational facility of the IMS.

Monitoring of radionuclide noble gases plays an essential role in the verification system of the Treaty, as was demonstrated following the announced nuclear tests by the Democratic People's Republic of Korea in 2006 and 2013. It also proved to be invaluable following the nuclear accident at Fukushima, Japan, in 2011. In line with its priorities, the Commission continued to focus on the noble gas monitoring programme in 2021 through close cooperation with the developers of next generation noble gas systems. The acceptance process for the SPALAX NG noble gas system was successfully concluded, so that now two next generation systems have been accepted for use in the IMS.

As of the end of the year, 31 noble gas systems were installed (78% of the planned total of 40) at IMS radionuclide stations. Of these, 25 systems were certified as meeting the stringent technical requirements.

PTEs are key elements of quality assurance and quality control (QA/QC) of IMS laboratories.

For the noble gas PTE, the proficiency test framework has reached enough maturity and the first official noble gas PTE was held in 2021.

All these advancements contribute to the prospective completion of the IMS network.

Status of the Installation and Certification Programme for International Monitoring System Stations as of 31 December 2021

IMS Station Type	Installation Complete		Under Construction	Contract Under Negotiation	Not Started
	Certified	Not Certified			
Primary seismic	44	1	1	1	3
Auxiliary seismic	109	7	1	-	3
Hydroacoustic	11	-	-	-	-
Infrasound	53	1	1	-	5
Radionuclide	72	-	1	2	5
Total	**289**	**9**	**4**	**3**	**16**

Installations and Certifications of Noble Gas Systems at Radionuclide Stations as of 31 December 2021

Total Number of Noble Gas Systems	Installed	Certified
40	31	25

Certifications of Radionuclide Laboratories as of 31 December 2021

Total Number of Laboratories	Certified for Particulate Capability	Certified for Noble Gas Capability
16	14	4

Agreements for Monitoring Facilities

The Commission has the mandate to establish procedures and a formal basis for the provisional operation of the IMS before the Treaty enters into force. This includes concluding agreements or arrangements with States that host IMS facilities to regulate activities, such as site surveys, installation or upgrading work, and certification and post-certification activities (PCAs).

In order to efficiently and effectively establish and sustain the IMS, the Commission needs to fully benefit from the immunities to which it is entitled as an international organization, including exemption from taxes and duties. Consequently, facility agreements or arrangements provide for the application (with changes where appropriate) of the Convention on the Privileges and Immunities of the United Nations to the activities of the Commission or explicitly list the privileges and immunities of the Commission. This may require a State that hosts one or more IMS facilities to adopt national measures to bring these privileges and immunities into effect.

In 2021, the Commission continued to address the importance of concluding facility agreements and arrangements and their subsequent national implementation. The absence of such legal mechanisms in some cases results in substantial costs (including in human resources) and major delays in sustaining certified IMS facilities. These costs and delays adversely affect the availability of data from the verification system.

Of the 89 States that host IMS facilities, 49 have signed a facility agreement or arrangement with the Commission, and 41 of these agreements and arrangements are in force. States are showing increased interest in this subject, and it is hoped that ongoing negotiations will be concluded in the near future and that negotiations with other States may be initiated soon.

Post-Certification Activities

Following the certification of a station and its incorporation into the IMS, its operation focuses on the delivery of high quality data to the IDC.

PCA contracts are fixed cost contracts between the Commission and some station operators. These contracts cover station operations and various preventive maintenance activities. The total expenditure of the Commission related to PCAs in 2021 was US$22 391 777. This amount covers the costs related to PCAs for 183 IMS facilities, including noble gas systems and radionuclide laboratories.

Each station operator submits a monthly report on PCA performance, which the Provisional Technical Secretariat (PTS) reviews for compliance with operation and maintenance (O&M) plans. The Commission has developed standardized criteria for the review and evaluation of the performance of station operators.

The Commission continued to standardize the services provided under PCA contracts. It requested all new budget proposals to follow a standard O&M plan template. By the end of 2021, 138 out of 167 stations and noble gas systems under PCA contracts had submitted O&M plans in the standard format.

Sustaining Performance

The life cycle of the IMS facilities proceeds from conceptual design and installation to operation, sustainment, disposal of parts and rebuilding. Sustainment covers maintenance through necessary preventive maintenance, repairs, replacement, upgrades and continuous improvements to ensure technological concurrency of the monitoring capabilities. This process involves management, logistics, coordination and support for the full life cycle of each facility component, performed as efficiently and effectively as possible. In addition, as IMS facilities reach the end of their designed life cycles, there is the need to plan, manage and optimize the recapitalization (i.e., replacement) of each facility in order to minimize downtime and make full use of resources.

The Commission is focused on identifying the root causes of failures at IMS stations. Ongoing efforts to improve data availability based on IMS-wide failure analysis include upgrades to station electrical power systems, grounding and station infrastructure, equipment standardization, appropriate sparing levels at IMS stations and depots, and enhanced and targeted station operator technical training courses.

The optimization and performance enhancement involves the continuous improvement of data quality, reliability, and resilience. Therefore the Commission continued to put emphasis on QA/QC, state of health (SOH) monitoring, IMS facility calibration activities (which are essential for the reliable interpretation of detected signals) and the improvement of IMS technologies. These activities contribute to maintaining a credible and technologically relevant monitoring system.

Logistics

The central logistics support function was established in 2019 and is designated as a centre of expertise and experience, providing cross-Divisional integrated logistical support. The central logistics support manages and operates the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) Technology Support and Training (TeST) Centre in Seibersdorf, Austria. It utilizes the TeST Centre as a logistics platform to play a central role for the PTS in shipping, warehouse management, goods/asset management and for the build-up and sustainment of verification activities. Considering that local Austrian authorities in Seibersdorf issued a certificate of completion to the PTS in August 2021 and that the facility was formally handed over to the PTS by the general contractor, the full responsibility for the facility within the PTS lies with the IMS Division.

The TeST Centre continued its operations to store, inter alia, OSI equipment and to undertake regular operational activities in support of its programme to develop, test, maintain and rapidly deploy inspection techniques and auxiliary equipment. While on-site training, events and exercises are still affected by the COVID-19 pandemic, virtual station operator training sessions were hosted from the TeST Centre.

The PTS maintained its capability for supportability analysis which underpins the planning and oversight of the recapitalization and sustainment decision making processes, while ensuring overall operational availability of stations. This activity involved documenting and maintaining the infrastructure, integrating data from various sources and using tools to prepare and analyse the data to find and share actionable insights, contributing to the development of a systematic approach to sustainment decisions in the future.

Supply and support contracts related to equipment and services for IMS facilities continued to be established and maintained as an important component of the sustainment strategy.

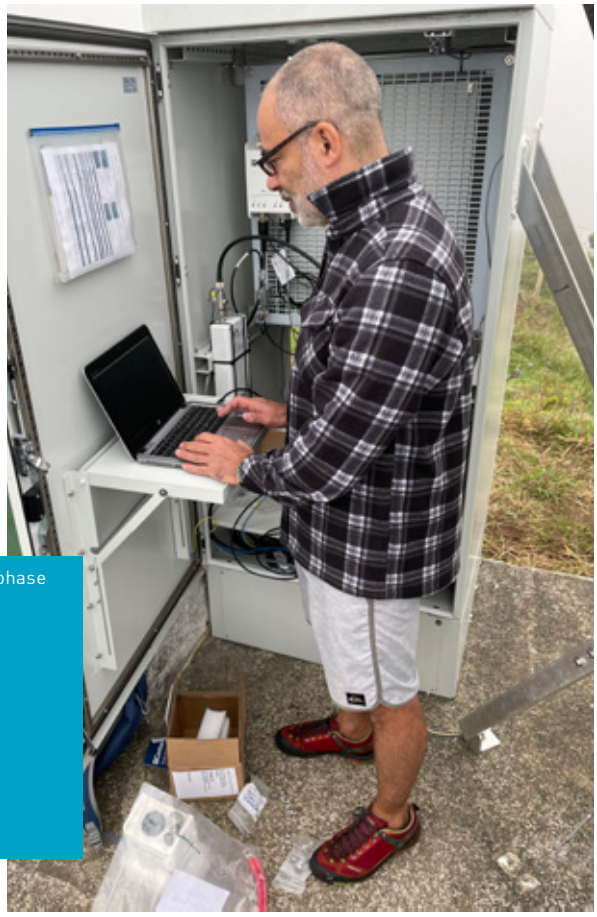
The Commission continued to work with States and station operators to enhance shipment procedures for IMS equipment and consumables and ensure their timely tax- and cost-free customs clearance. Shipping and customs clearance processes continued to be time consuming and resource intensive. This increases the time needed to repair an IMS station and reduces the data availability of that station. The Commission therefore continued to seek measures to enhance the supply, distribution and storage of equipment and consumables to IMS stations. The establishment and national implementation of facility agreements contributes to smooth import and customs processes.

Maintenance

The PTS provides maintenance support and technical assistance at IMS facilities around the globe. During 2021, numerous maintenance requests were addressed, including long running data availability problems at several IMS facilities. In lieu of undertaking preventive and corrective maintenance visits due to COVID-19 related travel restrictions, the PTS provided enhanced remote assistance to station operators and relied on them as well as contractors and other sources of support to perform such tasks.

A programme to standardize equipment at radionuclide stations has largely been completed. The programme aimed to overcome obsolescence and address equipment becoming non-standard as newer equipment is rolled out to newly certified stations. This resulted in improved data availability and simplified sustainability. The IMS is planning to implement equipment standardization at SHI stations.

As the entity closest to an IMS facility, the station operator is in the best position to prevent problems at stations and ensure timely resolution of any problems that occur. In 2021, the Commission continued to advance the technical capabilities of station operators. In addition to providing technical training for operators, an online training session for radionuclide manual particulate station operators was held in 2021 from the TeST Centre in Seibersdorf, Austria. In addition, training sessions were held for radionuclide and SHI public key infrastructure (PKI) operators, and online technical training for station operators of IMS infrasound stations with nanometrics and Guralp equipment. Station visits by PTS staff included handson training for local staff. IMS maintenance staff conducted two station visits in 2021, to RN11 to restore data availability and a visit to HA7 for an equipment upgrade.



Testing equipment at T phase station HA7.

Central recording facility maintenance issues including remedial actions for Global Positioning System roll over, central recording facility main power supply and pertinent civil works were addressed at IS14/HA3 as well as troubleshooting the intra-site communication system and data acquisition systems at IS14. Additional fuel and generator maintenance was assured to sustain the operation of the stations during the COVID-19 pandemic. Continuous remote support and technical training was provided to station operators.

Complete and updated station specific technical documentation contributes to the efficient sustainment of IMS stations. Excellent progress was made in 2021 in the creation and maintenance of this documentation. Over 50 standard operating procedures (SOPs) were reviewed, edited and finalized.

The combination of technical training for station operators, better coordination between the operators and the Commission to optimize PCA contracts, and improved station specific O&M plans and station information contributed to enhancing the capability of station operators to undertake more sophisticated maintenance tasks at their stations. This is essential for the sustainment and performance of the IMS network.

Recapitalization

The final phase in the life cycle of equipment for IMS facilities involves its replacement and disposal. In 2021, the Commission continued to recapitalize IMS facility components as they reached the planned end of their operational life cycle.

When managing recapitalization, the Commission and station operators took into account both life cycle data and station specific failure analysis and risk assessment. To optimize the obsolescence management of the IMS network and associated resources, the Commission continued to prioritize the recapitalization of components with high failure rates or risks and components whose failure would cause significant downtime. At the same time, the replacement of components that proved to be robust and reliable is delayed beyond the planned end of their operational life cycles, where suitable, in order to optimize the use of available resources.

Several recapitalization projects were in progress or completed at certified IMS facilities in 2021, involving a substantial investment in human and financial resources. In four cases, namely PS49, AS102, IS56, and IS58, recapitalization was followed by revalidation to ensure that the stations continued to meet technical requirements.

Testing equipment at PS49.

Several important recapitalization projects have also been finalized this year with revalidation planned in 2022, e.g. IS47, HA7 and PS24.

Several large scale recapitalization and upgrade projects were initiated in 2021 with an estimated completion date in 2022-2023, among which IS18, IS19, IS35, IS40, IS51 and PS26.

Environmental Compliance

Successful completion of the nearshore cable inspection and environmental survey at HA4, by the French Southern and Antarctic Lands in collaboration with the hydroacoustics team in the IMS, marks a required milestone to ensure compliance with environmental mandates on station installation and operation. The mission relied on the research and supply vessel Marion Dufresne II and involved multiple segment remotely operated vehicle surveys and diving operations.

Engineering Solutions

The engineering and development program for IMS facilities aims to improve the overall availability and quality of data and the cost effectiveness and performance of the IMS network by designing, validating and implementing solutions. Systems engineering is implemented throughout the life cycle of an IMS station and relies on standardization of interfaces, equipment and modularity. Engineering and development solutions consider both end to end systems engineering of stations and optimized interaction with data processing by the IDC.

The Commission continued its work to optimize the performance of the IMS facilities and the monitoring technologies. Analysis of station incident reports and failures help identify the main causes of data loss and assist subsequent analysis of subsystem failures responsible for downtime.

Cougar-XT Compact remotely operated vehicle with cable tracking magnetometer and 500 metre umbilical cable (procured specifically for the 2021 HA4 nearshore cable inspection and environmental survey), onboard the Marion Dufresne II.

In 2021, a practical agreement was signed between the Commission and the International Bureau of Weights and Measures. This arrangement provides an official framework for a continued, long term collaboration between the Commission and the International Bureau of Weights and Measures in the field of low frequency sound and vibration as well as radionuclide particulates and gases.

In 2021, the Commission concentrated its engineering efforts on the following:

- Collaboration with the International Bureau of Weights and Measures on measurement science for IMS seismoacoustic monitoring technologies.

- Enhancements to the standard station interface (SSI) software. A new release was delivered, which includes a new input module to interface with Nanometrics Centaur equipment, enhancements to the user experience by simplifying the interface for management of software configurations, improved resiliency through the investment in new integration tests, and the involvement of external laboratories as beta testers. In order to better support station operators and PKI operators using the SSI software, the Commission initiated a survey to collect information and configuration files from all workstations running the SSI software at IMS SHI stations. The Commission plans to use the results of this survey to better understand how the SSI software is used across the network, and to refine its development roadmap.

- Development of procedures for assessing and testing current IMS station power systems with the objective of assessing station power supplies, identifying station vulnerabilities and initiating maintenance or upgrade actions when necessary.

- Enhancements to the internal Multi-Technology Integration Portal, including the visualization of data quality metrics and station parameters with the objective of supporting station troubleshooting and configuration activities.

- Development of the CalxPy software to support the calibration of IMS seismoacoustic stations against a reference system. This included the support of the scheduled calibration process for infrasound stations and packaging for both IDC and National Data Centre (NDC) in a box environments.

- Investigation of nearshore underwater cable sustainment solutions through conducting studies into: cable replacement options, underwater jointing options, system cathode options, and the conduct and feasibility of horizontal directional drilling to protect cables from damage in the nearshore energetic surf zone.

- Development of the next generation of noble gas systems. SPALAX NG has completed IMS acceptance testing; MIKS and Xenon International are undergoing acceptance testing. The PTS will continue planning for the deployment of all new systems.

- Continued evaluation of automated particulate radionuclide sampler Cinderella G2 and its integration into IMS station software and hardware environment.

- Hybrid modular design for hydroacoustic hydrophone stations: a prototype latch mechanism was developed that enables disconnection of a node from the trunk or internode cable after deployment. Initial testing was conducted in a water tank. Next development steps include integration with wet-mate connectors, load and tension laboratory testing, and potential remotely operated vehicle testing in a dockside environment.

- Roll-out of new Digital Data Formatter Interface (DDFI) Enhanced Backfill and Remote Diagnostics Capability at HA1 – the first hydrophone hydroacoustic station with this capability. Additionally, a lightning protection system was installed by the station operator (Geoscience Australia).

- Technical deliberations on viable solutions for the re-establishment of hydroacoustic station HA8 and drafting of engineering requirements for the most sustainable option.

These initiatives further improved the reliability and resilience of IMS facilities. They also enhanced the performance of the network and increased the robustness of IMS stations, thus contributing to the extension of their life cycles and containing the risks of data downtime. Moreover, these initiatives increased the data availability and the quality of data processing and of data products.

Auxiliary Seismic Network

The Commission continued to monitor the operation and sustainment of auxiliary seismic stations in 2021.

In accordance with the Treaty, the regular O&M costs of each auxiliary seismic station, including the cost of physical security, are the responsibility of the State hosting it. However, practice has shown that this constitutes a significant challenge for auxiliary seismic stations in developing countries that do not belong to a parent network with an established maintenance programme.

The Commission has encouraged States that host auxiliary seismic stations with design deficiencies or with problems related to obsolescence to review their ability to cover the cost of upgrading and sustaining their stations. However, obtaining the appropriate level of technical and financial support remains difficult for several host States.

To address this, the European Union (EU) continued to support the sustainment of auxiliary seismic stations that are hosted by developing countries or countries in transition. This initiative includes action to return stations to an operational state and the provision of transportation and funds for additional PTS personnel to provide technical support. The Commission continued its discussions with other States whose parent networks include several auxiliary seismic stations in order to make similar arrangements.

Quality Assurance

In addition to improving performance at individual stations, the Commission accords great importance to ensuring the reliability of the IMS

Borehole seismometer installation at AS90.

network as a whole. Hence, its engineering and development activities in 2021 continued to focus on measures for data surety and calibration.

QA/QC activities for seismoacoustic capability continued with the completion of measurements performed in the framework of the first intercomparison exercise for infrasound sensors. QA/QC activities for seismoacoustic capability also continued with the initiation of type approval processes for two new infrasound sensor models.

The PTS continued to develop new functionalities for software (Calibration Activities Management Tool, SSI calibration module and CalxPy) used to support the implementation of scheduled calibration activities at IMS seismoacoustic stations.

The PTS also deployed and configured the SSI calibration module at six seismic stations. This allowed yearly scheduled calibration activities to be performed at these stations including full frequency calibration results sent in IMS 2.0 format to the PTS.

Calibration plays a significant role in the verification system, as it determines and monitors parameters needed to properly interpret signals recorded by IMS facilities. This is achieved either by direct measurement or by comparison against a standard.

Under the QA/QC programme for radionuclide laboratories, the Commission assessed the 2019 PTE and accepted four laboratory surveillance reports at RL9, RL10, RL11 and RL16.

QA/QC activities for noble gas capability continued with the execution of two intercomparison exercises for the noble gas capability of radionuclide laboratories.

IMS configuration management was administered ensuring that proposed changes at IMS stations are assessed to determine their effect on cost, effort and performance including data availability. Configuration management provides verifiable records of station configurations and equipment ensuring that IMS monitoring facilities continue to meet IMS technical specifications and operational requirements.

2

THE GLOBAL COMMUNICATIONS INFRASTRUCTURE

Highlights

High GCI availability maintained following the migration to new infrastructure

An average of 29.5 gigabytes of data and products transmitted per day

Two additional links installed for NDCs in the United Arab Emirates and Ghana

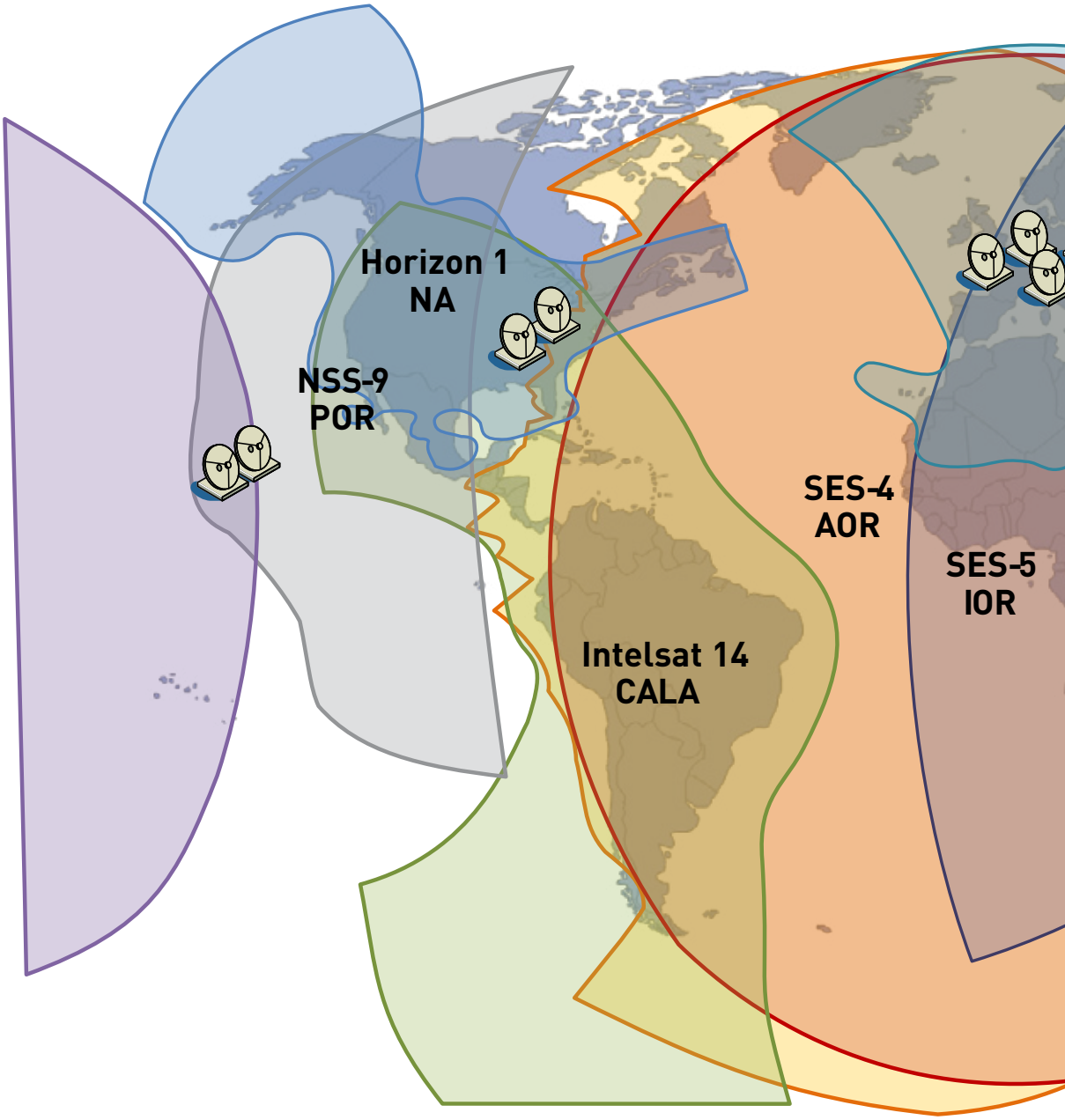
The Global Communications Infrastructure uses a combination of communications technologies including satellite, cellular, Internet and terrestrial communication links to enable the exchange of data between IMS facilities and States around the world and the Commission. The GCI first transports raw data from the IMS facilities in near real time to the IDC in Vienna for processing and analysis. It then distributes the analysed data to States Signatories along with reports relevant to verification of compliance with the Treaty. Increasingly, the GCI is also being used as a means for the Commission and station operators to monitor and control IMS stations remotely.

The current, third generation of the GCI began operation in 2018 under a new contractor. Its various communication links are required to operate with 99.5% availability and its terrestrial communication links with 99.95% availability. The GCI is required to send data from transmitter to receiver within seconds. It uses digital signatures and keys to ensure that the transmitted data are authentic and have not been tampered with.

Technology

IMS facilities, the IDC and States Signatories can exchange data, via their local earth stations fitted with a very small aperture terminal (VSAT), through one of several commercial geostationary satellites. These satellites cover all parts of the world, other than the North and South Poles. The satellites route the transmissions to hubs on the ground, and the data are then sent to the IDC via terrestrial links. Complementing this network, independent subnetworks employ a variety of communications technologies to carry data from IMS facilities to their respective national communications nodes connected to the GCI, from where the data are routed to the IDC.

In situations where VSATs are not in use or are not operational, other technologies such as broadband global area networks (BGANs), 3G/4G or virtual private networks (VPNs) can provide alternative means of communication. A VPN uses existing telecommunications networks to transmit data privately. Most of the VPNs for the GCI use the basic public infrastructure of the Internet together with a variety of specialized protocols to support secure encrypted communications. VPNs are also used at some sites to provide a backup communication link in case of failure of a VSAT or terrestrial link. For NDCs with a viable Internet infrastructure, a VPN is the recommended medium for receiving data and products from the IDC.

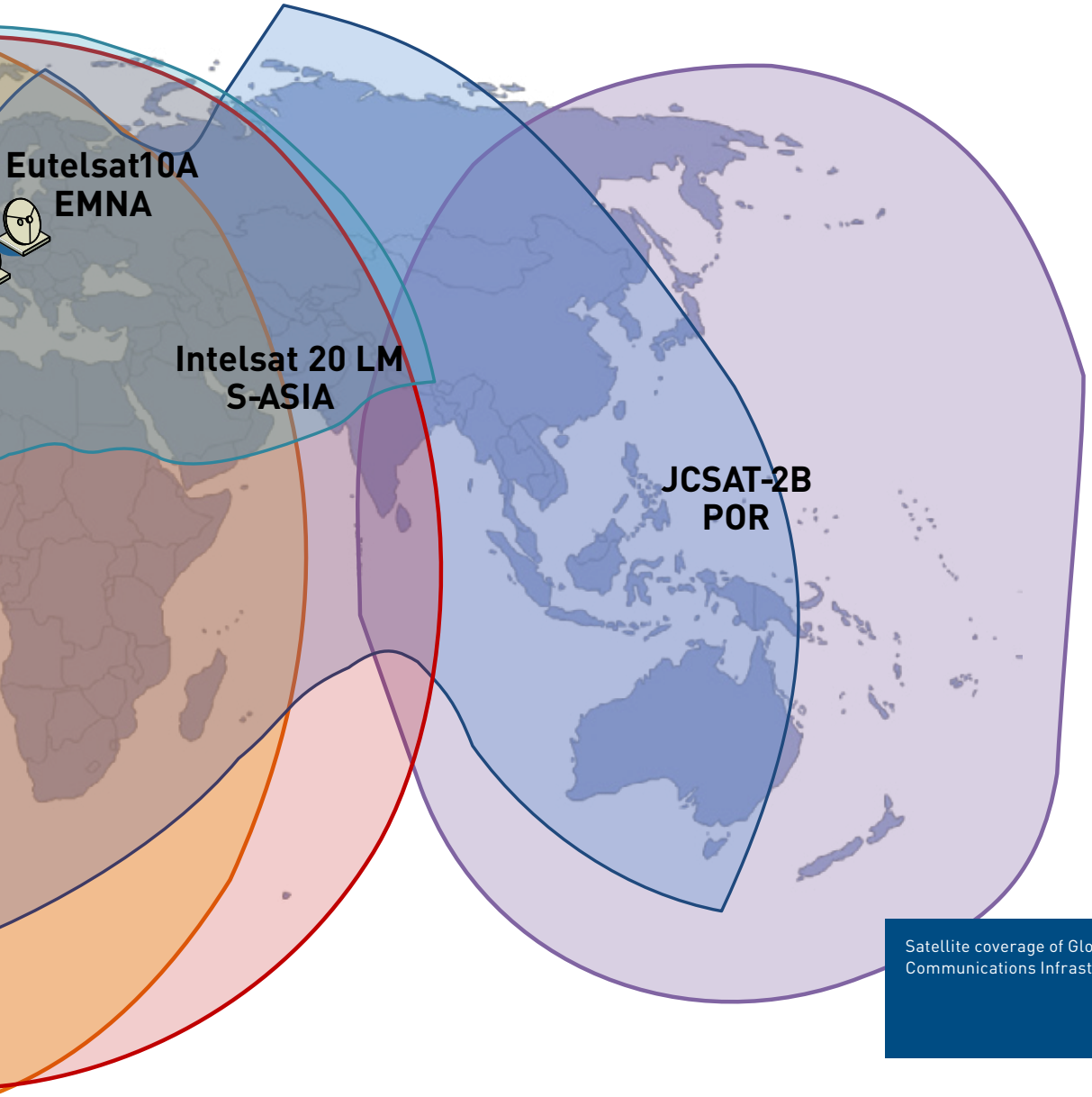


Operations

At the end of 2021, the GCI network included 266 redundant links. Of these, 207 are primary VSAT links backed up by 3G (117 links), BGAN (78 links), VPN (6 links) or VSAT (6 links). There are also 42 VPN links with VPN or 3G backup, 10 links with 3G primary and BGAN backup and 7 terrestrial multiprotocol label switching links. In addition, 71 independent subnetwork links and 6 Antarctic communication links were operated by 10 States Signatories to carry IMS data to a GCI connection point. In total, the combined networks have over 600 different communication links to transport data to and from the IDC.

The Commission measures the compliance of the GCI contractor against the operational target of 99.5% availability in 1 year using a rolling 12-month availability figure. In 2021, the absolute availability was 96.62%. The adjusted availability for GCI III was 99.94%.

The figure of 29.5 gigabytes data per day is calculated from GCI III monitoring systems on the basis of filtering all traffic to the receivers in the IDC by port and protocol used for the transmission of GCI data and products. It specifically excludes network management overhead and use of GCI links to transfer data directly between stations and NDCs.



Satellite coverage of Global Communications Infrastructure III.


SnT
2021
25

3 THE INTERNATIONAL DATA CENTRE

Highlights

The ability of the IDC to work remotely in face of COVID-19 restrictions

Substantial progress in IDC progressive commissioning activities

Progress towards implementation of procedures for special studies and expert technical analysis

The International Data Centre operates the IMS and the GCI. It collects, processes, analyses and reports on the data received from IMS stations and radionuclide laboratories and then makes the data and IDC products available to States Signatories for their assessment. In addition, the IDC provides technical services and support to States Signatories.

The Commission has created full computer network redundancy at the IDC to ensure a high level of availability of its resources. A mass storage system provides archiving capacity for all verification data, which now cover approximately 21 years. Most of the software used in operating the IDC has been developed specifically for the Treaty verification regime.

Operations: From Raw Data to Final Products

Seismic, Hydroacoustic and Infrasound Events

The IDC processes the data collected by the IMS as soon as they reach Vienna. The first data product, known as Standard Event List 1 (SEL1), is an automated waveform data report that lists preliminary waveform events recorded by the primary seismic and hydroacoustic stations. It is completed within one hour of the data being recorded at the station.

The IDC issues a more complete waveform event list, Standard Event List 2 (SEL2), four hours after first recording the data. SEL2 uses additional data requested from the auxiliary seismic stations along with data from the infrasound stations and any other waveform data that arrive late. After a further two hours have elapsed, the IDC produces the final, improved automated waveform event list, Standard Event List 3 (SEL3), which incorporates any additional late arriving waveform data. All of these automated products are produced according to the schedules that will be required when the Treaty enters into force.

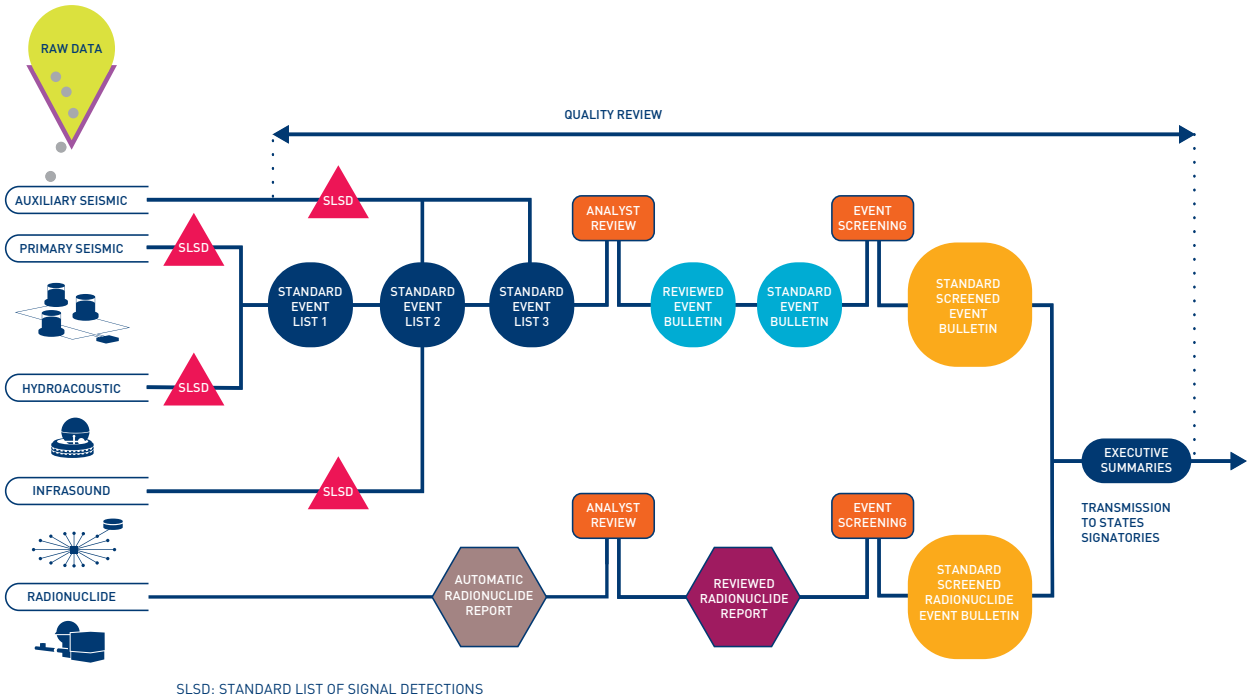
IDC analysts subsequently review the waveform events recorded in SEL3 and correct the automated results, adding missed events as appropriate to generate the daily Reviewed Event Bulletin (REB), aided by automatic scanning tools. The REB for a given day contains all waveform events that meet the required criteria. During the current provisional operating mode of the IDC, the REB is targeted to be issued within 10 days. After the Treaty enters into force, the REB will be released within two days.

An automatic stage of processing takes place after analyst review where additional characterization parameters are computed for REB events specifically to allow screening of natural events via a few screening criteria on these parameters. This results in the building of the Standard Event Bulletin which includes the characterization parameters and the Screened Standard Event Bulletin, a subset of the Standard Event Bulletin retaining events not screened out.

Radionuclide Measurements and Atmospheric Modelling

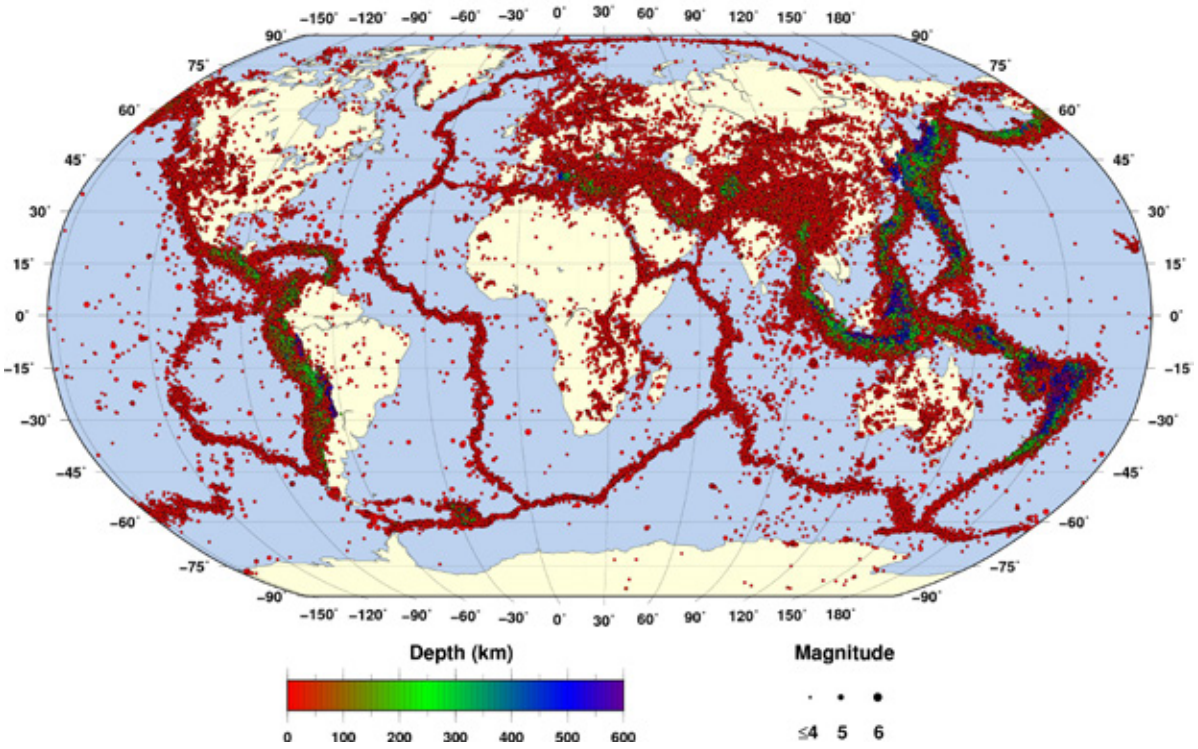
Spectra recorded by particulate and noble gas monitoring systems at IMS radionuclide stations typically arrive several days later than the signals from the same events recorded by the waveform stations. The radionuclide data are automatically processed to produce an Automatic Radionuclide Report within the

International Data Centre Standard Products



SLSD: STANDARD LIST OF SIGNAL DETECTIONS

2000-2021 Reviewed Event Bulletin (704 502 Events)



schedules required after entry into force of the Treaty. After review by an analyst under the schedules for provisional operation, the IDC issues a Reviewed Radionuclide Report for each full spectrum received.

The Commission performs daily atmospheric backtracking calculations for each of the IMS radionuclide stations with near real time meteorological data obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF) and from the National Centres for Environmental Prediction. Images generated from calculations based on ECMWF data are appended to each Reviewed Radionuclide Report. Using software developed by the Commission, States Signatories can combine calculations from ECMWF and National Centres for Environmental Prediction with radionuclide detection scenarios and nuclide specific parameters to define regions in which sources of radionuclides may be located.

To corroborate the backtracking calculations, the Commission collaborates with the World Meteorological Organization (WMO) through a joint response system. This system enables the Commission to send requests for assistance in the case of suspicious radionuclide detections to 10 regional specialized meteorological centres or national meteorological centres of the WMO located around the world. In response, the centres aim to submit their computations to the Commission within 24 hours.

Distribution to States Signatories

After these data products have been generated, they must be distributed in a timely way to States Signatories. The IDC provides subscription and Internet based access to a variety of products, ranging from near real time data streams to event bulletins and from gamma ray spectra to atmospheric dispersion models.

Further development of the Integrated CTBTO Operations Centre

Since the establishment of the integrated CTBTO Operations Centre (COPC), the facility has gradually become the central IMS performance monitoring and control hub, where preventive, condition based, planned and corrective maintenance is coordinated. As part of the PTS strategy regarding COVID-19 the COPC business continuity has allowed for mission-critical O&M functions to be carried out.

The PTS has completed the first full version of the concept of operations of the COPC, which was officially issued on the Experts Communication System (ECS) as an Information Paper on 23 November 2021

(CTBT/PTS/INF.1595). Although most of the functions described in the concept are already being performed by the various technical teams, some have yet to be integrated into the central control hub; this process will continue in the years to come.

Services

An NDC is an organization in a State Signatory that has technical expertise in the Treaty verification technologies and has been designated by the national authority of the State. Its functions may include receiving data and products from the IDC, processing data from the IMS and elsewhere, and providing technical advice to the national authority.

Build-Up and Enhancement

International Data Centre Commissioning

The mandate of the IDC is provisional operation and testing of the system in preparation for operation after entry into force. The IDC Progressive Commissioning Plan provides milestones that mark progress in this endeavour and control mechanisms, including:

- The Progressive Commissioning Plan itself;
- Draft Operational Manuals, which set requirements;
- The validation and acceptance test plan (VATP);
- A review mechanism, which allows States Signatories to determine if their verification requirements can be met by the system.

Build-up, continuous enhancement, performance monitoring and testing of the IDC are essential to its commissioning. The activities of the Commission in this respect are guided by a framework for monitoring and testing performance that has been developed by the PTS.

The cycle of four experiments from 2016 to 2019 concluded with the release of the technical and evaluation reports for Experiment 4 in 2020. An assessment report on the four experiments was released in 2021 taking stock of the results and plotting a path forward taking into account the lessons that have been learned for future experiments. The IDC continued to address the recommendations that were made in the evaluation reports of the first four experiments compiled by the Quality Management and Performance Monitoring (QMPM) Section.

The Commission also continued drafting the VATP that will be used in phase 6 of IDC progressive commissioning. The activities in this area continue to involve technical meetings, interaction on the ECS and discussions during sessions of Working Group B (WGB). Specifically, during 2021, the PTS conducted a technical meeting on the next revision of the VATP, discussed the assessment report on the first cycle of four experiments, reviewed a newly developed Test Implementation Plan (TIP) and the plans for the 2021 experiment.

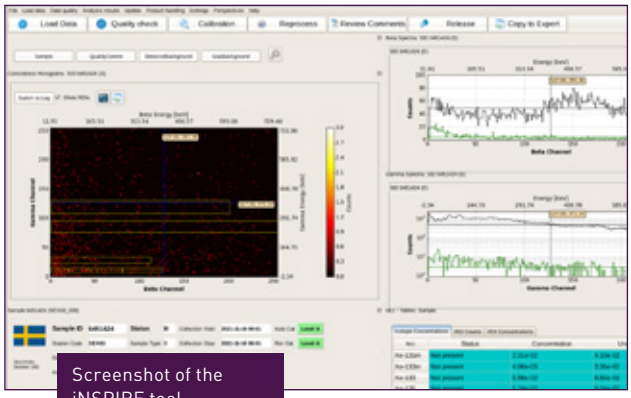
Security Improvements

The Commission continued to identify and address risks to its operational environment and to strengthen security controls on information technology. Measures to safeguard information technology assets, including mitigating risks of malware attacks, were taken; new vulnerability assessment and penetration test solutions were tested and are in progress of being introduced to the Information Security Steering Committee for production roll-out.

The Commission continued to make progress in security governance. The certification and accreditation process was improved and it was submitted to the Information Security Steering Committee for clearance and roll-out. The PTS information security policies and manual were revisited and reviewed by a joint working group of focal points and are currently undergoing the last phases of senior management review prior to deploying in production.

To ensure an effective information security programme, the Commission improved on cyber awareness services delivered to PTS staff, in close cooperation with the United Nations International Computing Centre. The programme focuses on the key tenets of information security: protection of confidentiality, integrity and availability of information assets. The programme successfully ensures a high security posture of PTS staff and information assets.

The Commission continued to ensure high available rates of PKI services. The services improved by implementing a new service-level agreement part of the newly negotiated contract with the vendor (Verizon). Improved PKI monitoring services were tested and are scheduled for deployment in 2022.



Screenshot of the iNSPIRE tool.

Software Enhancements

Radionuclide software development efforts focused on moving toward open source, comprehensive software that will meet the needs of the future and be used both in IDC operations and in NDCs. Software efforts are underway to improve capacities at several processing stages. Beginning with station data handling, the new automatic Software Tool for RAdionuclide Data Analysis (autoSTRADA) is intended for the automatic processing of data from both IMS particulates stations and noble gas systems. AutoSTRADA is a python language based, license-free application using shared libraries with the iNtegrated Software Platform for the Interactive Review (iNSPIRE). The initial release of autoSTRADA which handles data from beta–gamma coincidence based noble gas systems, including next generation technologies (SAUNA III, SPALAX, Xenon International and MIKS), has been used in the IDC operations since August 2021.

With the aim of replacing the current license based code Virtual Gamma Spectroscopy Laboratory, the IDC initiated the development of a new, open source, Monte Carlo (Geant4) based simulation tool for detector systems. The new tool will cover high purity germanium and beta–gamma coincidence based detection systems in use at IMS stations, including upcoming noble gas technologies making use of high resolution detectors. The software design includes a wide range of new features for more automated use in IDC operations. A first release of GRANDSim with particulates functionality is currently installed in the IDC test bed environment. GRANDSim was built in a virtual machine and made available to NDCs along with relevant documentation for alpha testing. An initial version of GRANDSim with the functionality for particulates went through pre-release testing by IDC analysts during the second semester of 2021.

The new review tool iNSPIRE was initially deployed in IDC operations in December 2020 to allow extensive testing by analysts in an operational context. iNSPIRE replaces the Saint2 and Norfy software applications. This first release covers the functionalities for beta–gamma noble gas data analysis; particulate capabilities are expected to be forthcoming. iNSPIRE has been used in IDC operations since May 2021 to release reviewed spectra from beta–gamma coincidence based noble gas systems, including next generation technologies (SAUNA III, SPALAX, Xenon International and MIKS).

With the aim of further empowering NDCs, the IDC developed a novel Web based application, dubbed RN Toolkit. RN Toolkit offers several options that the user can customize for accommodating specific needs for in-depth spatial-temporal analysis of anthropogenic activity concentrations in radionuclide samples, at both the particulate stations and the noble gas systems of the IMS, that might be released into the air by a nuclear test.

Screenshot of the RN Toolkit application.

A first version of RN Toolkit was released to NDC authorized users in March 2021, under the CTBTO single sign-on portal.

According to Part I, paragraph 19 of the Protocol to the CTBT, the IDC may conduct special studies to provide in-depth, technical reviews by expert analysis of data from the IMS to improve the estimated values for the standard signal and event parameters resulting in an Updated Radionuclide Report (URR). Special studies can be conducted upon the request of a State Party or by the Organization. In this regard, the IDC has developed a software solution for creating a URR based on the concept design as presented during the second expert meeting on radionuclide/atmospheric transport modelling (ATM) expert technical analysis (ETA) and special studies in October 2020.

The implementation involved the creation of a new database schema RMSEXPERT, appropriate features in the novel software applications iNSPIRE for interactive analysis and autoSTRADA for automatic processing as well as in the programs for sample categorization and product generation. After successful testing, URR was promoted to IDC operations in August 2021. The Verification Data Messaging System and the secure web portal have been enhanced since August 2021 to allow NDC authorized users to retrieve URR. The replication to an external database has also been extended to include the tables of the RMSEXPERT schema.

The implementation phase of the IDC SHI re-engineering project, which began in 2019, is progressing. The aim is to achieve a modern, maintainable, open-source SHI processing system based on the deliveries of the Geophysical Monitoring System by the NDC in the United States of America. The initial focus was to prototype the integration of IDC software components, such as the array processing software DTK-PMCC, and adding system monitoring and alerting onto the baseline of the second Geophysical Monitoring System delivery. This system was the basis for the evaluation from NDC members during the alpha testers group (ATG) activities in 2021. Two ATG sessions, held in March and October 2021, allowed participants to examine the application program interface, the data storage mechanism and the user interface of the current state of the re-engineered system. The focus of the re-engineering project is now on the station SOH monitoring system, adapting the SOH system received from the NDC in the United States of America to SOH monitoring requirements of the Commission. The next session of the ATG is planned to start in June 2022. It will involve the station SOH component. Additional software components such as the initial capabilities for the interactive analyst interface from the Geophysical Monitoring System and threshold monitoring, delivered by the Norwegian NDC, are being evaluated.

The PTS continued to develop advanced automatic and interactive software that uses state of the art machine learning and artificial intelligence techniques. This includes NET-VISA, a bayesian approach to network processing of SHI data. An interactive module has been developed and provides analysts with NET-VISA events upon demand in addition to the SEL3 automatic bulletin generated by the legacy system, global association. This functionality has been available to all analysts since 1 January 2018. Analysis of the provenance of the REB events shows that about 10% originate from NET-VISA, as expected from previous tests. A test has been performed in a three-pipeline environment on a virtual machine to generate a three-month historical data set where NET-VISA is used to generate SEL1, SEL2, and SEL3. The testing involved the auxiliary seismic station data request mechanism, reproducing the operational configuration very closely. The results of the test have been distributed to the authorized users for evaluation and a presentation was made by an expert at a virtual expert meeting on advances in waveform processing, special studies and ETA in October 2021. One of the outcomes of the evaluation was that the test should be repeated on more recent data to allow for a more direct comparison with the current operational system. This is now in place with the NET-VISA three-pipeline configuration running on a virtual machine in parallel to provisional operations.

This test also includes an alternative SEL3 pipeline where global association is run at SEL3 time and analysts can request these events on demand, simulating the configuration targeted for future operations where the roles of global association and NET-VISA are swapped. Several months of the test results will be provided to the authorized users for evaluation and

analysts will review a few days of this parallel configuration to produce an alternate REB. This will be compared with the standard REB.

The IDC has been testing an updated set of source specific travel time corrections for stations of the IMS seismological networks. This set of corrections includes corrections for the most recent stations for which corrections had not been available previously. It is based on the most recent version of the regional seismic travel time velocity model and the corrections are accompanied by corresponding uncertainties. This updated set of source specific travel time corrections is expected to improve the products of automatic processing (SEL1, SEL2 and SEL3) by associating additional regional phases to events. It will also improve both the accuracy and precision of event spatial-temporal location of the IDC event bulletins, including the REB. Testing is expected to be completed in the first semester of 2022.

In accordance with the Protocol to the CTBT, one of the duties of the IDC is to progressively enhance its technical capabilities as experience is gained in the operation of the IMS. To this end, the IDC has been working on enhancing the quality of the automatic bulletins (SEL1, SEL2, SEL3) and reducing the workload of analysts by tuning the station detection thresholds. In particular, the aim is to minimize the rate of the phases missed by the automatic detection system and therefore added by the analysts, and to maximize the rate of phases detected by the automatic system and associated to events with the sum of observations of associated phases (association rate). The detection and feature extraction and station processing software have been run using different thresholds for all primary seismic stations on a year's worth of data and have been statistically analysed. This effort is expected to be concluded in the first semester of 2022.

Further development, testing and comparison with the REB and SEL3 of the prototype XSEL and Spot Check software, as based on waveform cross-correlation and using historical REB events as master events, has resulted in the quality improvement of the XSEL solutions and higher rate of match with the man-made and automatic events. The interactive Spot Check Tool is under development with the front-end graphical user interface under independent testing. The back-end Spot Check processing is enhanced with several algorithms for detection and local association. The XSEL routine processing has recovered numerous small aftershocks of the Democratic People's Republic of Korea explosions, including those after the third and fourth underground nuclear explosions, which were also confirmed by independent interactive analysis. Detailed study of the Democratic People's Republic of Korea's aftershocks sequence allowed it to distinguish the fifth and sixth underground nuclear explosion aftershocks by the level of mutual correlation at IMS stations PS31 and PS37.

The development of the redesigned detector and interactive review tools based on progressive multichannel correlation DTK-PMCC and DTK-(G)PMCC continued throughout 2021 with a strong emphasis on bringing the software toolkit to an operational level for the IDC, while reinforcing the functionalities for NDC users. The efforts focused on answering all use cases for interactive analysis by the IDC, while the station processing portion is already fully compliant with the IDC automatic processing system needs. Throughout the year the periodically updated software package processed infrasound data in real time for all IMS infrasound arrays in IDC development and IDC test environments. At the end of 2021, a major release of the software package was delivered and successfully implemented and evaluated. The remaining efforts, prior to introduction in IDC operations, are on analyst training and ease of use for routine analysis. The real time processing of data from hydrophone triplets continues in the IDC development pipeline in preparation for the homogenization of software components. The various major releases were implemented in NDC in a box and made available to its user base.

The project to upgrade the ATM pipeline by including the upgraded version of the Lagrangian particle dispersion model FLEXPART has focused on the implementation of one of the enhancements present in FPv09-CTBO, called Vtables. The work on the new version FPv10-CTBTO (FLEXPART version 10, adjusted to the needs of the CTBTO) is ongoing. These changes will provide computational performance gains and more reliable and robust processing.

The IDC, with funding from EU Council Decision VII, conducted three ATM projects to quantify the uncertainties and the confidence level in ATM guidance, to evaluate the benefits of increasing resolution and to develop a launching interface to quickly produce forward and backward ATM simulations. All three projects were completed by December 2020. The scientific results were presented at the CTBT: Science and Technology 2021 conference (SnT2021).

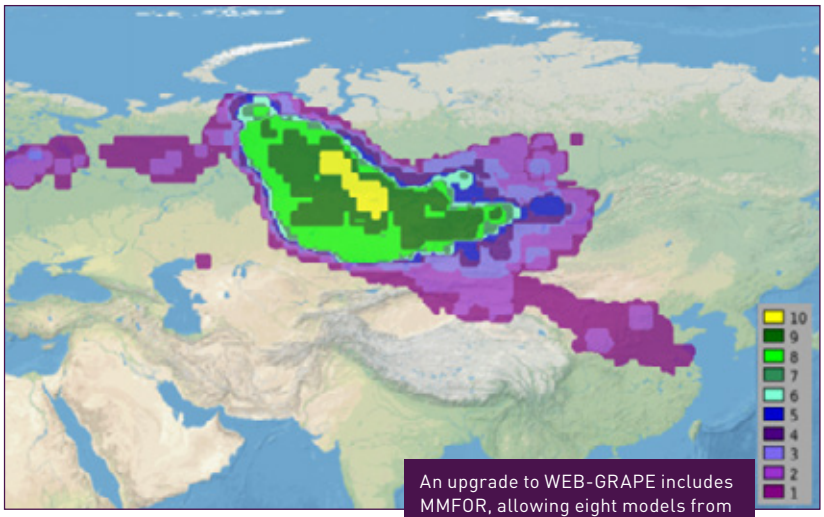
In February 2021, the IDC initiated two related projects through funding from the EU Council Decision VIII to generate a validation data set and a software system to evaluate xenon background estimators and to conduct an exercise to identify the best approach for a new method to estimate the xenon background concentration. Within the reporting period, the preparation of the "1st Nuclear Explosion Signal Screening Open Inter-Comparison Exercise 2021" was finalized and launched. The test data set was prepared with input from internationally recognized experts from the radionuclide/ATM community and consists of real IMS observations with additional contributions from hypothetical nuclear test releases. A set of validation metrics was defined to measure the performance of background estimation to generate the best screening results with regard to the objective of identifying nuclear test signals.

During the reporting period, the WEB-GRAPE Internet based service available in production was upgraded twice: in April and in September. The upgraded version in April, version 2.06, included the following technical and functional enhancements:

- Improved scalability by adjusting resource availability to demand;
- Several usability and stability enhancements;
- New functionality called MMFOR (i.e., the multiple model field of regard).

This latter functionality provides the ability to calculate, overlap and intercompare the field of regard products for an ensemble of models received from Regional Specialized Meteorological Centres.

The new version 2.1.3, available since September 2021, includes a new functionality called possible source region and supports the automatic generation of MMFOR. The new feature allows to render MMFOR with all available models and to generate URLs which could be integrated in all future Standard Screened Radionuclide Event Bulletins for Level 5 samples.



An upgrade to WEB-GRAPE includes MMFOR, allowing eight models from Regional Specialized Meteorological Centres and two models from CTBTO to overlap.

NDC in a box

A new NDC in a box radionuclide software package version 5 on CentOS 7 was released in August 2021 to NDC authorized users and includes radionuclide software enhancements recently deployed in IDC operations. The major highlight of the release is the integration of the new autoSTRADA software. The first version of autoSTRADA performs the automatic processing of beta–gamma coincidence based noble gas data. In addition to the net count calculation method, a beta–gamma matrix analysis module delivered by the Swedish Defense Research Agency has been integrated into autoSTRADA under a MIT license. autoSTRADA handles the already operated beta–gamma noble gas systems (SAUNA II) as well as next generation

technologies (SAUNA III, SPALAX NG, Xenon International and MIKS). The radionuclide NDC in a box automatic pipeline for beta–gamma noble gas data processing switched from bg_analyze over to autoSTRADA. A new version of iNSPIRE which interfaces with autoSTRADA is also included in the new release. In addition, the radionuclide NDC in a box database is also updated in terms of schema and configuration (new stations, new detectors and new Monte Carlo parameters). The new release is supported on CentOS 7 and uses the Red Hat package management system Yellowdog Updater, Modified (YUM). This simplifies installation on physical and virtual machines based on Red Hat Linux operating systems and allows seamless future updates. Two options are available to end users for installing the new radionuclide software package: NDC in a box virtual machine; or installation from the IDC repository using the YUM package management tool.

Upgrades of the SHI components of the NDC in a box software package were released throughout 2021, as new updates became available. These releases integrated major updates of SeiscomP3, Geotool and DTK-(G) PMCC. Upcoming enhancements include replacing Geotool with a new version, GeotoolQt. Upon completion of documentation and testing tasks, GeotoolQt will replace the old, Motif, version of Geotool. The old Motif version will remain part of NDC in a box until all NDCs have migrated to the new application. The Seedlink service, providing near real time waveform data for primary seismic, hydroacoustic and infrasound stations to GCI connected NDCs, reached operational status at the beginning of the reporting period.

International Noble Gas Experiment and Atmospheric Radioxenon Background

The 28 IMS noble gas systems that are in provisional operation at IMS radionuclide stations continued to send data to the IDC in 2021. Data from the 25 certified systems and one system under certification are processed in IDC operations, while data from the remaining 2 non-certified systems were processed in the IDC test bed. The Commission made significant efforts to ensure a high level of data availability for all systems through preventive and corrective maintenance and regular interaction with station operators and system manufacturers.

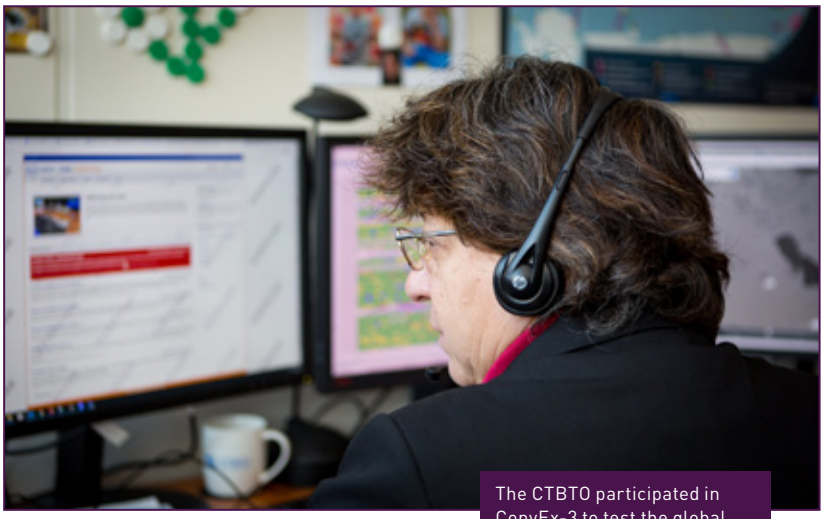
Although the background levels of radioxenon are currently measured at 28 locations as part of the International Noble Gas Experiment, they are still not understood in all cases. A good understanding of the noble gas background is crucial for the identification of potential indications of a nuclear explosion.

An initiative funded by the EU to improve understanding of the global radioxenon background, which started in December 2008, continued in 2021 with EU funding. The objective of this project is to characterize the global radionuclide background and to provide empirical data for validating the calibration and performance of the IMS verification system. In 2021, the Commission continued operating two transportable noble gas systems in Horonobe and Mutsu, Japan. The Commission plans to use the results from this campaign to develop and validate enhanced methods to better identify the source of events that cause the frequent radioxenon detections at radionuclide station RN38 in Takasaki, Japan. These methods will be applied to all IMS stations in order to enhance the capabilities to identify a radioxenon signal that might indicate a nuclear test. A third transportable noble gas system refurbished in 2019 was ready to be deployed to a new site in Fukuoka, Japan, but due to various reasons this was not possible in 2020 nor in 2021.

Civil and Scientific Applications of the Verification Regime

In November 2006, the Commission agreed to provide continuous IMS data in near real time to recognized tsunami warning organizations. The Commission subsequently entered into agreements or arrangements with a number of tsunami warning centres approved by the United Nations Educational, Scientific and Cultural Organization to provide data for tsunami warning purposes. By the end of 2021, 18 such agreements or arrangements had been made with organizations in Australia, Chile, France, Greece, Indonesia, Italy, Japan, Madagascar, Malaysia, Myanmar, the Philippines, Portugal, the Republic of Korea, the Russian Federation, Thailand, Turkey and the United States of America.

IMS infrasound data and IDC products can provide valuable information on a global scale regarding bodies entering the atmosphere. The Commission pursues its collaboration with the University of Oldenburg in Germany on a near real time monitoring system for atmospheric impacts from small near-earth objects, with the involvement of the United Nations Office for Outer Space Affairs and its partners.



The CTBTO participated in ConvEx-3 to test the global response to a fictional nuclear accident.

Real time detection of a volcanic eruption can help reduce the air traffic hazard of ash clouds clogging jet engines. Eruptions around the world are recorded by IMS infrasound stations and reported in IDC products. It is now established that information obtained by infrasound technology is also useful to the civil aviation community. The Commission continues its collaboration with the Volcanic Ash Advisory Centre in Toulouse, France, and extends it to other partner Volcanic Ash Advisory Centres under the patronage of the WMO, the International Civil Aviation Organization and the Atmospheric dynamics Research InfraStructure in Europe community. The Volcanic Ash Advisory Centre in Toulouse presented its volcanic advisory system as well as the volcanic information system that is currently under development, the latter being based on IMS infrasound data, during an invited talk in the disaster risk mitigation elements of the SnT2021 conference.

The Commission contributes to radiological and nuclear emergency response in the framework of its membership in the Inter-Agency Committee on Radiological and Nuclear Emergencies. In 2021, the Commission participated in the ConvEx exercises including the 36 hour international emergency exercise ConvEx-3 (2021) with 77 countries and 11 other international organizations.

The range of scientific applications of IMS data is increasing, including to studies of marine life, the environment, climate change and other areas. Several new contracts for cost-free access to specific IMS data through the virtual Data Exploitation Centre were signed with academic institutions.

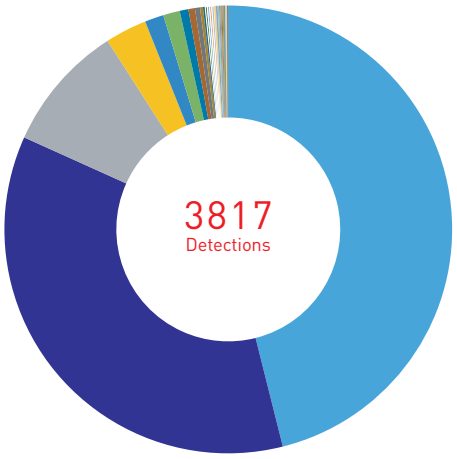
Enhanced Hydroacoustic and Seismic Waveform Modelling

Work continues on developing modelling capabilities to simulate hydroacoustic signals from T-station data. Current efforts build on previous work developing canonical solutions to seismoacoustic propagation, with an additional objective of improving similarities between simulated and observed waveforms by estimating geometry (sensor location, seabed layering, bathymetry) and environmental (oceanographic and geophysical) properties that enhance this similarity.

Development of Special Studies and Expert Technical Analysis Capabilities

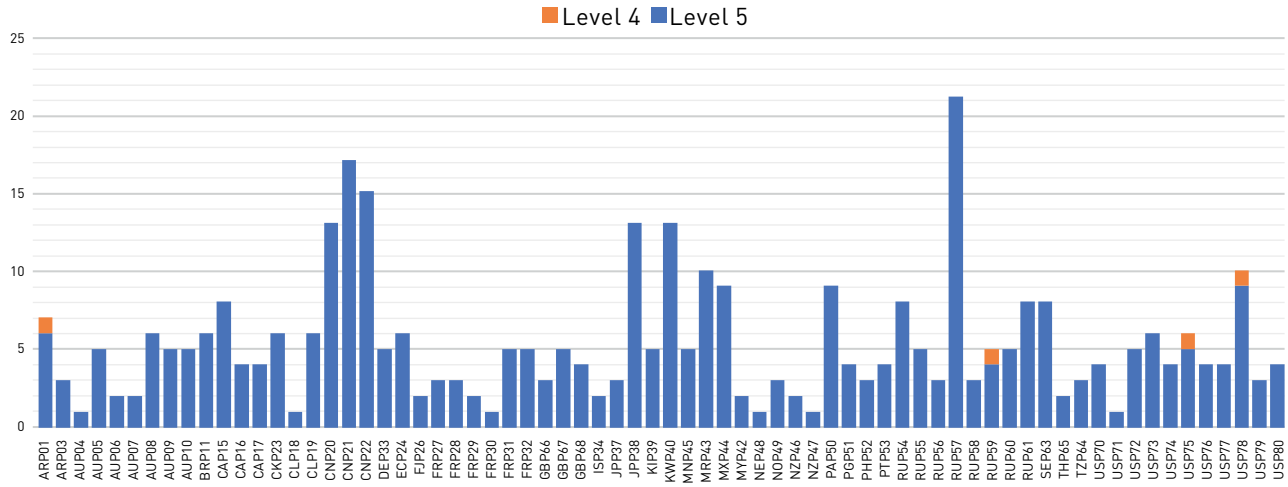
Work continued in both gaining capabilities and clarifying procedures and processes for executing special studies and ETA. In October SHI and radionuclide experts joined in online meetings to present the latest research developments and discuss the practical aspects of executing a special study or ETA under the requirements laid out in the operational manual. Together the experts also continued developing a list of suitable methods, gave their feedback on the first draft standard operating procedures and the draft template for the State Requested Methods Report. Progress was made in developing the methods for ETA, creating URR capabilities in IDC operations and implementing the Updated Event Bulletin on the testbed.

Treaty Relevant Radionuclides Detected in 2021

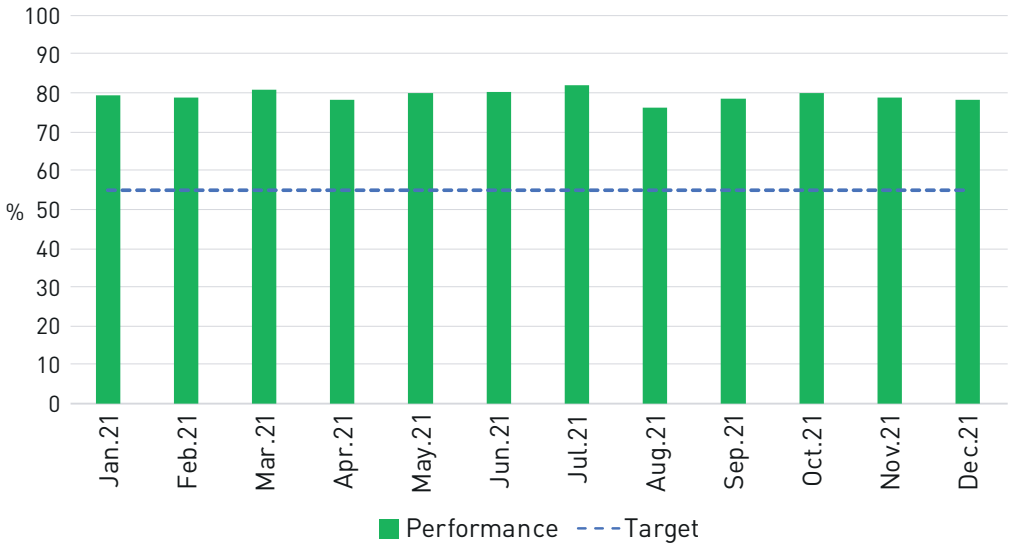


NA-24	(1759)	CO-58	(6)	SC-46	(2)
CS-137	(1361)	CR-51	(6)	BA-140	(2)
I-131	(351)	K-42	(6)	ZR-89	(1)
CO-60	(115)	ZN-69M	(6)	AG-111	(1)
CS-134	(52)	CE-144	(5)	SB-124	(1)
TC-99M	(46)	FE-59	(5)	RB-84	(1)
MN-54	(24)	CE-141	(4)	I-135	(1)
NB-95	(18)	RU-106	(3)	AU-198	(1)
SB-122	(14)	RU-103	(3)	SB-127	(1)
I-133	(8)	ZR-97	(3)	CE-143	(1)
ZN-65	(6)	ND-147	(3)	MO-99	(1)

Radionuclide Events Recorded by IMS Particulate Stations in IDC Operations in 2021



Correctly Categorized Automatically Processed Radionuclide Sample Spectra



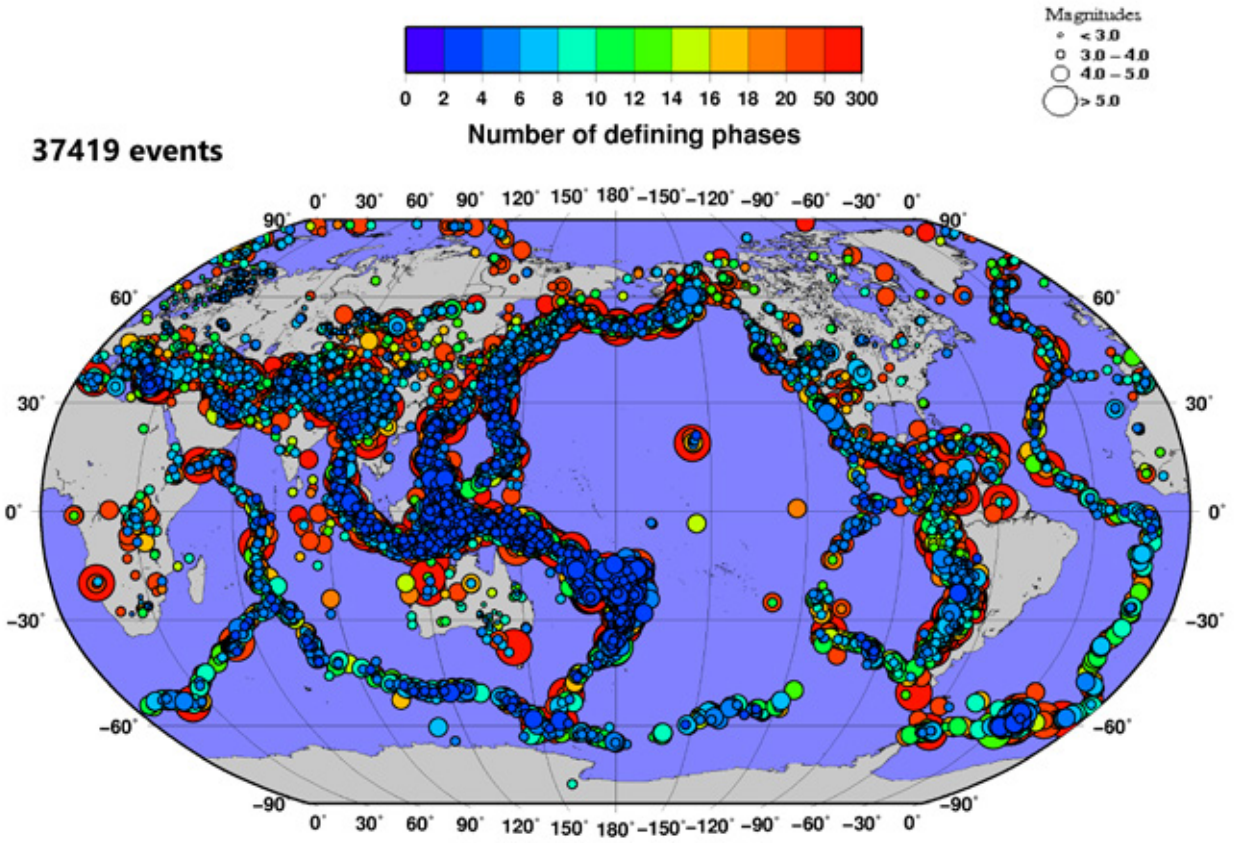
Updating Documentation of Basic IDC Analysis Procedures

In line with the responsibilities of the IDC set forth in the draft IDC Operational Manual Rev. 7, and in particular the provision of implemented methods and algorithms to all States Parties, efforts have been made to update technical documents with transparency about changes. This ensures open and convenient tracking of individual changes in the documents.

Formats and Protocols for Messages, IDC-ENG-SPC-103.Rev.7.3. Efforts have continued to reflect the latest developments of IMS data and IDC products since 2016. Updates regarding the definition of the radionuclide laboratory report for noble gas samples have been completed in 2021. Other improvements include the addition of a glossary and an abbreviations list. A new revision is expected to be released in the first semester of 2022.

The new revision of the IDC database schema, IDC-ENG-MAN-104.Rev.6, is the first review since 2002 and was released at the beginning of 2021. The 2002 version, which has been in use, is outdated with respect to recent developments in analysis procedures and software.

IDC processing of the SHI data user guide, IDC/OPS/MAN/001/Rev.2, has replaced Rev.1 and has been available to NDC users through the secure web portal since January 2021. Efforts to further update this document have continued and sections regarding the mb:Ms screening criterion, calculation of phase amplitude and period, the calculation of source specific station corrections and the mb magnitude estimation using the maximum likelihood method have been updated. An updated version of this user guide is expected to be released in 2022.



Events, with magnitude, that occurred during 2021.

CTBT: Science and Technology Conferences

The SnT2021 conference took place from 28 June to 2 July 2021 with more than 1600 registrations from 150 countries and the PTS. For the first time, the conference was organized in a hybrid format. The opening session on the first day (28 June 2021) took place in the Hofburg palace with a limited presence (approximately 200 participants) and was broadcast live to over 1000 online participants. The remaining four days (29 June to 2 July) were held on the virtual conference portal and managed from within the Vienna International Centre (VIC) with about 1500 participants. The virtual part included the traditional scientific and technical sessions as well as panels, invited talks, e-posters, side events, virtual round table discussions and breakout video rooms.

SnT2021 covered two main themes. First, the 25th anniversary of the opening for signature of the Treaty presented an opportunity to review the scientific and technological advancements made and to project what developments can be expected in the next 25 years. It was marked with a series of invited talks and associated panels, discussing the evolution over the last 25 years, and the challenges and prospects for the future. Second, the COVID-19 pandemic and associated restrictions have been a resilience test for the monitoring system; a test from which valuable lessons can be learned. This was discussed in several dedicated sessions of oral presentations describing the experience and lessons from around the world, as well as in a panel that addressed these questions in a wider perspective.

The SnT2021 content is captured in a conference report that will be completed in 2022. Two complementary initiatives are also taking place. First, some of the scientific and technological advancements presented during SnT2021 and depicted in the publication "Nuclear Explosion Monitoring and Verification: Scientific and Technological Advances" are portrayed in a special issue of the Pure and Applied Geophysics journal (July 2021) Volume 178, Issue 7, Springer Nature. Second, a monograph on key technical accomplishments of the verification regime will be compiled for the 25th anniversary of the opening for signature of the CTBT.

The hybrid nature of the SnT2021 conference meant sessions were streamed online.

4 ON-SITE INSPECTION

Highlights

Development of the OSI programme of work for 2022-2023 and future OSI exercise programme

Finalization of the first comprehensive draft list of equipment for use during OSIs

Conclusion of the third training cycle for OSI inspectors

The IMS and IDC monitor the world for evidence of a nuclear explosion. If such evidence were to be detected, the Treaty provides for concerns about possible non-compliance with the Treaty to be addressed through a consultation and clarification process. After the Treaty enters into force, States can also request an OSI, which is the final verification measure under the Treaty.

The purpose of an OSI is to clarify whether a nuclear explosion has been carried out in violation of the Treaty and to gather facts that might assist in identifying any possible violator.

Since any State Party can invoke an OSI at any time, the capability to conduct such an inspection requires policies and procedures to be developed and inspection techniques to be validated before the Treaty enters into force. In addition, OSIs require adequately trained personnel, approved core inspection equipment, appropriate logistics and related infrastructure to sustain a team of up to 40 inspectors in the field for a maximum of 130 days while enforcing the highest standards of health, safety and confidentiality.

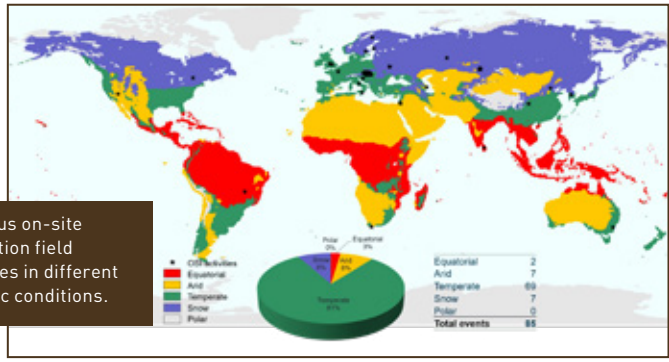
Over the years, the Commission has continuously strengthened its OSI capabilities through the preparation and development of OSI elements, the conduct of field tests and exercises, and the evaluation of its OSI activities. With the conclusion of the OSI action plan 2016-2019, the third training cycle and OSI exercise plan 2016-2020, the Commission has started a new cycle of OSI development by planning the OSI programme of work for 2022-2023 and the future OSI exercise programme.

Programme of Work for 2022-2023

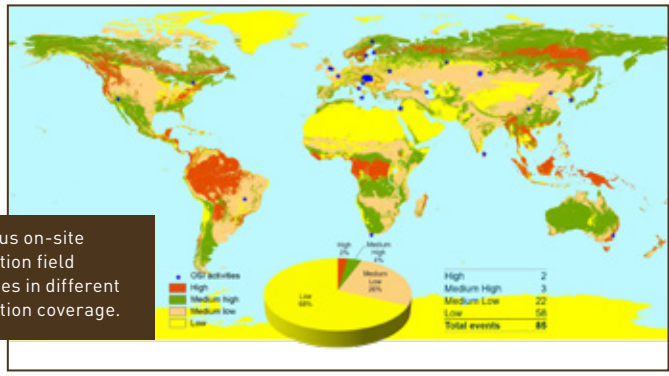
The COVID-19 pandemic resulted in substantial disruption to the regular activities of the OSI Division including the planned conduct of the field build-up exercises (BUEs) which were originally scheduled in 2020, subsequently postponed to 2021 and ultimately cancelled.

The OSI Division therefore began conceptual planning for a future programme of work to further improve the readiness of the Organization to conduct OSIs by the time of entry into force of the CTBT. In order to provide structure and transparency regarding the expected work of the OSI Division in the short term until such a point where field testing and validation activities are possible, the PTS has developed a two-year programme of work. An initial concept was presented to the Fifty-Seventh Session of WGB in August 2021 prior to its finalization and publication in December 2021.

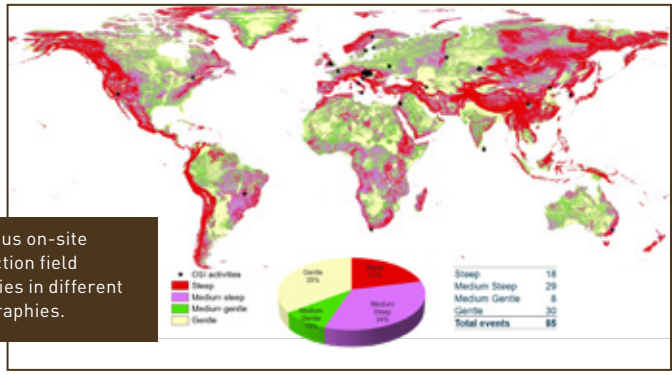
The OSI programme of work for 2022-2023 covers the breadth of tasks expected to be undertaken by the OSI Division during 2022 and 2023. However, its implementation must remain flexible to adapt to changing circumstances in these uncertain times.



Previous on-site inspection field activities in different climatic conditions.



Previous on-site inspection field activities in different vegetation coverage.



Previous on-site inspection field activities in different topographies.

Policy Planning and Operations

OSI policy planning and operations efforts during 2021 were focused on reviewing the outcomes and results of the 2016-2019 OSI action plan and the implementation of the OSI exercise plan.

Following the recommendations from OSI Workshop 24 to focus on OSI in challenging environments and events other than underground, a technical report on operationalization of OSI in different environments was finalized and published. Four challenging environments were identified: mountainous areas, high seas, extreme climates and high vegetation areas.

As the Geospatial Information Management for OSI (GIMO) system could not be tested, since the planned BUEs had been cancelled, the OSI Division conducted an operational test of selected GIMO applications. The objectives of the operational test were a demonstration of selected aspects of GIMO functionality and a stress test of GIMO including the capabilities of the local area networks at the inspection team working and receiving areas. The operational test successfully proved the advanced state of GIMO development and served to underscore that GIMO, in terms of existing and planned functions, meets the requirements of inspection team functionality. Furthermore, the tested GIMO components were shown to be stable, streamlined, integrated and user friendly. The technical report for the test was published in Information Paper CTBT/PTS/INF.1603.

The OSI ultra-high frequency radio system has been updated and the maintenance of the remaining communications equipment was carried out in January 2022. Preparations for an expert meeting in communications to be held in April 2022 started in accordance with the approved plan. Due to COVID-19 restrictions

GIMO working area with 10 zero client terminals, network switch and server. The test configuration closely mimics the deployment configuration with the exception that the server itself would be located in a sealed, air-conditioned intermodal transport container during an OSI.

the communication field tests planned for 2021 were postponed and will include testing of an updated concept for OSI communications as well as an updated OSI communication system.

The OSI Division continued to support the health and safety initiatives of the Commission during the COVID-19 pandemic with the distribution of protective equipment. This included masks for staff members and external stakeholders with access to operational areas. Links were established with other international organizations in Vienna in order to have a coordinated response to the pandemic.

As part of the PTS wide health and safety project, initiated to develop a Health and Safety Policy in line with the Medium Term Strategy 2018-2021, the OSI Division continued development of the OSI related health and safety documentation, procedures and specification of the relevant equipment.

A number of Quality Management System (QMS) documents were reviewed and updated, notably the SOP on point of entry procedures, the SOP on OSI data and information management and the use of GIMO, and the work instruction on developing and handling the progress inspection report, proposal to conduct drilling, request to extend the inspection duration and recommendation to terminate the inspection.

Several policy planning and operations subject matter experts participated in SnT2021 as conveners and moderators of OSI related sessions, as well as presenters of papers and e-posters.

On-Site Inspection Exercise Programme

As the two field BUEs had to be cancelled due to the COVID-19 pandemic, the Integrated Field Exercise 2014 (IFE14) remains the last large scale OSI field exercise conducted. In response to comments from States Signatories at WGB, the OSI Division began initial work on the development of a programme of future OSI field exercises.

The Executive Secretary provided a formal mandate to initiate the exercise development and implementation process in August 2021. The aim of the future exercise programme shall be to demonstrate and evaluate the current level of OSI capabilities and to identify areas for further improvement in order to prepare the CTBTO to conduct effective OSIs upon entry into force of the Treaty.

In September 2021 the OSI Division established a Consultative Group of Experts with selected experts from States Signatories in various OSI areas invited to participate. The objective of the Consultative Group of Experts is to leverage the expertise of States Signatories and obtain guidance and advice on strategic, technical and substantive matters for the PTS on its development and implementation of future OSI exercises.

The PTS subsequently developed a draft OSI exercise programme based on the feedback that was published in January 2022.

Equipment Procedures and Specifications

Through the consolidation of the findings of the OSI action plan 2016-2019, the OSI Division finalized the first comprehensive draft list of OSI equipment specifications, which was submitted as Information Paper CTBT/PTS/INF.1573. The draft list was prepared in accordance with guidance provided by WGB and adopted by the Preparatory Commission. The document provides for specifications relating to the core equipment for inspection activities and techniques specified in Part II, paragraph 69 of the Protocol to the CTBT, with the exception of drilling (paragraph 69 (h)). It is now available for in-depth technical discussion with national experts with the objective of consolidating the draft list prior to its consideration by States Signatories at subsequent sessions of WGB and the Preparatory Commission.

Detailed technical reporting on OSI technology development was advanced in order to preserve and institutionalize current OSI capabilities. A series of technical reports documenting the history of equipment development, chronicling the design, testing and validation steps for each technique, were drafted. To date, four draft technical reports have entered the editorial process, with several others in preparation. It is expected that the technical reports will be published in 2022.

The ongoing operationalization of the Equipment Storage and Maintenance Facility portion of the TeST Centre gained momentum thanks to partial breaks from the operational limitations introduced due to the COVID-19 pandemic. Progress was made on the Equipment and Instrumentation Management for OSI (EIMO) system, which serves as an interface to interact with the database of OSI configurations, systems and items. EIMO was also developed and tested for the receiving and working areas. The version of EIMO designed for operational use at headquarters is now routinely used to facilitate the management of the maintenance, calibration and protection of equipment. The development of EIMO, incorporating equipment maintenance plans coupled with the gradual roll-out of radio-frequency identification technology to track equipment movement, sealing of containers as a norm and streamlining of internal procedures, means that OSI is moving closer towards operational readiness.

To enable the design and fabrication of components for inspection techniques and support equipment, facilities in the maintenance area of the TeST Centre have been enhanced with 3-D printers, an oven for annealing and a 3-D scanner.

Airborne Techniques

A project on airborne magnetics concluded with a field test for the detection of OSI-relevant observables. This followed a review of the current state-of-the-art of this particular technique and the modelling of magnetic signatures created by six different groups of OSI-relevant observables. The findings of the work will be incorporated into a technical report on airborne magnetics.

Airborne field test for the detection of OSI-relevant observables.

Geophysical Inspection Techniques

An adapted version of the passive seismological monitoring for aftershocks software was released for remote offline use. This underlines the maturity of the technique and provides valuable material for training. It is a milestone in capacity building and training as it is the first time software related to an inspection technique is available on demand for remote training and practice purposes.

To maintain the capability to transmit data acquired for passive seismological monitoring for aftershocks between the inspection area and the base of operations (BOO), the OSI Division initiated an upgrade of equipment and software with delivery and testing slated for 2022.

Measurements of Radioactivity and Radionuclide Particulate Related Inspection Techniques

With respect to the detectors in the OSI field laboratory, additional and modular lead layers were designed and added to fit to the cooling rods. These protect the germanium crystals from background radiation emitted from the ground, enhancing the detectability by 40% or more for OSI relevant radionuclides in sample measurements in the OSI field laboratory.

A computer test bed configuration for the OSI field laboratory was acquired and installed at the TeST Centre. The configuration includes servers and networked client computers to validate new or upgraded operating systems, software modules or equipment before their incorporation into an operational configuration.

OSI field laboratory software development focused on the streamlining of data flow for the chain of custody and sample measurement. A partial field laboratory workflow was demonstrated during the June 2021 operational test of the GIMO system, together with particulates and noble gas environmental sampling and gamma radiation monitoring techniques. The feedback collected and lessons learned were documented in the Information Paper CTBT/PTS/INF.1603 and will support the further development of software elements in the OSI field laboratory.

Portable high purity germanium detector.

As part of the maintenance programme, gamma radiation monitoring sensors were calibrated for energy and efficiency by an external laboratory. Procedures for calibration and reporting were revised and acceptance criteria and key performance indicators were added. These procedures will be incorporated into OSI QMS documentation, together with new records as sensor calibrations are conducted, to provide for long term monitoring and identification of any performance degradation.

Noble Gas Related Inspection Techniques

Noble gas sampling configurations were upgraded in line with specifications set out in CTBT/PTS/INF.1573. As part of the upgrade, data loggers were procured for the readout and storage of data from meteorological sensors. In addition, four systems for monitoring subsurface gas quality were designed, constructed and delivered. The degassing system to extract noble gases from water was redesigned and constructed, with delivery expected in 2022. This will complete the current cycle of noble gas sampling acquisitions. Sampling capabilities will be tested in-house in 2022 and 2023.

A prototype liquid argon scintillation detector was delivered and had promising experimental results. The final report identified areas for system enhancement, notably with respect to argon purity and light collection efficiency. These recommendations resulted in further development of the prototype system, with the findings expected to be reported in late 2022.

The upgrade of the SAUNA system commenced with the aim to further increase and standardize sample throughput and improve sample chain of custody. The design manufacturer of the system, the Swedish Defense Research Agency, was contracted to design, construct and deliver a multi-sample inlet and radio-frequency identification tags, along with the necessary software to operate this new hardware. Delivery, installation and training is expected in the second quarter of 2022.

Field Operations Support

A report on the overall development of a preparedness and deployment capability for OSI equipment was produced. This was based on an in-depth review of documentation and reports to clarify the concept of preparedness and deployment in the context of an OSI. The report integrates all key components and enablers of preparedness, rapid deployment and in-field support for an inspection and includes guidance on its implementation by covering

Deployment of a magnetometer.

aspects on the management and delivery of the deployment capability. The report also provides guidance for future work towards the delivery of the required logistics support and readiness for the entry into force of the CTBT.

A comprehensive overview was conducted of OSI electrical equipment holdings to categorize the equipment and define testing requirements to comply with safety obligations and European standards. Guidelines for equipment electrical safety check requirements were delivered and these are currently being integrated into EIMO.

The managed replacement of BOO infrastructure with modularized units commenced with the delivery of accommodation modules. This is the first set of standardized and interoperable modules. The phased replacement will continue in 2022 with further accommodation modules followed by other areas of the BOO.

The testing of the redesigned Intermodal Rapid Deployment System containers in a field laboratory configuration was completed, including an on-site visit by the container design engineers. Several areas were identified to improve the field functionality of the containers. The procurement of an amended design was initiated to resolve these deficiencies and plan for a redesigned prototype to be delivered in 2022.

The last major products of the OSI action plan projects, related to OSI logistics and operations support, were delivered in 2021 due to delays caused by COVID-19 restrictions. The cataloguing of delivered products was completed and the testing of function and interoperability in suitable field activities is planned for 2022-2023.

On-Site Inspection Documentation

Activities during 2021 involved providing support to WGB in its elaboration of the draft OSI Operational Manual, coordinating revision of OSI QMS documents, and maintaining the document repository. This included the OSI e-Library and documentation rooms at the VIC and the TeST Centre.

The OSI Division continued to provide substantive, technical and administrative assistance to WGB in its third round of elaboration of the draft OSI Operational Manual. Despite the curtailed work programme of WGB due to the pandemic, the Task Leaders were offered support in their efforts to advance substantive discussion on the issues related to the Operational Manual.

Preparations have commenced for OSI Workshop 25 to be held in 2022 with in-person participation, providing the worldwide pandemic situation permits. The workshop aims to conduct in-depth technical discussions on the first comprehensive draft list of equipment for use during OSIs with a view to its review and further development.

The existing OSI QMS documents have been continuously revised based on lessons learned from the implementation of OSI action plan for 2016-2019 and the BUE launch phase exercise. Seven documents on topics including health and safety standards, management of electronic recording devices, inspection team point of entry activities, inspection team negotiations, progress inspection report drafting, and planning and management of OSI exercises have been revised. Revisions of the documents on establishing the BOO, health and safety manual, SOPs and work instructions have been initiated.

Efforts have been made to consolidate the OSI QMS documentation system. The list of the OSI topic codes for documentation has been revised within the PTS QMS framework to reflect improved and future OSI related procedures and techniques. OSI QMS forms and templates have continued to be updated to ensure both the contents and format meet current requirements.

The management and enhancement of the OSI e-Library continued in 2021. The update of the underlying software of the e-Library was completed resulting in the e-Library version 2.0. The new version enjoys improved maintenance efficiency and simplified user management. The synchronization of the e-Library from headquarters to the field can now be conducted automatically every 24 hours, replacing the previous manual replica functionality, which marks a technical improvement for the platform.

OSI documentation room at the CTBTO Test Centre.

On-Site Inspection Training Courses and Workshops

The OSI Division conducted 11 training activities in 2021 with an aggregate participant number of 586 in all courses, illustrating the Division's resilience and business continuity despite COVID-19.

The third training cycle for OSI inspectors (3TC), principally designed to develop and validate the training curricula for use after entry into force of the Treaty, concluded in May 2021 with the delivery of the last scheduled course delayed by COVID-19. The pandemic has required a shift from a hybrid learning approach to a fully online teaching model and all training events were conducted online.

The leadership skills course was the last scheduled course of the 3TC programme and was conducted in an interactive online format. Twenty-four surrogate inspectors representing 12 States Signatories, as well as OSI staff slated to deploy as the inspection team leadership for the BUEs before its cancellation, participated in this course. These acquired competencies are planned to be tested in a field environment in future OSI field training exercises.

Following the conclusion of the 3TC, the expert meeting on further development of the OSI inspector training programme was conducted online from 21-25 June 2021. The aim of the meeting was to evaluate the implementation of the 3TC, identify and address any training gaps and provide recommendations for the next OSI training work programme that is now under development. A summary of the planning, preparations, method of work and output of the meeting can be found in CTBT/PTS/INF.1598. In total, 74 subject matter experts on all OSI activities representing 42 States Signatories and 15 PTS staff attended the meeting.

Implementing a key recommendation from the expert meeting, an online OSI Community of Practice website was launched in October 2021. It enables the global OSI community to keep in touch, exchange ideas and stay informed about the latest OSI updates and developments. In addition, the site serves as a resource hub and features

various discussion boards, live streams and summaries of various events, newsletters and internal social networking features.

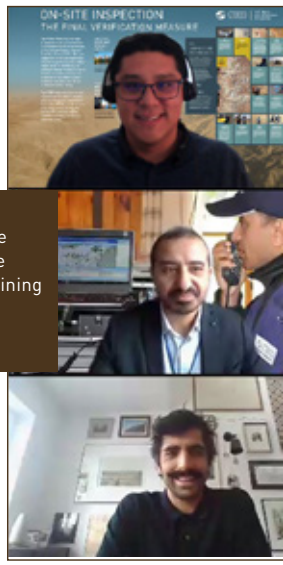
Noting the on-site training schedule gap with the cancellation of the BUEs, the PTS continued to engage with the surrogate inspector trainees from all training cycles with a series of monthly webinars from July 2020 to March 2021. The monthly webinars covered OSI training topics that aimed to provide refresher training and kept the trainees engaged with OSI topics remotely. By March 2021, three OSI specific webinars were conducted with an aggregate participant number of 382 surrogate inspectors representing 52 States Signatories.

An important development of the OSI remote training programme is the deployment of a series of Web based software training courses on OSI operational software that can be accessed remotely by trainees. This initiative provides remote access to functional versions of processing and analytical software used in OSI techniques and field data management tools.

In June 2021, a test user group comprised of eight seismic technique experts from seven States Signatories successfully tested the remote software training package on passive seismological monitoring of aftershocks software. This marks the first time that software related to an inspection technique was made available remotely to trainees. The test was followed by a refresher webinar on 29-30 November 2021 and will be delivered as a task based remote software training course to all seismic technique surrogate inspectors on 13 and 14 December 2021. The software training package will eventually be available as a Web based on-demand user-directed remote training course for the foreseeable future.

From 27 October 2021, a series of biweekly remote software training sessions on EIMO were delivered to all surrogate inspectors and will continue until 2022. This course provided hands-on remote training on essential EIMO functionalities using a simulated point of entry environment. During this reporting period, 62 surrogate inspectors representing 29 States Signatories participated in the training.

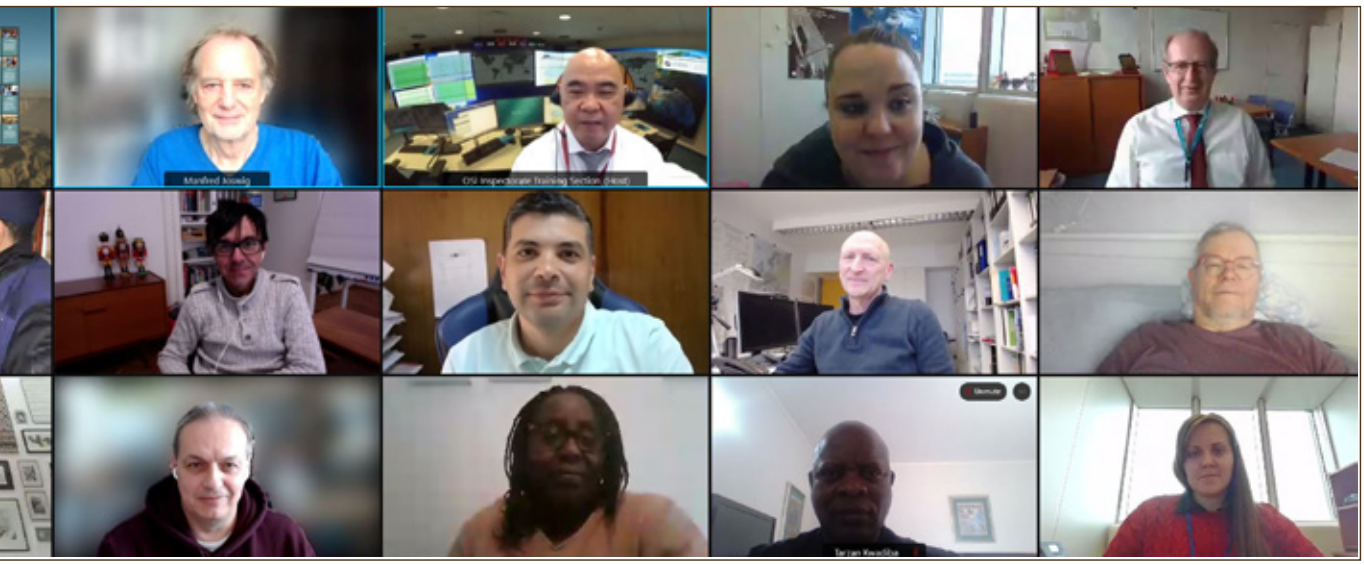
EIMO remote software training.



Participants attending the EIMO remote software training session.

Filming an e-learning module.

Inside the remote software training room.



5 IMPROVING PERFORMANCE AND EFFICIENCY

Highlights

Further development and consolidation of the Quality Management System

Consolidation and enhancement of robust performance monitoring tools and refinement of key performance indicators

Technical evaluation of IDC progressive commissioning and progress in the operationalization of OSI capability

At all stages of the process of establishing the Treaty's verification system, the Commission aims for effectiveness, efficiency, sustainability and client orientation (i.e., States Signatories and NDCs). The Quality Management System of the PTS is an essential element of a robust verification system for the Commission.

Continual improvement is essential for the QMS and, together with rigorous performance monitoring and evaluations, it ensures that the work to establish the verification system complies with the requirements of the Treaty, its Protocol and the guidance of the Commission.

Evaluation

The comprehensive review of all evaluations of the first cycle of four experiments covering all functionalities of the IMS, IDC and GCI components in the context of the progressive commissioning of the IDC has been completed.

In order to ensure continual improvement of the verification system, the follow-up on the status of implementation of recommendations and improvements resulting from the evaluation of the first cycle of experiments continues in close cooperation with the IDC.

A sustainable evaluation methodology is consolidated for independent evaluations to be performed by a team composed of experts from States Signatories, assisted by QMPM, up to the elaboration of the final evaluation report to be presented to States Signatories.

A new series of experiments is being prepared based on lessons learned from the first cycle, including the development of TIPs focussing on specific quality aspects of the verification system and the development of related performance indicators as part of the progressive commissioning of the IDC.

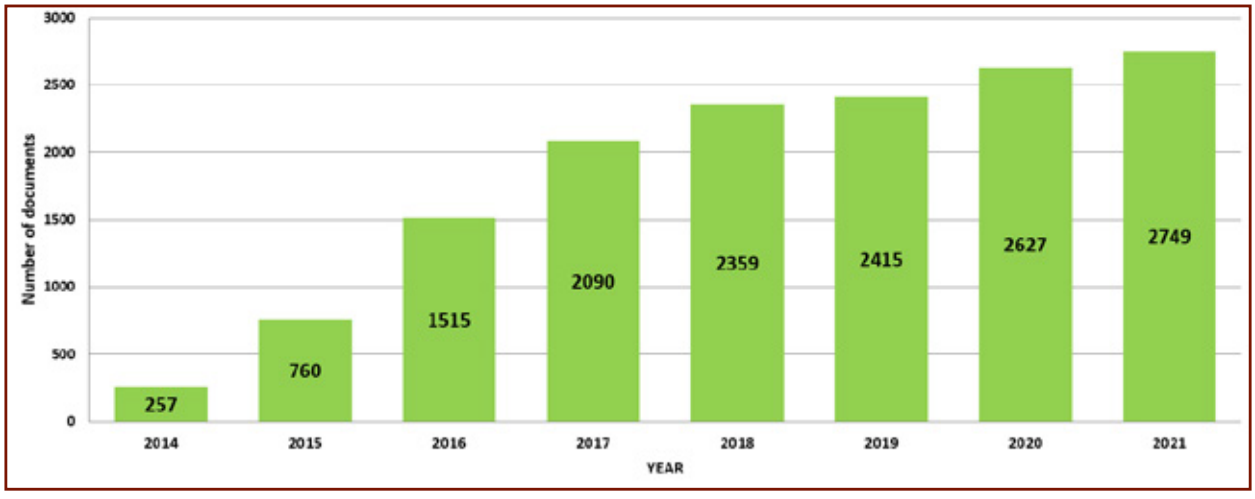
The Evaluation Information Management System prepared for the OSI BUEs was maintained for the evaluation of future OSI exercises, based on lessons learned from past exercises.

Performance Monitoring

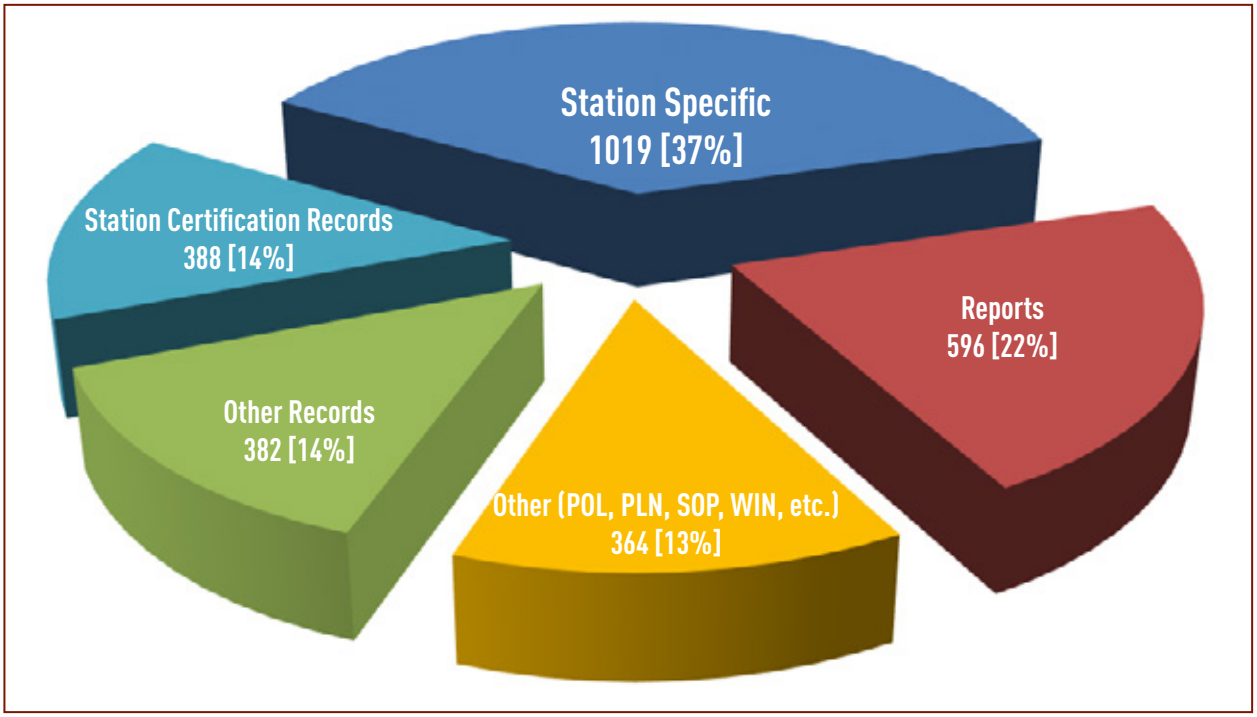
The implementation and the closure of recommendations and improvements resulting from evaluations are formally tracked, as part of the continual improvement process of the QMS applied to the verification system.

The PTS continues to enhance performance monitoring tools, including the performance reporting tool (PRTool) accessible to experts from States Signatories, primarily focusing on the quality of processes, data and products related to the development and provisional operation of the verification system.

Number of Documents in the Quality Management System Repository



Distribution of Quality Management System Documents



A technology refreshment of PRTool has been carried out to ensure accurate and sustainable monitoring of the various components of the verification system. This ensures that every function is continuously monitored independently of the technical solution implemented during a particular period of time to validate the long term sustainability of a well performing verification system.

A quality assurance process for validation of metrics and performance indicators has been formalized to complete the configuration management of the performance monitoring software, ensuring the reliability and sustainability of the performance monitoring tools of the PTS.

Specific metrics and performance indicators are being developed in preparation for future experiments within the IDC Progressive Commissioning Plan in association with the Test Implementation Plans specific to each experiment.

Quality Management

The continued development of a QMS is instrumental in providing States Signatories and the Commission with the necessary confidence in the functioning of the PTS and in its products and services.

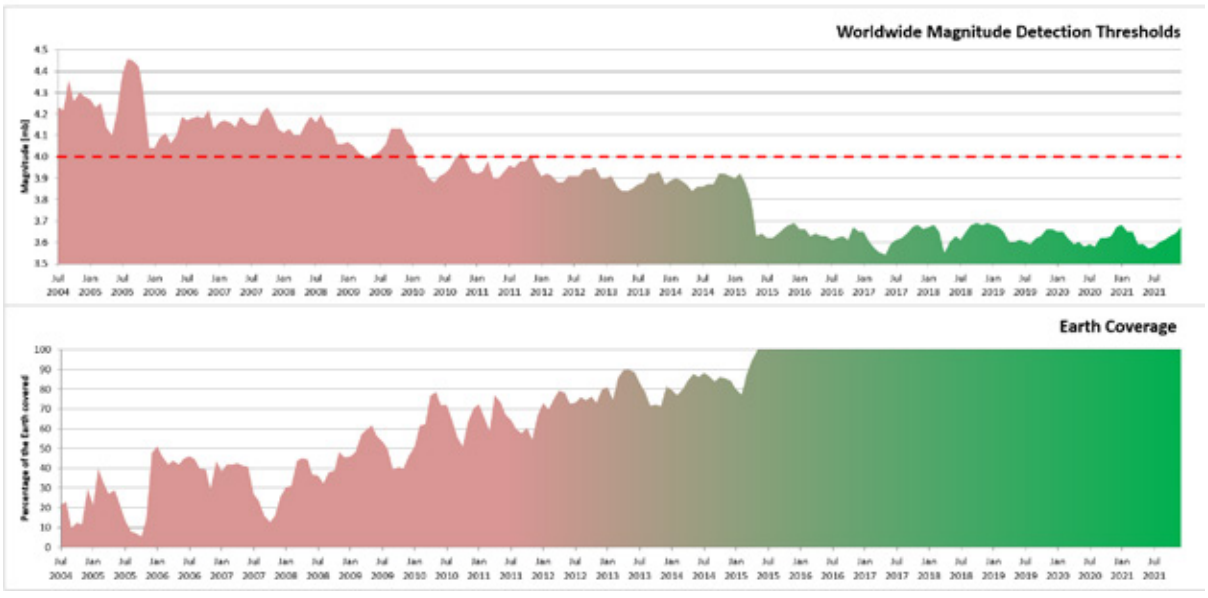
The foremost quality objectives of the PTS are to provide States Signatories with data and products of the highest quality and to continuously improve efficiency and effectiveness in all its activities.

The PTS continued to develop its QMS, fostering a quality culture amongst PTS staff for a shared understanding and commitment to the PTS mission and its quality objectives.

With more than 2700 documents filed, the QMS documents management system, an essential part of the QMS, provides univocal access to the latest approved versions of documentation with a significant effort on formalizing procedures in 2021.

In order to continue consolidating the reliability of data and products of the verification system, QMPM is collaborating with the IMS, IDC and OSI Divisions to progressively align, as appropriate, the ongoing practices related to the production of data and products to ISO 17025 requirements. Client orientation is an essential principle of the QMS. Therefore the Commission continued to prioritize feedback from NDCs, which are the main users of its data, products and services, and to encourage them to actively contribute through the established channels to review the implementation of their recommendations. The tracking of recommendations resulting from evaluations is being used to support closing NDC recommendations.

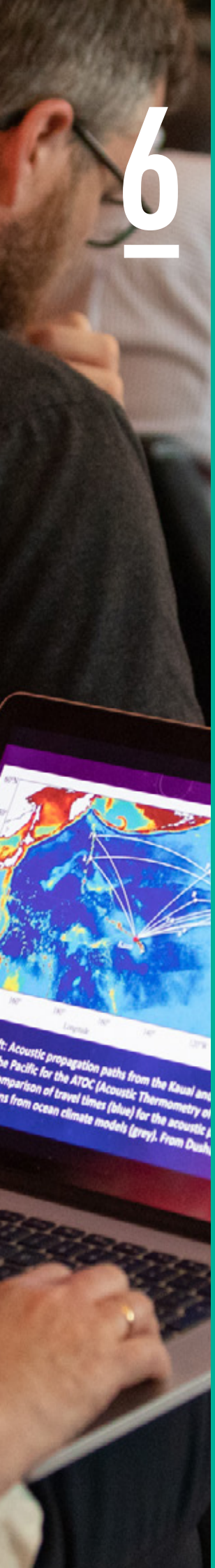
2004-2021 Continuous Assessment of Global Seismic Detection Capacity



Top: Time evolution of worldwide magnitude detection thresholds.
Bottom: Time evolution of the percentage of the total surface of the earth for which events of magnitude mb=4.0 can be detected at 90% confidence level.

Improvement of Timeliness of the Interactively Reviewed Products

Left: Reviewed Radionuclide Report for noble gas monitoring systems.
Centre: Reviewed Radionuclide Report for radionuclide particulate stations.
Right: Reviewed Event Bulletin for seismic, hydroacoustic and infrasound technologies.



6 INTEGRATED CAPACITY DEVELOPMENT

Highlights

Continued capacity development activities

Ensuring integration of NDC capacity building with policy and educational outreach activities

Further development of online events and e-learning

The Commission offers States Signatories training courses and workshops on technologies associated with the three pillars of the verification regime – the IMS, the IDC and OSI – as well as on the political, diplomatic and legal aspects of the Treaty. These courses help to strengthen national scientific and decision making capabilities in relevant areas and assist in developing capacities in States Signatories to effectively confront the political, legal, technical and scientific challenges facing the Treaty and its verification regime.

In some cases, the Commission provides equipment to NDCs to increase their capacity to participate actively in the verification regime by accessing and analysing IMS data and IDC products. There is a need to update the knowledge and experience of national experts as technologies expand and improve. By enhancing the technical capabilities of States Signatories, these activities empower all stakeholders to participate in the implementation of the Treaty and to enjoy the civil and scientific benefits of its verification regime.

Training courses are held in person at the Commission headquarters in Vienna and at other locations, often with the assistance of host States, as well as virtually via videoconferencing. The capacity building programme is funded through the Regular Budget of the Commission and through voluntary contributions. All training activities have a well-defined target group, offer detailed content, and are complemented by the educational platform and other outreach activities to the broader scientific community and civil society.

Activities

The Commission offered States Signatories a wide range of training courses and workshops aimed at strengthening capacities in areas relevant to the Treaty. Capacity development activities also included the provision of hardware and software to NDCs, especially those in developing countries, enabling them to access and analyse IMS data and IDC products. They also included training courses and workshops on various OSI activities.

Due to the COVID-19 pandemic, many of the capacity development events of the Commission were moved online in 2021. Through virtual videoconferencing, the Commission was able to provide and conduct online training courses, expert meetings and workshops. The Commission is building upon experiences gained from 2020 in hosting events virtually. Some recordings of these technical virtual events are being archived in order to engage the next generation for use as future training material and for reference purposes. In addition, the number of experts on scientific and technical issues related to the verification regime attending workshop and expert meetings has significantly increased due to online attendance, despite the challenges of maintaining audience engagement during such activities.

International Data Centre and National Data Centre Training Courses and Workshops

Integrated capacity development and training activities in 2021 continued online, based on the lessons identified in 2020 in handling the unprecedented challenges due to the COVID-19 pandemic. In 2021, NDC technical staff, station operators and experts from States Signatories participated in 21 online events (8 online NDC training courses, 6 online training sessions for station operators, 5 online technical expert meetings, 1 online workshop and a webinar for station managers).

Eight training courses on NDC capacity building took place during the reporting period. Their objectives were to understand the roles of NDCs in the verification regime, to build and/or to improve NDC capabilities, to provide participants with sufficient knowledge for accessing and using IMS and IDC data and for Treaty verification and civil and scientific applications purposes including using NDC in a box and SeisComP3 software.

- An online training course on NDC capacity building: access and analysis of waveform IMS data and IDC products took place from 8 to 12 February 2021 with 44 participants from 25 countries.
- An online training course on NDC capacity building: access and analysis of radionuclide IMS data and IDC products from 1 to 12 March 2021 with 45 participants from 25 countries.
- An online NDC capacity building training course on access and analysis of waveform IMS data and IDC products took place from 5 to 9 July 2021 with 44 participants from 31 countries.
- An online NDC capacity building: NDC waveform training course using SeisComP3 for the Africa and Eastern Europe regions took place from 27 September to 1 October 2021 with 14 participants from 13 countries.
- An online training course on NDC capacity building: access and analysis of radionuclide IMS data and IDC products from 4 to 15 October 2021 with 43 participants from 22 countries.
- An online NDC capacity building: NDC waveform training course using SeisComP3 for the Latin America and the Caribbean and North America and Western Europe regions took place from 18 to 22 October 2021 with 15 participants from 9 countries.
- An online NDC capacity building: NDC waveform training course using SeisComP3 for the Middle East and South Asia and South-East Asia, the Pacific and the Far East regions took place from 1 to 5 November 2021 with 13 participants from 13 countries.
- An online NDC capacity building training course on access and analysis of waveform IMS data and IDC products took place from 8 to 12 November 2021 with 26 participants from 18 countries.

Five online technical and expert meetings were organized to address particular and customized issues related to improvements and/or testing of the CTBT verification systems in coordination with and under the guidance of States Signatories.

- An online IDC SHI reengineering ATG technical meeting was held in two sessions. The first session took place from 13 to 14 April 2021 and the second session on 27 October 2021. Fourteen participants from 12 countries and the PTS attended the technical meeting. The objectives of the technical meeting were to present the scope of the testing session, to provide the current status of development, to guide the testers on the discovery of newly developed features and to enable ATG members to run testing scripts and adapt them to different test cases.
- An online technical meeting on the IDC VATP took place from 23 to 24 June 2021. Forty-two participants from 22 countries and the PTS attended the technical meeting. The objectives of the meeting were to discuss the VATP Rev. 5.2 and to review draft TIPs and templates to be used during the 2021 experiment.
- An online technical meeting on SHI software engineering at the IDC took place from 5 to 6 July 2021. Fifty-four participants from 23 countries and the PTS attended the meeting. Technical meetings are held periodically to provide a forum for experts from States Signatories to review and give feedback on re-engineering phase 3 progress and plans.
- A virtual expert meeting on advances in waveform processing and special studies took place from 18 to 22 October 2021. Seventy-five experts from 27 countries and the PTS attended the meeting. The objective of this technical expert meeting was twofold. Part of the meeting was dedicated to exploring advances to waveform processing that may improve the IDC waveform pipeline processing, including tools and methodologies for testing and validation. The second part of the meeting was dedicated to discussions on waveform special studies and ETA.
- A virtual expert meeting on special studies and ETA with radionuclide and ATM methods took place from 18 to 22 October 2021. Sixty-one experts from 19 countries and the PTS attended the meeting. The objectives of this technical expert meeting were to review methods that may be suited for special studies and ETA, explore the potential use of various non-IMS data for State Requested Methods Report and advance common understanding of procedures and methods to be developed.

Six training sessions and one webinar for station operators and managers took place during the reporting period. Their objectives were to facilitate interaction with the PTS on matters related to the operation and maintenance of IMS facilities; to illustrate the ongoing development of digital modules for station operation, SOH and data monitoring, hardware and software configuration.

- An online technical training session for station operators of IMS seismic and hydroacoustic T phase stations with nanometrics and Guralp equipment took place from 22 to 26 March 2021. Forty-six participants from 30 countries attended this training session. The objective of the training session was to provide station operators with knowledge and technical understanding on the operations, maintenance and management of an IMS waveform station using nanometrics Europa-T and Guralp DM24 digitizers.
- An online technical training session for station operators of IMS infrasound stations with nanometrics and Guralp equipment took place from 26 to 30 April 2021. Twenty-three participants from 13 countries attended this training session. Participants learned how to efficiently perform essential tasks for station operation, reporting and configuration management, to conduct proper SOH and data monitoring, and to proceed with methodical equipment and software configuration and maintenance.
- A webinar for station managers of IMS stations operating under PCA took place on 10 June 2021. Forty-six participants from 25 countries attended this webinar. The webinar objective was to brief the station managers about the new PCA proposal templates and clarification of relevant issues.
- An online training session for a new station operator at Tristan da Cunha took place from 16 to 18 August 2021. One participant attended this training session. The objectives were to provide the new station operator with knowledge about the three IMS stations located on the island as well as the technical understanding about the operation, maintenance and management of the stations.
- An online technical training session for station operators of manual radionuclide stations took place from 6 to 8 September

2021. Twenty-six participants from 10 countries attended this training session. The objectives were to provide station operators with knowledge and technical understanding about the operation, maintenance and management of a manual radionuclide station and to provide online training for the various operational and maintenance procedures.

- An online technical training for station managers of IMS stations operating under PCA contracts took place from 15 to 19 November 2021. Thirty-four participants from 18 countries attended this training session. The objectives were to provide station managers with the knowledge and technical understanding about the PTS procurement process, how to initiate a change in the station budget, and how to plan for operations and maintenance at IMS stations under PCA contracts.
- An online technical training for PKI operators for radionuclide and waveform stations took place from 22 to 26 November 2021. Fifty-four participants from 32 countries attended this training session. The objectives were to provide PKI operators with basic knowledge and technical understanding about data authentication, PKI concepts and terminology and data surety.

One workshop took place during this reporting period: the online International Noble Gas Experiment workshop 2021, which took place from 22 to 26 November 2021. One hundred and twenty-four participants from 27 countries and the PTS attended this workshop. The purpose of the workshop was to present and evaluate the most recent advances in noble gas monitoring in support of the CTBT. The International Noble Gas Experiment workshop 2021 was the largest PTS technical event hosted online next to SnT2021 and the specialized technical meeting on the preventive and predictive maintenance of the IMS which took place online in 2020.

Two capacity building systems procured with EU Council Decision VII funding have been installed and commissioned at two NDCs in Afghanistan and Morocco in January and February 2021, respectively. Due to travel restrictions related to the COVID-19 pandemic, both systems were assembled by NDC technical staff and configured with remote assistance from the PTS and began to receive and process IMS data in real time mode. Two more systems were delivered to NDCs whose staff are working on setting up the equipment.

Sixteen sets of the new capacity building system equipment were procured by the PTS in 2021, six of which were funded by the EU Council Decision VIII. Eight new systems have already been delivered to the TeST Centre and will be further distributed to NDCs upon their request which can be submitted to the PTS through the Permanent Missions. Another

The online capacity building NDC waveform training course using SeisComP3.

eight systems are planned to be delivered to the TeST Centre during the second quarter of 2022.

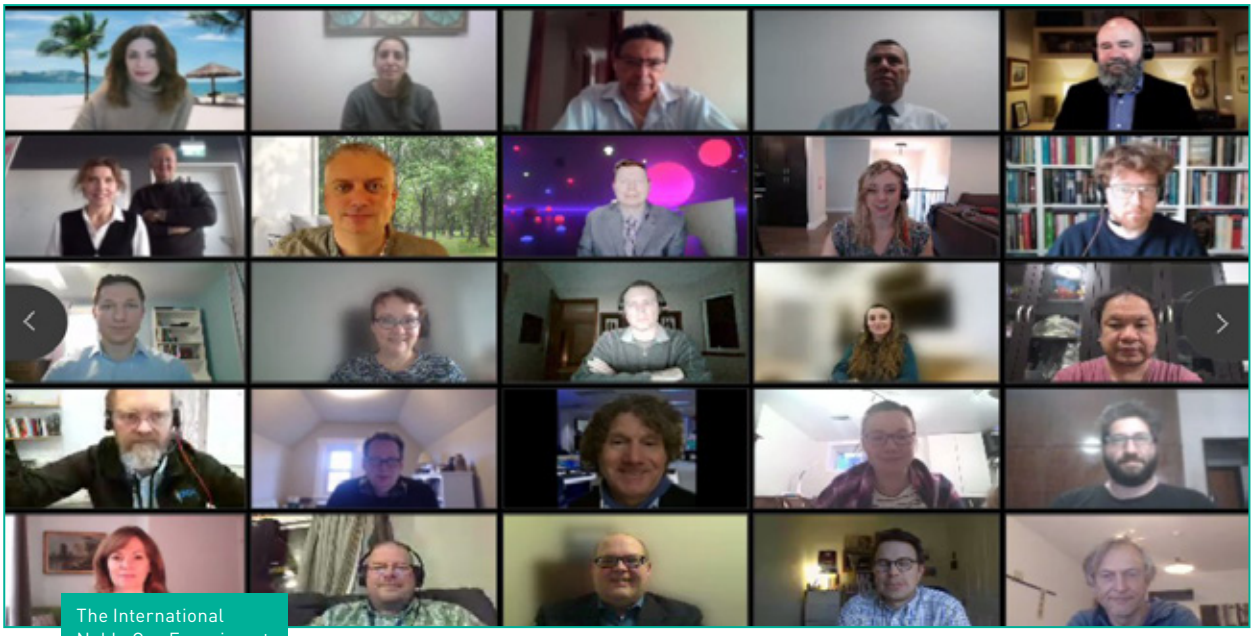
Approximately 50 participants subscribed to the NDC e-learning course on access to and application of IMS data and IDC products in 2021.

Participation of Experts from Developing Countries

The project for the participation of technical experts from developing countries in official technical meetings of the Preparatory Commission was established in 2006, initially for a period of three years and subsequently extended.

The project selected experts from the following 22 States, including 8 women, in 2021: Bolivia, Chile, Cuba, the Dominican Republic, Iran (Islamic Republic of), Jordan, Kazakhstan, Lebanon, Libya, Malaysia, Mexico, Myanmar, Namibia, Nepal, Niger, Paraguay, the Philippines, South Africa, Sudan, Tajikistan, Venezuela and Uzbekistan. All supported experts are representatives of national authorities for Treaty related issues, NDCs or relevant academic institutions.

During 2021, experts supported under the project participated at the Fifty-Sixth and Fifty-Seventh Sessions of WGB. The experts attended both sessions of WGB remotely due to the COVID-19 pandemic restrictions introduced by several countries, including the host country. Participation in the project provided the experts with a broader understanding of the verification related work of the PTS and the benefits of access to IMS data and IDC products. The project also provided the experts and the PTS with an opportunity to further develop cooperation between the Commission and the respective States on verification related matters, including specific technical issues or projects related to IMS stations and NDCs.



The International Noble Gas Experiment workshop attracted 124 participants from 27 countries.

7 OUTREACH

Highlights

Growing high level engagement with States and active youth outreach activities

Comprehensive public and media outreach strategy

Increased virtual outreach activities

The outreach activities of the Commission aim to encourage the signature and ratification of the Treaty, to enhance understanding of its objectives, principles and verification regime and of the functions of the Commission, and to promote the civil and scientific applications of the verification technologies. These activities entail interaction with States, international organizations, academic institutions, the media and the general public.

Towards Entry into Force and Universality of the Treaty

The CTBT will enter into force when it is ratified by the 44 States listed in Annex 2 of the Treaty. These are States that formally participated in the final stage of the negotiation of the Treaty in the Conference on Disarmament in 1996 and possessed nuclear power reactors or nuclear research reactors at that time. Eight of the 44 States have not yet ratified.

As of 31 December 2021, 185 States had signed and 170 States had ratified the Treaty, including 36 Annex 2 States. Cuba signed and ratified the Treaty on 4 February 2021; the Comoros ratified the Treaty on 19 February 2021.

Despite the lack of ratifications by the remaining eight Annex 2 States, the Treaty is already widely considered to be an effective instrument of collective security and an important pillar of the nuclear non-proliferation and disarmament regime. Political support for the Treaty, for its urgent entry into force and for the work of the Commission, continued to be strong in 2021. This was shown by the emphasis placed on the Treaty at numerous high level events and by many senior governmental officials and non-governmental leaders.

An increasing number of States, key decision makers, international and regional organizations, and representatives of civil society participated in activities aimed at advancing further ratifications of the Treaty, including by the remaining Annex 2 States. The Commission conducted consultations with many of the States that had not yet ratified or signed the Treaty.

States Signatories kicked off the 25th anniversary year of the Treaty with the convening of the 12th Article XIV conference, held virtually on the margins of the high level segment of the general debate of the seventy-sixth session of the United Nations General Assembly (UNGA) on 23 and 24 September 2021. The event offered a platform for expression of strong support for the Treaty and the work of the Organization.

Group of Eminent Persons and CTBTO Youth Group

The Group of Eminent Persons (GEM) was established by the Executive Secretary in 2013 to advance entry into force of the Treaty. The group examines political and technical developments related to the CTBT and identifies concrete action and new initiatives that could be explored to accelerate entry into force of the Treaty.

On 28 June 2021, several GEM members actively participated in the SnT2021 conference, contributing to the high level opening by discussing the main challenges ahead for the CTBT, its entry into force and universalization. On 23 September 2021, at the Article XIV conference, GEM members issued a statement promoting the importance of the Treaty in the global non-proliferation and disarmament architecture.

Twenty years after the opening for signature of the CTBT, it is clear that entry into force and implementation will be in the hands of the next generation of leaders and policy makers. Therefore the CTBTO Youth Group (CYG) was launched in 2016.

The CTBTO Youth Group met online in 2021.

The objectives of the CYG are to revitalize the discussion around the CTBT among decision makers, academia, students, subject experts and the media; to raise awareness of the importance of the nuclear test ban; to build a basis for knowledge transfer to the younger generation; to involve new technologies in the promotion of the CTBT (social media, digital visualization and interactive means of delivering information); and to place the CTBT on the global agenda.

The group is open to all students and young professionals who are pursuing careers dedicated to global peace and security, and who wish to actively engage in promoting the CTBT and its verification regime.

Since its launch in 2016, the CYG has grown to 1156 members. A considerable number of its members come from the Annex 2 States whose ratification is needed for the CTBT to enter into force.

The work of the CYG remained in an online format in 2021. The CTBTO ensured that youth have a seat at the table in United Nations fora to make their voices heard. This featured, for the first time, a CYG member at the United Nations Security Council meeting, held on 27 September 2021 under the presidency of Ireland to mark the CTBT's 25th anniversary. CYG members also participated in the high level webinar hosted by the Vienna Center for Disarmament and Non-Proliferation on the future of the CTBT in promoting nuclear verification and disarmament (1 CYG member from a non-ratifying Annex 2 State) and the Article XIV conference (1 CYG member from a non-ratifying Annex 2 State). Forty-nine CYG members took part in the SnT2021 conference as speakers and presenters (15 CYG members from non-ratifying Annex 2 States).

Tailored youth focused capacity building events were also prepared by the CYG Task Force. These included the Citizen Journalism Academy (89 CYG members, 25 selected as citizen journalists to cover SnT2021, 5 CYG members from non-ratifying Annex 2 States), designed to boost the communication and social media skills of young experts, and the CTBTO Youth Group Research Fellowship (26 CYG members including 10 from non-ratifying Annex 2 States and 1 from a non-ratifying non-Annex 2 State). This was in addition to a series of CYG webinars, run as part of the Building Bridges, Nurture Partnerships, Embrace Dialogue project, designed to open the generally closed nuclear disarmament sphere to best practice exchanges with other spheres such as climate change advocacy and gender empowerment (3 CYGs from non-ratifying Annex 2 States). The 6th Anniversary Report has been prepared to highlight all of the activities of the CYG from the time of its inception.

Interacting with States

The Commission continued efforts to facilitate the establishment of the verification regime and to promote participation in its work. It also maintained a dialogue with States through bilateral contacts in capitals and interaction with Permanent Missions in Berlin, Geneva, New York and Vienna. A major focus of this interaction was on States that host IMS facilities and States that have not yet signed or ratified the Treaty, in particular those listed in Annex 2.

With over 1100 members, the CTBTO Youth Group remains an important part of the Organization's outreach efforts.

The Executive Secretary increased his proactive high level engagement with States to promote the Treaty, advance its entry into force and universalization, and promote the use of the verification technologies and data products.

The Executive Secretary met with the President of Kazakhstan in August 2021.

The Executive Secretary participated in several bilateral meetings and other high level events at which he met several heads of State and Government as well as foreign ministers. These included a bilateral meeting with the President of Kazakhstan, the Minister of Foreign Affairs of Azerbaijan;

The Brazilian Minister of Science, Technology and Innovation paid a visit to the CTBTO headquarters.

the Minister of Science, Technology and Innovation of Brazil; the Deputy Minister for Multilateral and Global Affairs of the Ministry of Foreign Affairs of the Republic of Korea; the Deputy Minister of International Relations and Cooperation of South Africa; the Principal Secretary, State Department for University Education and Research, Ministry of Education, Science and Technology of Kenya; the Minister of Foreign Affairs and Worship of Costa Rica; the Minister of Foreign Affairs and Cooperation of Timor-Leste; and the Minister for Foreign Affairs and Minister for Women of Australia.

Promoting parliamentary engagement, the Executive Secretary interacted with a number of parliamentarians from States Signatories.

During his international visits, engagements in Vienna as well as at virtual meetings, the Executive Secretary also interacted with several other foreign ministers and other ministers of States Signatories and observers.

On behalf of the Executive Secretary, the Director of the Legal and External Relations Division attended the virtual handover ceremony of the Asia-Pacific Group on 18 February 2021 and addressed the meeting.

On 22 February 2021, the Executive Secretary held a virtual meeting with the Minister of Foreign Affairs and International Cooperation of the Comoros.

From 7 to 8 April 2021, the Executive Secretary visited the Gambia and held meetings with the President, the Speaker of the National Assembly, the Minister of Foreign Affairs, International Cooperation and Gambians Abroad and the Minister of Defence.

The Minister of Foreign Affairs of Azerbaijan paid a courtesy call to the Executive Secretary on 25 May 2021.

From 19 to 21 July 2021, the Executive Secretary made a working visit to the Russian Federation and held a meeting with the Minister of Foreign Affairs as well as high level officials at the Ministry of Defence, the State Atomic Energy Corporation Rosatom and the Moscow State Institute of International Relations.

The Minister of Science, Technology and Innovation of Brazil paid a courtesy call to the Executive Secretary on 9 August 2021.

On 26 to 27 August 2021, the Executive Secretary paid a visit to Kazakhstan on the eve of the International Day against Nuclear Tests (IDANT), and met with the President of Kazakhstan, the Deputy Prime Minister and Minister of Foreign Affairs and the Minister of Energy. On 26 August 2021, the Executive Secretary visited the National Nuclear Center in Kurchatov where he met with the Deputy Director General and visited the former Semipalatinsk Test Site.

On 6 September 2021, the Executive Secretary met with the Foreign Minister of Denmark in Copenhagen on the margins of the 17th Annual NATO Conference on Arms Control, Disarmament and Weapons of Mass Destruction Non-Proliferation.

As part of his outreach activities, the Executive Secretary travelled to South Africa in October 2021.

From 9 to 10 September 2021, the Executive Secretary undertook a mission to the United States of America and met the Deputy Assistant Secretary of State, senior officials from the Bureau of International Organization Affairs from the Department of State, the Under Secretary of State for Arms Control and International Security, the Special Assistant to the President and Senior Director for Arms Control, Disarmament, and Nonproliferation at the National Security Council, senior officials from the National Nuclear Security Administration and the Chair of the Arms Control Association Board of Directors in Washington D.C. The Executive Secretary also participated in a policy roundtable discussion with civil society experts hosted by the Arms Control Association.

The Executive Secretary visited a primary seismic array in Norway, part of the IMS network.

From 4 to 6 October 2021, the Executive Secretary undertook a mission to Moscow, the Russian Federation, and met the Commander of the Special Monitoring Service in the Ministry of Defence, the Minister of Foreign Affairs and the Deputy Director General of Rosatom. The Executive Secretary also participated in a roundtable discussion with Russian non-proliferation and arms control experts.

From 20 to 23 October 2021, the Executive Secretary undertook a mission to Johannesburg, South Africa. During his visit he met with the Deputy Minister of lnternational Relations and Cooperation, the Chairperson of the South African Council for Non-Proliferation of Weapons of Mass Destruction and the Chief Executive Officer of the South African Nuclear Energy Corporation.

From 24 to 27 October 2021, the Executive Secretary undertook a mission to Nairobi, Kenya and met with the Director General for Bilateral and Political Affairs at the Ministry of Foreign Affairs and the Principal Secretary, State Department for University Education and Research, Ministry of Education, Science and Technology. The Executive Secretary also addressed high school students and students at the University of Nairobi about issues related to nuclear non-proliferation and the importance of the CTBT.

From 22 to 23 November 2021, the Executive Secretary undertook a mission to Geneva, Switzerland during which he met with the Permanent Representatives of Barbados, Brunei Darussalam, Gabon, the Gambia, Haiti, Jamaica, Mauritius, Niger, Rwanda and Somalia.

On 2 December 2021, the Executive Secretary visited the Atomic Weapons Establishment in Aldermaston, United Kingdom, and met with officials including the Director of Strategy and Policy, Defence Nuclear Organisation in the Ministry of Defence.

The Executive Secretary undertook a mission to Norway from 16 to 17 December 2021 during which he met the Minister of Foreign Affairs and the State Secretary to the Minister of Foreign Affairs and took part in an event hosted by the Norwegian Seismic Array: 25 years with the CTBT.

Outreach Through the United Nations System, Regional Organizations, Other Conferences and Seminars

The Commission continued to take advantage of global, regional and subregional conferences and other gatherings to enhance understanding of the Treaty and to advance its entry into force and the build-up of the verification regime.

The Executive Secretary addressed the United Nations Security Council in New York.

On 27 September 2021, Ireland, holding the presidency of the United Nations Security Council for September, organized a briefing on the Treaty to mark its 25th anniversary. The briefing provided the United Nations Security Council with the opportunity to reflect on the significant achievements of the Treaty in the 25 years since its opening for signature, as well as advocate concrete actions to advance its entry into force and universalization.

United Nations Security Council members delivered strong statements of support for the Treaty and its verification regime, highlighting the success of the Treaty as a core component of the international nuclear disarmament and non-proliferation regime, and calling for urgent action to bring the Treaty into force. The Executive Secretary, together with the United Nations Under-Secretary-General and High Representative for Disarmament Affairs and a Kenyan member of the CYG, addressed the United Nations Security Council to underscore the historic significance of the Treaty in its 25th anniversary year.

IDANT in 2021 coincided with the 30th anniversary of the closure of the former Soviet Union's nuclear test site in Semipalatinsk. This anniversary was commemorated around the world on 29 August, with events also taking place at the United Nations in New York and Vienna, as well as in Astana, Kazakhstan.

On 28 January 2021, the Executive Secretary addressed a virtual conference at the Vienna Center for Disarmament and Non-Proliferation, co-organized by the Article XIV Co-Chairs, on "Strengthening the Comprehensive Nuclear-Test-Ban Treaty and its Verification Regime".

On 17 March 2021, the Executive Secretary virtually addressed Student/Young Pugwash UK of the British Pugwash.

On 12 April 2021, the Executive Secretary virtually addressed the meeting commemorating the 25th anniversary of the African Nuclear-Weapon-Free Zone Treaty.

On 27 April 2021, the Executive Secretary participated in a virtual international conference jointly organized with the Government of Turkmenistan on "Ensuring peace, stability and security: Strengthening international and regional cooperation in the field of disarmament".

The Executive Secretary delivered a virtual address to the Conference on Disarmament on 25 May 2021.

On 28 May 2021, the Director of the Legal and External Relations Division delivered a virtual address on behalf of the Executive Secretary to the international exchange program of the Center for Strategic and International Studies - Project on Nuclear Issues Mid-Career Cadre.

On 16 June 2021, the Executive Secretary signed a practical arrangement with the Regional Network for Education and Training in Nuclear Technology, which brings together 15 universities from 8 countries.

On 18 June 2021, the Executive Secretary delivered a statement to the 4th Anthropocene Forum in Heiligenblut am Grossglockner, Austria, on the topic of "Ecosystem in danger. How nuclear testing endangers our ecosystem".

On 28 June 2021, the Executive Secretary addressed the EU-CTBTO discussion on

"Securing a nuclear test-free world for youth and the next generations", co-organized with the European Union and the CYG.

On 6 July 2021, the Executive Secretary held a virtual keynote address on youth engagement at the Share Africa conference.

The Executive Secretary virtually addressed the meeting commemorating the 12th anniversary of the entry into force of the African Nuclear-Weapon-Free Zone Treaty on 15 July 2021.

On 4 August 2021, the Executive Secretary virtually addressed the Korea Advanced Institute of Science and Technology, Nuclear Nonproliferation Education and Research Center 2021 conference.

The Director-General of the United Nations Office at Vienna welcomed the Executive Secretary.

On 5 August 2021, the Executive Secretary paid a courtesy visit to the Director-General of the United Nations Office at Vienna and Executive Director of the United Nations Office on Drugs and Crime.

On 11 August 2021, the Executive Secretary paid a courtesy visit to the Director General of the United Nations Industrial Development Organization.

On 11 August 2021, the Nuclear Nonproliferation Education and Research Center Fellows from the Korea Advanced Institute of Science and Technology paid a virtual visit to the Preparatory Commission. The visit included virtual tours of the COPC and IMS technologies, as well as a virtual lecture and discussion session.

On 17 August 2021, the Executive Secretary paid a courtesy visit to the Director General of the International Atomic Energy Agency.

On 23 August 2021, the Executive Secretary held a teleconference call with United Nations Under-Secretary-General and High Representative of Disarmament Affairs.

On 30 August 2021, the Executive Secretary participated in a thematic panel session on "Advancing Together: Resilience and Innovation in Nuclear Materials" during the 2021 Institute for Nuclear Materials Management and European Safeguards Research and Development Association Joint Annual Meeting, in which he focused his remarks on "Innovation and Resilience in the Mission of the CTBT".

On 6-7 September 2021, the Executive Secretary participated in the 2021 NATO Conference on Arms Control, Disarmament and WMD Non-Proliferation.

On 8 September 2021, the UNGA convened a high level plenary meeting to commemorate and promote IDANT. Upon the invitation of the President of the seventy-fifth session of the UNGA, the Executive Secretary delivered a keynote speech calling on all States to do their utmost to advance the entry into force and universalization of the Treaty. Participants, recounting the serious impacts of nuclear testing on human health, the environment and international peace and security, unanimously called on the remaining eight Annex 2 States to take the necessary actions to advance entry into force of the Treaty.

On 21 October 2021, the Executive Secretary participated in the 5th Conference of States Parties to the African Nuclear-Weapon-Free Zone Treaty. He met with the Executive Secretary of the African Commission on Nuclear Energy, the Director of the Radiation Safety and Nuclear Security Authority of Mauritius and the Chairperson of the Radiation Protection, Safety, and Nuclear Security Authority of Mauritania.

On 13-14 November 2021, the PTS attended the United Nations Office for Disarmament Affairs Regional Meeting for Middle Eastern States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons in Amman, Jordan.

The PTS attended the Amman Security Colloquium on 16-17 November 2021, organized by the Arab Institute of Security Affairs, in Jordan.

Meeting delegates at the 5th Conference of States Parties to the Treaty of Pelindaba in South Africa.

During the Executive Secretary's visit to Geneva from 22 to 23 November 2021, he met the Chief a.i. of the Conference on Disarmament Secretariat and Conference Support Branch, United Nations Office for Disarmament Affairs, the Director-General of the United Nations Office in Geneva and the Secretary-General of the Conference on Disarmament, and the Director of the Geneva Centre for Security Policy.

From 29 November to 1 December 2021, the Executive Secretary participated in the Wilton Park dialogue on supporting the Treaty on the Non-Proliferation of Nuclear Weapons diplomacy in Steyning, United Kingdom.

During these meetings and conferences, the Executive Secretary interacted with a number of heads and other senior officials of international and regional organizations.

Public Information

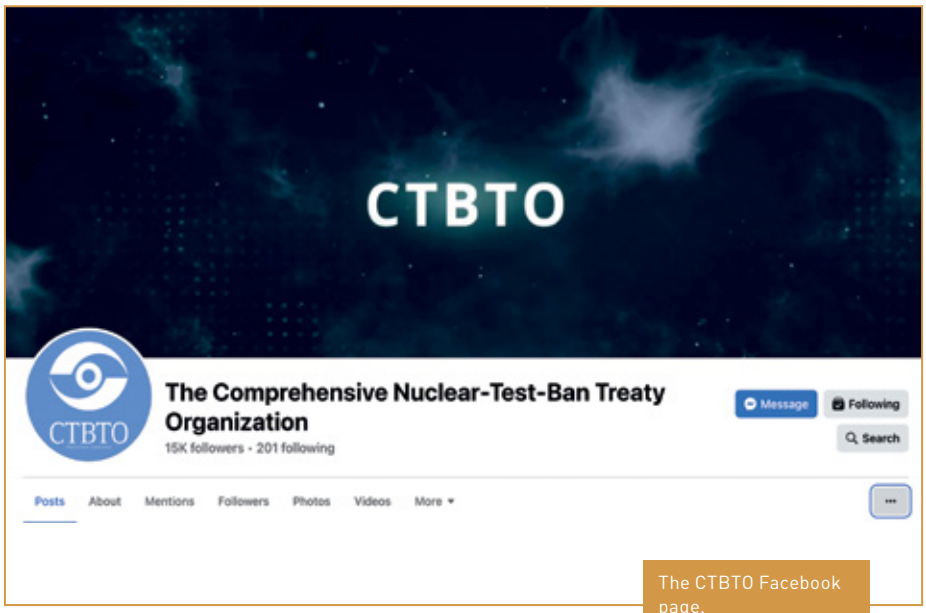
The importance of online communication channels remained paramount in 2021, particularly due to continuing constraints on in-person meetings and outreach opportunities caused by the COVID-19 pandemic. A range of key events throughout the year, including the signature and/or ratification of the CTBT by Cuba and the Comoros, the hybrid SnT2021 conference, the arrival of a new Executive Secretary, IDANT, high profile addresses to the UNGA and United Nations Security Council, the Article XIV conference and – not least – the 25th anniversary of the Treaty's opening for signature, offered strong opportunities to promote the CTBT and the work of the CTBTO. The PTS ensured extensive coverage of these and other events, anniversaries, and stories on its social media accounts (Twitter, Facebook, YouTube, Flickr and LinkedIn) and through the public website. Wherever possible, video streaming of significant interventions by the Executive Secretary was made available via the website.

The number of Twitter followers continued to rise steadily, reaching 22 976 by early December 2021, an increase of 1600 since the end of 2020. Engagement with posts has been routinely high, indicating effective impact. For example, the 25th anniversary video tweeted on 24 September received over 60 000 impressions and was viewed more than 7000 times by early December, with an engagement rate of 1.5%.

The CTBTO Twitter page.

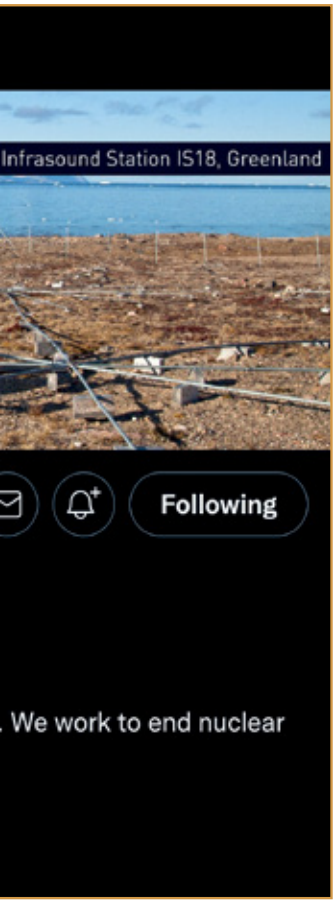
The CTBTO Facebook page had over 14 000 likes by late 2021, with a total daily reach of 578 unique users, while Flickr had 120 000 views during the reporting period. Eighty-one videos were uploaded to the YouTube channel, 30 of them related to

SnT2021, and there were 71 000 views of the channel's content. The Organization's website had 770 000 visitors, of which nearly half (312 000) were new visitors.



The CTBTO Facebook page.

Several videos were produced during the reporting period, including two 25th anniversary videos that were showcased at SnT2021 and were also used across social media platforms. In addition, a video on the 25th anniversary of the CTBT, which looked at AS25 and how the local team participates in training and capacity building, was produced and distributed to over 2200 broadcasters worldwide via UNifeed.



The PTS promoted IDANT with a social media video, extensive online coverage of the Executive Secretary and other speakers at the UNGA plenary session and prominent coverage on the CTBTO website.

As part of the ongoing observance of the 25th anniversary, the PTS worked with the United Nations Postal Administration to design and launch a sheet of commemorative stamps marking the milestone. The stamps are available for purchase on the United Nations Postal Administration website and have been presented as gifts from the Executive Secretary to ambassadors and other high level stakeholders.

The IMS map showing the 337 planned and operational facilities was redesigned. The new map was made available on the CTBTO website and promoted on social media.

The PTS promoted the International Gender Champions network in Vienna on social media, of which the Executive Secretary is a prominent member.

Global Media Coverage

Extensive media coverage of the CTBTO and the engagements by the Executive Secretary was ensured by liaising proactively with media outlets, as well as promoting news and engagements of the Executive Secretary on social media, press releases and media advisories. Missions with significant press coverage included Kazakhstan, the Russian Federation, the United States of America, South Africa, Kenya and Switzerland.

The PTS engaged the support of the United Nations Department of Global Communications to offer media briefings in New York and Geneva, a media stakeout following the briefing of the Executive Secretary to the United Nations Security Council in September 2021, and in-depth coverage by United Nations media outlets including UN News and UNifeed.

Press highlights included interviews with the Executive Secretary in *Reuters* (English), *Agence France Presse* (French, English, Spanish, Portuguese, Arabic), *Deutsche Presse Agentur* (German), *EFE* (Spanish), *Kommersant Daily* (Russian), *Arms Control Association* (English), and *Kyodo News* (Japanese), as well as a

the United Nations Information Service biweekly press briefing which generated media coverage from multiple local and international outlets.

The Preparatory Commission, the Treaty and its verification regime featured in a wide range of articles, blogs and broadcast pieces around the world. Outlets included *ABC News, ABWR, ACN - Noticias de Cuba, Agence France Presse, Agence d'information d'Afrique Centrale, Akorda Press Service, All Africa, All Things Nuclear, Amarillo Globe News, Ammon News, Anadolu Agency, ANSA, ANI, Arirang TV, Arms Control Association, Arms Control Wonk, Asia News Daily, The Associated Press, The Astana Times, The Australian, BBC News, Berliner Morgenpost, The Boston Globe, Breaking Defense, Brookings Institution, BusinessLine, Bulletin of the Atomic Scientists, China Daily, CGTN, The Conversation, Daily Advent, The Daily Mail, Daily Maverick, Daily News Egypt, The Daily Tribune, Defense One, Danbury News Times, Deutsche Welle, Diario-Expreso, The Dhaka Tribune, The Diplomat, The Diplomatic Insight, Deutsche Presse Agentur, Earth Sky, EFE, EU Today, Eurasia Review, European Leadership Network, The Express Tribune, FAN, First Post, Forbes, Foreign Affairs, Foreign Policy, Fox News, France 24, France Diplomacy, Frankfurter Allgemeine Zeitung, Freedom Newspaper, The Guardian, Geneva Solutions, Greek City Times, Grenz-Echo, Gulf Times, Head Topics Singapore, Hola News, The Hill, InDepthNews, IEEE Spectrum, The Indian Panorama, Infobae, Insider Voice, Interfax, The International News, The Interpreter, The Japan Times, KazInform International News Agency, KBC, Kommersant Daily, The Korea Times, KTAR News, Kyodo, Las Vegas Sun, Lenta, London Review of Books, Lowy Institute, The Mainichi Shimbun, Market Research Telecast, Market Screener, Med.com, Mehr News Agency, MENAFN, Mirage, Morocco World News, MSN, Nasdaq, The Nation, The National Interest, The National Review, New Delhi Times, New*

television interview with *France 24* (English) and in-depth conversations with *Spice FM* (English) in Kenya and *Ubuntu Radio* in South Africa. Events such as the UNGA session on IDANT, the Article XIV conference and the United Nations Security Council briefing also generated positive stories, including wide ranging quotes on the CTBT from high level officials including the United Nations Secretary-General, the President of the Russian Federation and the United Nations Under-Secretary-General and High Representative for Disarmament Affairs. A UN News report on the UNGA session was carried on several Indian news platforms. A press briefing by the Executive Secretary at the United Nations in New York resulted in an *Associated Press* (English) article which was picked up by numerous news outlets in the United States of America, including the *Washington Post, ABC News* and numerous local ABC broadcast affiliates. During a visit to Geneva, the Executive Secretary spoke at

Haven Register, New Straits Times, News.AZ, News für die Schweiz, News Ghana, Newsweek, Nippon, The North Africa Post, NPR, NTI, NTV, NWZonline, ORF Online, Penn Live, The Policy Times, El Potosí, PR Newswire, La Prensa Latina, Profil, The Public's Radio, Radio Cadena, Relief Web, Republic World, RFI, Sahara News, Spice FM, Sputnik International, The Star, Stuttgarter Zeitung, The Sun Daily, Swissinfo, Tasnim News Agency, Tass News Agency, Tech News Insight, The Times, The Times of India, The Times of Israel, Trend News Agency, UN News, United News of India, Uniontown Herald Standard, UrduPoint, U.S. News & World Report, VICE, Vietnamnet, Vietnam Plus, VOA Afrique, Voyennoye Delo, Vzglyad, The Washington Newsday, The Washington Post, The Weather Network, Westport News, Wion, Yahoo Noticias and Zeitung vum Lëtzebuerger Vollek.

National Implementation Measures

Part of the mandate of the Commission is to facilitate the exchange of information between States Signatories on the legal and administrative measures for implementation of the Treaty and, when requested, to provide related advice and assistance. Some of these implementation measures will be required when the Treaty enters into force and some may already be necessary during the provisional operation of the IMS and to support activities of the Commission.

In 2021, the Commission continued to promote the exchange of information between States Signatories on national implementation measures. It also made presentations on aspects of national implementation at workshops, seminars, training courses, external events and academic lectures.


UN

8 PROMOTING THE ENTRY INTO FORCE OF THE TREATY

Highlights

The 25th anniversary of the Treaty was an occasion to show strong political support for its entry into force

Foreign Ministers of Italy and South Africa commencing their work as the new coordinators of the Article XIV process

Ratification of the Treaty by the Comoros and Cuba

Article XIV of the Treaty concerns its entry into force. The article foresees a series of regular conferences to facilitate entry into force (commonly referred to as Article XIV conferences) if this has no taken place three years after the Treaty opened for signature. The first Article XIV conference took place in Vienna in 1999. Subsequent conferences were held in New York in 2001, 2005, 2009, 2011, 2013, 2015, 2017 and 2019, and in Vienna in 2003 and 2007.

The Secretary-General of the United Nations convenes the Article XIV conferences at the request of a majority of States that have ratified the Treaty. Both ratifying and signatory States participate in these conferences. Decisions are taken by consensus of the ratifying States, taking into account views expressed at the conference by signatory States. Non-signatory States, international organizations and NGOs are invited to attend as observers.

Article XIV conferences discuss and decide on what measures, consistent with international law, may be undertaken to accelerate the ratification process in order to facilitate entry into force of the Treaty.

Conditions for Entry into Force

The entry into force of the Treaty requires ratification by all 44 States listed in its Annex 2. These so-called Annex 2 States are States that formally participated in the final stage of the negotiation of the Treaty in the Conference of Disarmament in 1996 and possessed nuclear power reactors or nuclear research reactors at that time. As of 31 December 2021, 36 of these 44 States had ratified the Treaty. Of the eight Annex 2 States that had yet to ratify the Treaty, three still had not signed it.

The presidency of the Article XIV conference was shared by Italy and South Africa.

2021 Article XIV Conference

The 12th Article XIV conference was held on 23 and 24 September 2021 on the margins of the opening of the seventy-sixth session of the UNGA. Due to the COVID-19 pandemic the conference was held virtually.

The Article XIV conference was held virtually in 2021.

Coinciding with the 25th anniversary of the CTBT's opening for signature on 24 September 1996, the conference presented an opportunity to take stock of the achievements towards completion of the verification regime of the Treaty, and express the continued firm political commitment and support of the international community for the entry into force of the Treaty and its universalization.

Shared Presidency

The presidency of the conference was shared by the Deputy Minister of Foreign Affairs and International Cooperation of Italy, acting on behalf of the Minister of Foreign Affairs, as well as the Minister of International Relations and Cooperation of South Africa.

Expressions of Strong Support

During the conference, ministers and senior officials from more than sixty countries delivered statements of strong support for the Treaty, joining United Nations Secretary-General (who was represented by the United Nations Under-Secretary-General and High Representative for Disarmament Affairs), the President of the seventy-sixth session of the UNGA and the Executive Secretary, in making calls for its urgent entry into force and universalization.

The speakers underlined the significance of the Treaty for nuclear disarmament and non-proliferation and the established norm against nuclear testing. They called on non-ratifying States, in particular the remaining Annex 2 States, to ratify the Treaty as soon as possible. They also expressed appreciation for the activities of the Commission and the effective performance of the verification regime of the Treaty.

The Executive Secretary noted the steady progress towards universal recognition of the CTBT, with two further ratifications – by Cuba and the Comoros – since the last Article XIV conference in 2019, and further signatures and ratifications likely in the near future. He urged States to take action through bilateral, regional or multilateral initiatives to move towards universalization of the Treaty and complete its verification regime. He further referenced the civil and scientific applications of the verification regime as a virtual treasure trove of data that can be utilized for a variety of applications, such as climate change research and disaster warning and mitigation.

The conference unanimously adopted a Final Declaration that marks the milestone of the 25th anniversary of the Treaty by reaffirming the vital importance and urgency of the entry into force of the CTBT. The Declaration reasserts that "a universal and effectively verifiable Treaty constitutes a fundamental instrument in the field of nuclear disarmament and non-proliferation" and calls on the remaining States to sign and ratify it without delay. In this context, it welcomes opportunities to engage with the non-signatory States, in particular Annex 2 States.

The Final Declaration also calls on all States "to refrain from nuclear weapon test explosions or any other nuclear explosions, the development and use of new nuclear weapon technologies and any action that would undermine the object and purpose and the implementation of the provisions of the CTBT and to maintain all existing moratoria on nuclear weapon test explosions, while stressing that these measures do not have the same permanent and legally binding effect to end nuclear weapon testing and all other nuclear explosions, which can only be achieved with the entry into force of the Treaty."

It also proposes 15 practical measures to accelerate the ratification process and bring the Treaty into force. These include support for bilateral, regional and multilateral outreach initiatives, capacity building and training activities, and cooperation with civil society, international organizations and non-governmental organizations.

The Final Declaration stresses that participating States will continue to provide the technical and financial support required to enable the Commission to complete all of its tasks in the most efficient and cost effective way, in particular the further build-up of all the elements of the verification regime. It also expresses appreciation for the civil and scientific benefits of the monitoring technologies, including for tsunami warning.

In addition, the Final Declaration welcomes the range of mutually supportive ratification outreach activities, including the activities of the GEM and the CYG and the individual efforts of States Signatories.

Cuba depositing its instrument of ratification to the United Nations.

New Ratification and Signature of the Treaty

Cuba signed the Treaty and deposited its instrument of ratification on 4 February 2021. The Comoros also joined the ranks of ratifying States as it deposited its instrument of ratification on 19 February 2021. As of 31 December 2021, the number of ratifications of the Treaty stands at 170, and the number of signatures is 185. These new ratifications makes the Treaty one of the most adhered to international instruments in the field of disarmament and drives it closer to the desired objective of universality.


4 FRENCH

9 POLICY MAKING

Highlights

An increased number of meetings of the Commission and its subsidiary bodies despite COVID-19 restrictions

Appointment of the new Executive Secretary

Appointment of the Chairperson and Vice-Chairperson of WGB

The plenary body of the Commission, which is composed of all States Signatories, provides political guidance and oversight to the PTS. The plenary is assisted by two Working Groups.

Working Group A (WGA) deals with budgetary and administrative matters, while WGB considers scientific and technical issues related to the Treaty. Both Working Groups submit proposals and recommendations for consideration and adoption by the plenary meeting of the Commission.

In addition, an Advisory Group of experts serves in a supporting role, advising the Commission through WGA on financial and budgetary matters.

Meetings in 2021

The Commission and its subsidiary bodies each met in two regular sessions in 2021. The Commission also held several resumed sessions.

Among the major issues addressed by the Commission during 2021 were the appointment of the new Executive Secretary; promotion of the Treaty; the 25th anniversary of the opening for signature of the CTBT; adherence to the moratorium on nuclear testing; progress made on the completion of the IMS network; capacity building activities of the Commission; business continuity; the 2022-2023 Programme and Budget; guidance on the future use of noble gas background measurement systems; developing guidelines for holding non-scheduled sessions of the Commission; and the appointment of the Chairperson and Vice-Chairperson of WGB.

Meetings of the Commission and Its Subsidiary Bodies in 2021

Body	Session	Dates	Chairperson
Preparatory Commission	Resumed Fifty-Fifth	27 January 8, 26 March 17, 19-20 May 1-2 June	Ambassador Ivo Šrámek (Czech Republic)
	Fifty-Sixth	21-23 June	
	Fifty-Seventh	10-12 November 9-10, 21 December	
Working Group A	Fifty-Ninth	31 May-1 June	Ambassador Nada Kruger (Namibia)
	Sixtieth	18-19 October	
Working Group B	Fifty-Sixth	8-19 March	Acting Chairperson Mr Sergey Berezin (Kazakhstan)
	Fifty-Seventh	27 August-3 September	Mr Erlan Batyrbekov (Kazakhstan)
Advisory Group	Fifty-Sixth	10-12 May	Mr Michael Weston (United Kingdom)
	Fifty-Seventh	27-30 September 11 October	Acting Chairperson Mr Pedro Alexandre Penha Brasil (Brazil)

Supporting the Commission and Its Subsidiary Bodies

The PTS is the body that executes the decisions adopted by the Commission. It is multinational in composition: staff are recruited from States Signatories on as wide a geographical basis as possible. The PTS provides substantive and organizational support for the meetings of the Commission and its subsidiary bodies and in the periods between sessions, thus facilitating the decision making process.

Most of the sessions of the Commission and its subsidiary bodies were held virtually or in a hybrid format in 2021.

With tasks ranging from organizing conference facilities and arranging interpretation and translation to drafting the official documents of the various sessions, planning the annual schedule of sessions, and providing substantive and procedural advice to the Chairpersons, the PTS is a vital element in the work of the Commission and its subsidiary bodies.

In 2021, due to COVID-19 restrictions, most of the sessions of the Commission and its subsidiary bodies were held either virtually or in a hybrid format (virtually and in person). In addition, the number of meetings of the Commission and its subsidiary bodies increased considerably.

Virtual Working Environment

In addition to the ECS, which serves as the working environment for those unable to attend the regular sessions of the Commission and of its subsidiary bodies, through which proceedings are recorded and transmitted live, the PTS has, in view of COVID-19 restrictions, used the Interprefy platform for all sessions of the Commission and its subsidiary bodies, and the Webex platform for all informal and technical briefings. The PTS will continue to evaluate options to further facilitate remote participation in meetings of the Commission and its subsidiary bodies.

The ECS is a single sign-on infrastructure that provides a platform for continuous and inclusive discussion among States Signatories and experts on scientific and technical issues related to the verification regime, as well as information and access to all official documents issued.

As part of the virtual paper approach, through which the Commission is seeking to limit its output of printed documentation, the PTS continued to provide a print on demand service at all sessions of the Commission and its subsidiary bodies.

Information System on Progress in Fulfilling the Mandate of the Treaty

The Information System with Hyperlinks on Tasks Assigned by the Resolution Establishing the Preparatory Commission monitors progress made in meeting the mandate of the Treaty, the Resolution establishing the Commission and the guidance of the Commission and its subsidiary bodies. It uses hyperlinks to the official documentation of the Commission to provide up to date information on the tasks that remain to be completed in preparing for the establishment of the CTBTO at entry into force and the first session of the Conference of the States Parties. The system is available to all ECS users.

Appointment of the Executive Secretary

The Commission, at its resumed Fifty-Fifth Session on 20 May 2021, appointed Mr Robert Floyd as the next Executive Secretary, taking office on 1 August 2021, by acclamation, in accordance with the terms and conditions contained in CTBT/PC-54/2, Annex II.

Mr Robert Floyd, right, became the new Executive Secretary of the CTBTO in 2021.

Appointment of the Chairperson of Working Group B

The Commission, at its resumed Fifty-Fifth Session held on 8 March 2021, decided to appoint Mr Erlan Batyrbekov (Kazakhstan) as the Chairperson of WGB, in accordance with the procedures for appointment of the Chairpersons and Vice-Chairpersons of the subsidiary bodies of the Commission (CTBT/PC-45/2, Annex IV) for a term expiring on 31 December 2023.

At its Fifty-Seventh Session, the Commission appointed Mr Läslo Evers (the Netherlands) as Vice-Chairperson of WGB in accordance with the procedures for appointment of the Chairpersons and Vice-Chairpersons of the subsidiary bodies of the Commission (CTBT/PC-45/2, Annex IV), for a term expiring on 31 December 2024.

Appointment of the External Auditor to the Preparatory Commission for the Period 2022 to 2023

The Commission decided at its Fifty-Seventh Session to appoint the Accounts Chamber of the Russian Federation as External Auditor to the Preparatory Commission for the period 2022 to 2023.


50%
25%

10 MANAGEMENT

Highlights

Effective administrative support to ensure business continuity

Improving administrative and human resources policies, procedures and processes

Allocation of 81.4% of the budget to verification related activities

The PTS ensures effective and efficient management of its activities, including support of the Commission and its subsidiary bodies, mainly through the provision of administrative, financial, procurement and legal services.

The PTS also provides a wide variety of services including general services from arrangements concerning shipments, customs, visas, identity cards, laissez-passer, tax, travel and low value purchases to telecommunication services, standard office and information technology support and human resource management. Services provided by external entities are continuously monitored to ensure that they are being provided in the most efficient, effective and economical way.

Management is also involved in coordinating with the other VIC based international organizations (VBOs) over planning of office and storage space, usage of common space, maintenance of the premises, common services and security.

Throughout 2021, the Commission continued to focus on smart planning to streamline its activities and to increase synergy and efficiency. It also prioritized results based management.

Oversight

Internal Audit is an independent and objective internal oversight mechanism. Through the provision of assurance, advisory and investigation services, it contributes to the improvement of the governance, risk management and control processes of the PTS.

To maintain its organizational independence, Internal Audit, through its Chief, reports directly to the Executive Secretary and has direct access to the Chairperson of the Commission. The Chief of Internal Audit also independently prepares and submits to the Commission and its subsidiary bodies an annual report on internal audit activities.

In 2021, Internal Audit performed all audit assignments which were included in its approved annual work plan. Based on the audits performed, Internal Audit identified opportunities to mitigate risks and strengthen the overall control environment of the PTS. To this end, Internal Audit provided several recommendations to management.

In addition, Internal Audit undertook periodic follow-up exercises on the status of implementation of its recommendations and submitted relevant progress reports to the Executive Secretary, including specific analyses regarding the prioritization and chronology of all the recommendations.

In line with its mandate, Internal Audit continued to perform management support activities, such as providing advice on processes and procedures and participating as an observer at various PTS committee meetings. Furthermore, Internal Audit acted as the PTS focal point for the External Auditor.

During 2021, Internal Audit updated its Standard Investigation Protocols which describe the general procedures followed by the Section in conducting investigations at the PTS. In addition, Internal Audit participated in the network of the United Nations Representatives of Investigative Services.

The International Standards for the Professional Practice of Internal Auditing (Standards) of the Institute of Internal Auditors (IIA) require Internal Audit functions to put in place a quality assurance and improvement programme. As part of this programme, Internal Audit functions are required, inter alia, to have an external quality assessment at least once every five years. Following an open competitive bidding process, the IIA Austria was selected to conduct the external quality assessment of the PTS Internal Audit activities. This exercise was performed in 2021, and the independent and qualified external assessors concluded with the top rating scale that the PTS Internal Audit activities "Generally Conforms" to all the "Standards", the Definition of Internal Auditing and the Code of Ethics of the IIA.

Internal Audit continued to improve the quality of its services through specific activities. These include continuous monitoring as per the quality assurance and improvement programme, as well as exchanging methodologies and best practices through participation in periodic surveys and regular online meetings of the Representatives of Internal Audit Services of United Nations Organizations and of the network of the United Nations Representatives of Investigative Services.

Finance

2020-2021 Programme and Budget

The Budget for 2020 amounted to $67 210 100 and €56 275 800, corresponding to slightly less than zero real growth. The Commission uses a split currency system to lessen its exposure to fluctuations in the value of the US dollar against the euro. At the budget exchange rate of €1 to $1, the total US dollar equivalent of the 2020 Budget was $123 485 900. This represented a nominal growth of 1.8% but was almost constant in real terms (a decrease of $90 900).

On the basis of the actual average exchange rate in 2020 of €0.8778 to $1, the final total US dollar equivalent of the 2020 Budget was $131 320 100. Of the total Budget, 81% was originally allocated to verification related activities, including $15 471 803 for the Capital Investment Fund, which is dedicated to the build-up and sustainment of the IMS, and $8 589 463 for the multiyear funds that are dedicated to other long term verification related projects.

The Budget for 2021 totalled $68 101 500 and €57 001 100, corresponding to slightly less than zero real growth. At the budget exchange rate of €1 to $1, the total US dollar equivalent of the 2021 Budget was $125 102 600. This represented a nominal growth of 1.3% but was almost constant in real terms (a decrease of $71 100).

Enhanced Financial Resilience

Ensuring financial sustainability and resilience of the Organization in the aftermath of the COVID-19 crisis is a key priority. A major step was achieved in 2021 through the agreement by all States Signatories to approve an additional Working Capital Fund allotment (totalling $9.2 million) as part of the 2022-2023 Programme and Budget to cover four weeks of expenditures.

Assessed Contributions

As of 31 December 2021, the collection rates of the assessed contributions from States Signatories for 2021 were 92.9% of the US dollar portion and 92.9% of the euro portion. The number of States that had paid their 2021 assessed contributions in full as of 31 December 2021 was 114.

Expenditure

The expenditure for the Programme and Budget in 2021 amounted to $116 569 861, of which $15 066 935 was from the Capital Investment Fund, $6 365 290 was from the multiyear funds, and the remainder from the General Fund. For the General Fund, the unused budget was $26 488 308.

Distribution of the 2020-2021 Budget by Area of Activity

Area of Activity	2020 Budget (US$ millions)[a]	2021 Budget (US$ millions)[b,c]
International Monitoring System	42	39.8
International Data Centre	49.7	48.7
On-Site Inspection	12.4	11
Evaluation and Audit	2.4	2.3
Policy Making Organ Support	4.2	3.8
Administration, Coordination and Support	16	15.1
Legal and External Relations	4.6	4.4
Total	**131.3**	**125.1**

a) To convert the euro component of the 2020 Budget, an average exchange rate of €0.8778 to $1 was used.

b) To convert the euro portion of the 2021 allotment, the budgetary exchange rate of €1 to $1 was used.

c) Amounts include the 2014 cash surplus allocated to the multiyear funds in accordance with CTBT/PC-47/2.

Automation

The Finance Process Automation and Streamlining Project, launched in 2020 and aimed at streamlining activities in the finance area, was completed in 2021. The key project objective to reduce reliance on manual processes was achieved. The PTS managed to replace manual typing of invoice data into the Enterprise Resource Planning module by using optical character recognition software; replace phone calls and emails with electronic notifications wherever possible; and made the physical circulation and signing of documents redundant with workflow notifications and electronic approvals.

In 2021 approximately 3000 invoices and 500 various background documents were processed through the e-invoicing system.

General Services

During the reporting period, the cooperation and dialogue with the other VBOs continued in an uninterrupted manner. The PTS actively

participated in all inter-VBO committees, both decision making and advisory. During the reporting period, the PTS continued to seek the best value for money from the respective service providing VBO, using existing contracts for the supply of different goods and services and shifting to more efficient and cost effective service schemes.

In 2021, General Services worked on the development of PTS-wide procedures for the management of documents including their electronic handling and signature and the automation of document management processes.

Following the outbreak of the COVID-19 pandemic, and consistent with the PTS-wide approach, General Services continued to perfect working modalities aimed at ensuring a timely and uninterrupted provision of support and services in all areas of its work, including the processing, issuance and renewal of documents required to support the continuity of official PTS functions as well as staff needs. It also continued to support the implementation of the arrangements needed to comply with the applicable physical distancing measures in the workspace to provide a healthy and safe work environment, such as office moves and partitioning.

The PTS further consolidated the cross-Divisional arrangements in place to optimize the use of available space and accommodate pressing archiving needs to guarantee safe storage of the records and documentation of the Commission.

During the reporting period, General Services provided the necessary support related to travel and booking arrangements, including those following the COVID-19 pandemic and the measures adopted in response to it. In addition to this, General Services completed the booking of accommodation for participants in the SnT2021 conference, securing terms and conditions allowing it to cancel bookings made in a cost effective manner, if so needed.

General Services also continued to facilitate and support the activities and needs of the TeST Centre at Seibersdorf, Austria, and made further progress in modernizing its transport fleet, as required by the administrative regulations in place.

All customs declarations for the release of CTBTO equipment were processed and submitted to the customs clearing agents in a timely manner.

Procurement

In 2021, the PTS reached major milestones in the project implementation of streamlining Enterprise Resource Planning processes in the areas of several additional functionalities that provided significant benefit, allowing the PTS to address audit recommendations and optimize its resources.

Furthermore, in 2021 the Procurement Section successfully passed the EU pillar assessment (pillar 7: exclusion from access to funding and pillar 8: publication of information on recipients), which provided reasonable assurance to the European Commission that the PTS fulfils the requirements set out in the EU Financial Regulation.

Despite ongoing restrictions to on-site work due to the COVID-19 pandemic, the PTS sustained its operations in a flexible and agile manner and continued its procurement support to meet the programmatic needs of the PTS in a remote working environment.

The Commission obligated $63 220 427 through 819 procurements for high value purchases and $683 972 through 408 contractual instruments for low value purchases.

As of 31 December 2021, 147 IMS stations, 29 noble gas systems, 13 radionuclide laboratories and 4 radionuclide laboratories with noble gas capability were under contract for testing and evaluation or for PCAs.

Resources Mobilization

In a zero real growth budget environment, raising extrabudgetary resources for projects that converge with the strategic goals of the Commission is of increasing importance.

In 2021, the Commission welcomed the notification from a number of States announcing their decision to surrender their 2018-2019 cash surplus as a voluntary contribution (Australia, Denmark, Finland, Italy, New Zealand, the United Kingdom of Great

Britain and Northern Ireland and the United States of America) in favour of the sustainment sub-fund of the Capital Investment Fund, recapitalization of IMS stations, the Capacity Building Fund and the project for experts from developing countries to participate in official technical meetings of the Commission. The Commission also received voluntary contributions from notable country donors (Austria, China, France, New Zealand, Spain and the United States of America). In addition, the PTS continued to receive national contributions to fund PCAs for some certified stations, operation, maintenance and equipment support, technical assistance for radionuclide analysis and noble gas systems, and cost-free experts.

Human Resources

The Organization secured the human resources for its operations by recruiting high calibre candidates and retaining highly competent and committed staff, empowered to contribute at their best. Recruitment was based on obtaining the highest standards of professional expertise, experience, efficiency, competence and integrity. Full attention was paid to the principle of diversity and inclusion, equal employment opportunities, to the importance of recruiting staff on as wide a geographical basis as possible and to other relevant criteria in the Treaty and the Staff Regulations.

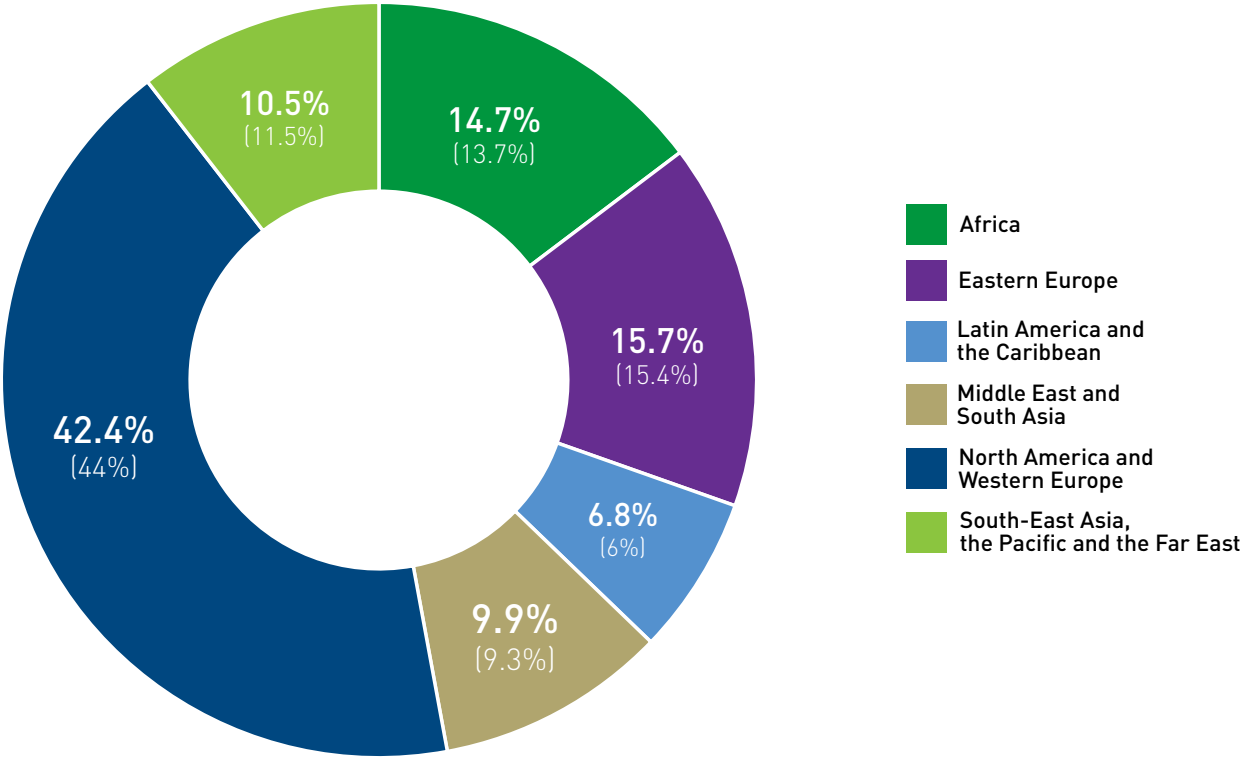
Throughout the year, the PTS continued its efforts to improve human resources policies, procedures and processes. As of 31 December 2021, there were 286 regular fixed term staff members of the PTS from 92 countries, compared with 277 staff members from 90 countries on 31 December 2020. In 2021, there were 191 staff members in the Professional and higher categories, while in 2020 there were 182. By the end of 2021, 36.6% of staff at the professional or higher level were women as compared to 31.8% at the end of 2020.

Fixed Term Staff Members by Field of Work as of 31 December 2021

Field of Work	Professional	General Service	Total
QMPM Section	3	-	3
IMS Division	32	24	56
IDC Division	79	17	96
OSI Division	22	7	29
Subtotal, verification related	*136*	*48*	*184*
Share, verification related	*71.2%*	*50.5%*	*64.3%*
Office of the Executive Secretary	5	2	7
Internal Audit	4	-	4
Human Resources Services	5	8	13
Division of Administration	22	20	42
Legal and External Relations Division	19	17	36
Subtotal, non-verification-related	*55*	*47*	*102*
Share, non-verification-related	*28.8%*	*49.5%*	*35.7%*
Total	**191**	**95**	**286**

Fixed Term Professional Staff by Geographical Region as of 31 December 2021

(Percentages as of 31 December 2020 are shown in brackets)



Fixed Term Staff Members by Grade, 2020 and 2021

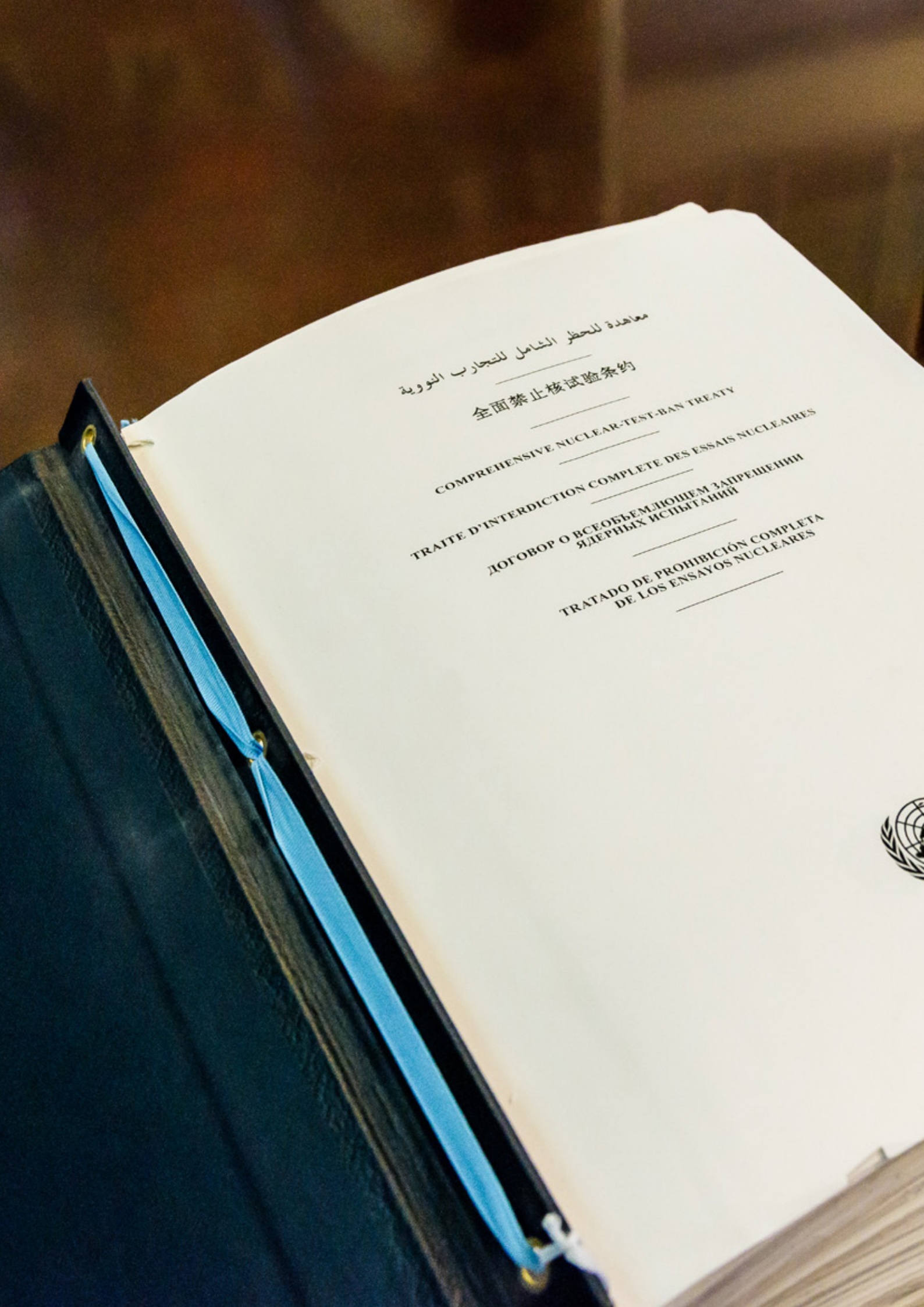
Grade	2020		2021	
D1	4	1.4%	6	2.1%
P5	24	8.7%	32	11.2%
P4	58	20.9%	59	20.6%
P3	66	23.8%	62	21.7%
P2	30	10.8%	32	11.2%
Subtotal	*182*	*65.7%*	*191*	*66.8%*
G7	1	0.4%	1	0.3%
G6*	5	1.8%	3	1%
G6	26	9.4%	27	9.4%
G5	43	15.5%	44	15.4%
G4	20	7.2%	20	7%
Subtotal	*95*	*34.3%*	*95*	*33.2%*
Total	**277**	**100%**	**286**	**(100%)**

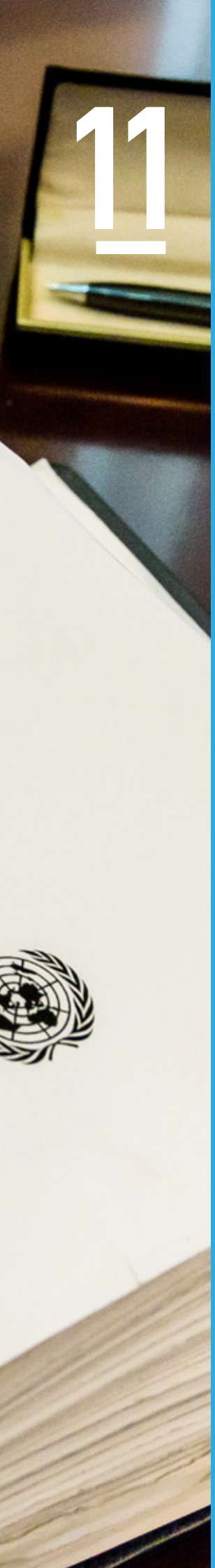
*Internationally recruited

Fixed Term Staff Members by Grade and Gender, 2020 and 2021

Grade	Male				Female			
	2020		2021		2020		2021	
D1	3	1.8%	3	1.9%	1	0.9%	3	2.4%
P5	18	11%	20	12.4%	6	5.3%	12	9.6%
P4	42	25.6%	40	24.8%	16	14.2%	19	15.2%
P3	47	28.7%	44	27.3%	19	16.8%	18	14.4%
P2	14	8.5%	14	8.7%	16	14.2%	18	14.4%
Subtotal	*124*	*75.6%*	*121*	*75.2%*	*58*	*51.3%*	*70*	*56%*
G7	-	-	-	-	1	0.8%	1	0.8%
G6*	5	3.1%	3	1.9%	-	-	-	-
G6	18	11%	18	11.2%	8	7.1%	9	7.2%
G5	13	7.9%	14	8.7%	30	26.6%	30	24%
G4	4	2.4%	5	3.1%	16	14.2%	15	12%
Subtotal	*40*	*24.4%*	*40*	*24.8%*	*55*	*48.7%*	*55*	*44%*
Total	**164**	**100%**	**161**	**100%**	**113**	**100%**	**125**	**100%**

*Internationally recruited


معاهدة للحظر الشامل للتجارب النووية
全面禁止核试验条约
COMPREHENSIVE NUCLEAR-TEST-BAN TREATY
TRAITE D'INTERDICTION COMPLETE DES ESSAIS NUCLEAIRES
ДОГОВОР О ВСЕОБЪЕМЛЮЩЕМ ЗАПРЕЩЕНИИ ЯДЕРНЫХ ИСПЫТАНИЙ
TRATADO DE PROHIBICIÓN COMPLETA DE LOS ENSAYOS NUCLEARES



11 SIGNATURE AND RATIFICATION

As of 31 December 2021

185 States Signatories
170 Ratified / 15 Signed But Not Ratified

STATES WHOSE RATIFICATION IS REQUIRED FOR THE TREATY TO ENTER INTO FORCE

ANNEX 2

44 States

36 Ratified / 5 Signed But Not Ratified / 3 Not Signed

State	Date of Signature	Date of Ratification
Algeria	15 Oct. 1996	11 Jul. 2003
Argentina	24 Sep. 1996	4 Dec. 1998
Australia	24 Sep. 1996	9 Jul. 1998
Austria	24 Sep. 1996	13 Mar. 1998
Bangladesh	24 Oct. 1996	8 Mar. 2000
Belgium	24 Sep. 1996	29 Jun. 1999
Brazil	24 Sep. 1996	24 Jul. 1998
Bulgaria	24 Sep. 1996	29 Sep. 1999
Canada	24 Sep. 1996	18 Dec. 1998
Chile	24 Sep. 1996	12 Jul. 2000
China	24 Sep. 1996	
Colombia	24 Sep. 1996	29 Jan. 2008
Democratic People's Republic of Korea		
Democratic Republic of the Congo	4 Oct. 1996	28 Sep. 2004
Egypt	14 Oct. 1996	
Finland	24 Sep. 1996	15 Jan. 1999
France	24 Sep. 1996	6 Apr. 1998
Germany	24 Sep. 1996	20 Aug. 1998
Hungary	25 Sep. 1996	13 Jul. 1999
India		
Indonesia	24 Sep. 1996	6 Feb. 2012
Iran (Islamic Republic of)	24 Sep. 1996	
Israel	25 Sep. 1996	
Italy	24 Sep. 1996	1 Feb. 1999
Japan	24 Sep. 1996	8 Jul. 1997
Mexico	24 Sep. 1996	5 Oct. 1999
Netherlands	24 Sep. 1996	23 Mar. 1999
Norway	24 Sep. 1996	15 Jul. 1999
Pakistan		
Peru	25 Sep. 1996	12 Nov. 1997
Poland	24 Sep. 1996	25 May 1999
Republic of Korea	24 Sep. 1996	24 Sep. 1999
Romania	24 Sep. 1996	5 Oct. 1999
Russian Federation	24 Sep. 1996	30 Jun. 2000
Slovakia	30 Sep. 1996	3 Mar. 1998
South Africa	24 Sep. 1996	30 Mar. 1999
Spain	24 Sep. 1996	31 Jul. 1998
Sweden	24 Sep. 1996	2 Dec. 1998
Switzerland	24 Sep. 1996	1 Oct. 1999
Turkey	24 Sep. 1996	16 Feb. 2000
Ukraine	27 Sep. 1996	23 Feb. 2001
United Kingdom	24 Sep. 1996	6 Apr. 1998
United States of America	24 Sep. 1996	
Viet Nam	24 Sep. 1996	10 Mar. 2006

SIGNATURE AND RATIFICATION OF THE TREATY BY GEOGRAPHICAL REGION

AFRICA

54 States

47 Ratified / 4 Signed But Not Ratified / 3 Not Signed

State	Date of Signature	Date of Ratification
Algeria	15 Oct. 1996	11 Jul. 2003
Angola	27 Sep. 1996	20 Mar. 2015
Benin	27 Sep. 1996	6 Mar. 2001
Botswana	16 Sep. 2002	28 Oct. 2002
Burkina Faso	27 Sep. 1996	17 Apr. 2002
Burundi	24 Sep. 1996	24 Sep. 2008
Cabo Verde	1 Oct. 1996	1 Mar. 2006
Cameroon	16 Nov. 2001	6 Feb. 2006
Central African Republic	19 Dec. 2001	26 May 2010
Chad	8 Oct. 1996	8 Feb. 2013
Comoros	12 Dec. 1996	19 Feb. 2021
Congo	11 Feb. 1997	2 Sep. 2014
Côte d'Ivoire	25 Sep. 1996	11 Mar. 2003
Democratic Republic of the Congo	4 Oct. 1996	28 Sep. 2004
Djibouti	21 Oct. 1996	15 Jul. 2005
Egypt	14 Oct. 1996	
Equatorial Guinea	9 Oct. 1996	
Eritrea	11 Nov. 2003	11 Nov. 2003
Eswatini	24 Sep. 1996	21 Sep. 2016
Ethiopia	25 Sep. 1996	8 Aug. 2006
Gabon	7 Oct. 1996	20 Sep. 2000
Gambia	9 Apr. 2003	
Ghana	3 Oct. 1996	14 Jun. 2011
Guinea	3 Oct. 1996	20 Sep. 2011
Guinea-Bissau	11 Apr. 1997	24 Sep. 2013
Kenya	14 Nov. 1996	30 Nov. 2000
Lesotho	30 Sep. 1996	14 Sep. 1999

State	Date of Signature	Date of Ratification
Liberia	1 Oct. 1996	17 Aug. 2009
Libya	13 Nov. 2001	6 Jan. 2004
Madagascar	9 Oct. 1996	15 Sep. 2005
Malawi	9 Oct. 1996	21 Nov. 2008
Mali	18 Feb. 1997	4 Aug. 1999
Mauritania	24 Sep. 1996	30 Apr. 2003
Mauritius		
Morocco	24 Sep. 1996	17 Apr. 2000
Mozambique	26 Sep. 1996	4 Nov. 2008
Namibia	24 Sep. 1996	29 Jun. 2001
Niger	3 Oct. 1996	9 Sep. 2002
Nigeria	8 Sep. 2000	27 Sep. 2001
Rwanda	30 Nov. 2004	30 Nov. 2004
Sao Tome and Principe	26 Sep. 1996	
Senegal	26 Sep. 1996	9 Jun. 1999
Seychelles	24 Sep. 1996	13 Apr. 2004
Sierra Leone	8 Sep. 2000	17 Sep. 2001
Somalia		
South Africa	24 Sep. 1996	30 Mar. 1999
South Sudan		
Sudan	10 Jun. 2004	10 Jun. 2004
Togo	2 Oct. 1996	2 Jul. 2004
Tunisia	16 Oct. 1996	23 Sep. 2004
Uganda	7 Nov. 1996	14 Mar. 2001
United Republic of Tanzania	30 Sep. 2004	30 Sep. 2004
Zambia	3 Dec. 1996	23 Feb. 2006
Zimbabwe	13 Oct. 1999	13 Feb. 2019

EASTERN EUROPE

23 States
23 Ratified

State	Date of Signature	Date of Ratification
Albania	27 Sep. 1996	23 Apr. 2003
Armenia	1 Oct. 1996	12 Jul. 2006
Azerbaijan	28 Jul. 1997	2 Feb. 1999
Belarus	24 Sep. 1996	13 Sep. 2000
Bosnia and Herzegovina	24 Sep. 1996	26 Oct. 2006
Bulgaria	24 Sep. 1996	29 Sep. 1999
Croatia	24 Sep. 1996	2 Mar. 2001
Czech Republic	12 Nov. 1996	11 Sep. 1997
Estonia	20 Nov. 1996	13 Aug. 1999
Georgia	24 Sep. 1996	27 Sep. 2002
Hungary	25 Sep. 1996	13 Jul. 1999
Latvia	24 Sep. 1996	20 Nov. 2001
Lithuania	7 Oct. 1996	7 Feb. 2000
Montenegro	23 Oct. 2006	23 Oct. 2006
North Macedonia	29 Oct. 1998	14 Mar. 2000
Poland	24 Sep. 1996	25 May 1999
Republic of Moldova	24 Sep. 1997	16 Jan. 2007
Romania	24 Sep. 1996	5 Oct. 1999
Russian Federation	24 Sep. 1996	30 Jun. 2000
Serbia	8 Jun. 2001	19 May 2004
Slovakia	30 Sep. 1996	3 Mar. 1998
Slovenia	24 Sep. 1996	31 Aug. 1999
Ukraine	27 Sep. 1996	23 Feb. 2001

LATIN AMERICA AND THE CARIBBEAN

33 States
32 Ratified / 1 Not Signed

State	Date of Signature	Date of Ratification
Antigua and Barbuda	16 Apr. 1997	11 Jan. 2006
Argentina	24 Sep. 1996	4 Dec. 1998
Bahamas	4 Feb. 2005	30 Nov. 2007
Barbados	14 Jan. 2008	14 Jan. 2008
Belize	14 Nov. 2001	26 Mar. 2004
Bolivia (Plurinational State of)	24 Sep. 1996	4 Oct. 1999
Brazil	24 Sep. 1996	24 Jul. 1998
Chile	24 Sep. 1996	12 Jul. 2000
Colombia	24 Sep. 1996	29 Jan. 2008
Costa Rica	24 Sep. 1996	25 Sep. 2001
Cuba	4 Feb. 2021	4 Feb. 2021
Dominica		
Dominican Republic	3 Oct. 1996	4 Sep. 2007
Ecuador	24 Sep. 1996	12 Nov. 2001
El Salvador	24 Sep 1996	11 Sep. 1998
Grenada	10 Oct. 1996	19 Aug. 1998
Guatemala	20 Sep. 1999	12 Jan. 2012
Guyana	7 Sep. 2000	7 Mar. 2001
Haiti	24 Sep. 1996	1 Dec. 2005
Honduras	25 Sep. 1996	30 Oct. 2003
Jamaica	11 Nov. 1996	13 Nov. 2001
Mexico	24 Sep. 1996	5 Oct. 1999
Nicaragua	24 Sep. 1996	5 Dec. 2000
Panama	24 Sep. 1996	23 Mar. 1999
Paraguay	25 Sep. 1996	4 Oct. 2001
Peru	25 Sep. 1996	12 Nov. 1997
Saint Kitts and Nevis	23 Mar. 2004	27 Apr. 2005
Saint Lucia	4 Oct. 1996	5 Apr. 2001
Saint Vincent and the Grenadines	2 Jul. 2009	23 Sep. 2009
Suriname	14 Jan. 1997	7 Feb. 2006
Trinidad and Tobago	8 Oct. 2009	26 May 2010
Uruguay	24 Sep. 1996	21 Sep. 2001
Venezuela (Bolivarian Republic of)	3 Oct. 1996	13 May 2002

MIDDLE EAST AND SOUTH ASIA

26 States

16 Ratified / 5 Signed But Not Ratified / 5 Not Signed

State	Date of Signature	Date of Ratification
Afghanistan	24 Sep. 2003	24 Sep. 2003
Bahrain	24 Sep. 1996	12 Apr. 2004
Bangladesh	24 Oct. 1996	8 Mar. 2000
Bhutan		
India		
Iran (Islamic Republic of)	24 Sep. 1996	
Iraq	19 Aug. 2008	26 Sep. 2013
Israel	25 Sep. 1996	
Jordan	26 Sep. 1996	25 Aug. 1998
Kazakhstan	30 Sep. 1996	14 May 2002
Kuwait	24 Sep. 1996	6 May 2003
Kyrgyzstan	8 Oct. 1996	2 Oct. 2003
Lebanon	16 Sep. 2005	21 Nov. 2008
Maldives	1 Oct. 1997	7 Sep. 2000
Nepal	8 Oct. 1996	
Oman	23 Sep. 1999	13 Jun. 2003
Pakistan		
Qatar	24 Sep. 1996	3 Mar. 1997
Saudi Arabia		
Sri Lanka	24 Oct. 1996	
Syrian Arab Republic		
Tajikistan	7 Oct. 1996	10 Jun. 1998
Turkmenistan	24 Sep. 1996	20 Feb. 1998
United Arab Emirates	25 Sep. 1996	18 Sep. 2000
Uzbekistan	3 Oct. 1996	29 May 1997
Yemen	30 Sep. 1996	

NORTH AMERICA AND WESTERN EUROPE

28 States

27 Ratified / 1 Signed But Not Ratified

State	Date of Signature	Date of Ratification
Andorra	24 Sep. 1996	12 Jul. 2006
Austria	24 Sep. 1996	13 Mar. 1998
Belgium	24 Sep. 1996	29 Jun. 1999
Canada	24 Sep. 1996	18 Dec. 1998
Cyprus	24 Sep. 1996	18 Jul. 2003
Denmark	24 Sep. 1996	21 Dec. 1998
Finland	24 Sep. 1996	15 Jan. 1999
France	24 Sep. 1996	6 Apr. 1998
Germany	24 Sep. 1996	20 Aug. 1998
Greece	24 Sep. 1996	21 Apr. 1999
Holy See	24 Sep. 1996	18 Jul. 2001
Iceland	24 Sep. 1996	26 Jun. 2000
Ireland	24 Sep. 1996	15 Jul. 1999
Italy	24 Sep. 1996	1 Feb. 1999
Liechtenstein	27 Sep. 1996	21 Sep. 2004
Luxembourg	24 Sep. 1996	26 May 1999
Malta	24 Sep. 1996	23 Jul. 2001
Monaco	1 Oct. 1996	18 Dec. 1998
Netherlands	24 Sep. 1996	23 Mar. 1999
Norway	24 Sep. 1996	15 Jul. 1999
Portugal	24 Sep. 1996	26 Jun. 2000
San Marino	7 Oct. 1996	12 Mar. 2002
Spain	24 Sep. 1996	31 Jul. 1998
Sweden	24 Sep. 1996	2 Dec. 1998
Switzerland	24 Sep. 1996	1 Oct. 1999
Turkey	24 Sep. 1996	16 Feb. 2000
United Kingdom	24 Sep. 1996	6 Apr. 1998
United States of America	24 Sep. 1996	

SOUTH EAST ASIA, THE PACIFIC AND THE FAR EAST

32 States

25 Ratified / 5 Signed But Not Ratified / 2 Not Signed

State	Date of Signature	Date of Ratification
Australia	24 Sep. 1996	9 Jul. 1998
Brunei Darussalam	22 Jan. 1997	10 Jan. 2013
Cambodia	26 Sep. 1996	10 Nov. 2000
China	24 Sep. 1996	
Cook Islands	5 Dec. 1997	6 Sep. 2005
Democratic People's Republic of Korea		
Fiji	24 Sep. 1996	10 Oct. 1996
Indonesia	24 Sep. 1996	6 Feb. 2012
Japan	24 Sep. 1996	8 Jul. 1997
Kiribati	7 Sep. 2000	7 Sep. 2000
Lao People's Democratic Republic	30 Jul. 1997	5 Oct. 2000
Malaysia	23 Jul. 1998	17 Jan. 2008
Marshall Islands	24 Sep. 1996	28 Oct. 2009
Micronesia (Federated States of)	24 Sep. 1996	25 Jul. 1997
Mongolia	1 Oct. 1996	8 Aug. 1997
Myanmar	25 Nov. 1996	21 Sep. 2016
Nauru	8 Sep. 2000	12 Nov. 2001
New Zealand	27 Sep. 1996	19 Mar. 1999
Niue	9 Apr. 2012	4 Mar. 2014
Palau	12 Aug. 2003	1 Aug. 2007
Papua New Guinea	25 Sep. 1996	
Philippines	24 Sep. 1996	23 Feb. 2001
Republic of Korea	24 Sep. 1996	24 Sep. 1999
Samoa	9 Oct. 1996	27 Sep. 2002
Singapore	14 Jan. 1999	10 Nov. 2001
Solomon Islands	3 Oct. 1996	
Thailand	12 Nov. 1996	25 Sep. 2018
Timor-Leste	26 Sep. 2008	
Tonga		
Tuvalu	25 Sep. 2018	
Vanuatu	24 Sep. 1996	16 Sep. 2005
Viet Nam	24 Sep. 1996	10 Mar. 2006

CTBT

VEINTICINCO AÑOS

TWENTY-FIVE YEARS

SECRETARÍA TÉCNICA PROVISIONAL DE LA COMISIÓN PREPARATORIA DE LA ORGANIZACIÓN DEL TRATADO DE PROHIBICIÓN COMPLETA DE LOS ENSAYOS NUCLEARES

PROVISIONAL TECHNICAL SECRETARIAT OF THE PREPARATORY COMMISSION FOR THE COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION

1996 – 2021

CTBTO
PREPARATORY COMMISSION

PUTTING AN
END TO NUCLEAR
EXPLOSIONS