The International Data Centre (IDC) is designed to collect, process, analyse and report on data received from facilities of the International Monitoring System (IMS), including the results of analyses conducted at certified radionuclide laboratories. The data and products are then transmitted to States Parties for their final assessment. Data and products are received and distributed through the Global Communications Infrastructure (GCI).

The IDC is situated at the Headquarters of the Preparatory Commission in the Vienna International Centre. A relational database management system forms the core of all information management. Full network redundancy has been created at the IDC to ensure high availability. A mass storage system provides archiving capacity for more than 10 years of verification data. The software utilized in operating the IDC is mostly developed specifically for the CTBT verification regime.
HIGHLIGHTS IN 2008

RELEASE of a new ‘NDC in a box’ software package to National Data Centres

ENTRY of the CTBTO–WMO response system into provisional operations

CONCLUSION of tsunami warning agreements and arrangements with Australia, Indonesia, Japan, the Philippines and the USA.

SUPPORT AND BUILD-UP

In 2008, support and build-up of the IMS continued with the testing and evaluation of data from new stations. Newly installed or upgraded stations were introduced into IDC operations. Other stations were installed in the IDC test bed.

FROM RAW DATA TO FINAL PRODUCT

The data collected by the IMS under provisional operations are processed immediately when they reach the IDC. The first automated data product, known as Standard Event List 1 (SEL1), is released within two hours of the arrival of raw data. This data product lists preliminary events recorded by the primary seismic and hydroacoustic stations.

Requests are then made for data from the auxiliary seismic stations. These data, combined with the data from the infrasound stations and any late-arriving data, are used to produce a more complete event list, SEL2, six hours after the arrival of initial data. SEL2 is improved again after 12 hours have elapsed to incorporate any additional late-arriving data, to produce the final automated event list, SEL3.

Analysts subsequently review events recorded in SEL3 to prepare the Reviewed Event Bulletin (REB). The REB for a given day contains all those events detected at IMS seismic, hydroacoustic and infrasound stations which meet specific 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, it is planned to release the REB within approximately two days.
Observations from events recorded by IMS radionuclide particulate and noble gas monitoring stations typically arrive several days later than the signals from the same events recorded by the seismic, hydroacoustic and infrasound stations. Radionuclide particulate data undergo both automatic and reviewed processing to produce an Automatic Radionuclide Report and then a Reviewed Radionuclide Report (RRR) for each full gamma ray spectrum received. The information in the REB and RRR will eventually be fused, associating seismoacoustic events with radionuclide detections.

OPERATIONS CENTRE

The Operations Centre, as the focal point for operational activities, is a crucial part of integrated operations. It consists of control, escalation and multimedia rooms and is equipped with state of the art technology. From there, staff of the PTS monitor the IMS facilities in real time. Activities of the centre include status reporting, operational incident management, and GCI data, network and systems operations.

Over 4000 incidents at facilities were registered and resolved in the centre in 2008. New key performance indicators (KPIs) based on statistics from the IMS Reporting System, GCI statistics and data availability values have been included in a performance reporting tool and have been made available to authorized users.

The tools employed in the Operations Centre in its day to day operations are being integrated into a system-wide incident tracking system based on open source technology, which provides a single interface for reporting and tracking...
all types of incident. Another important tool is the state of health (SOH) system. A prototype SOH tool, which provides the Operations Centre staff with a consolidated view of the relevant incident troubleshooting metrics, has been developed and installed in a testing environment with real data.

NATIONAL DATA CENTRES

A National Data Centre (NDC) is an organization with technical expertise in the CTBT verification technologies. Its functions may include sending IMS data to the IDC and receiving data and products from the IDC.

The ‘NDC in a box’ is a software package developed by the IDC for use at NDCs, giving them the capability to receive, process and analyse IMS data. A new version of the software was released in July 2008. Along with the traditional tools for receiving, testing and analysing continuous data from the PTS, the new package includes a tool for downloading source–receptor sensitivity data from the PTS and a tool for modelling atmospheric transport that analyses the relationship between a detection in the radionuclide network and possible emission points on the surface of the globe. By the end of 2008, the new IDC in a box had been distributed to more than 50 States Signatories through the IDC secure web site.

A total of 110 secure signatory accounts (one for each requesting State Signatory) had been established by the end of the year and 1098 users from these States Signatories had been authorized to access IMS data and IDC products and receive technical support. These are increases of 13 secure accounts (13%)
and 239 users (22%) over 2007. More than 1200 requests from authorized users regarding technical information were received and resolved, continuing the steady increase in requests, which have more than doubled since 2003.

SIMULATING SOUND PROPAGATION IN THE ATMOSPHERE

In 2008, the PTS acquired software for simulating sound wave propagation in the atmosphere. This software takes into account the heterogeneity of the atmosphere to predict the different types of infrasound phase passing between a source and a receiver, and calculates the travel times and other parameters for these arrivals.

In parallel, the PTS received the most recent version of an empirical global atmospheric model called HWM2007. This model replaces the 1993 version and more accurately describes the atmosphere on the basis of millions of integrated satellite data and surface meteorological data. Work has begun to combine HWM2007 with real time models available from the European Centre for Medium-Range Weather Forecasts, in order to construct a highly realistic atmospheric model of the earth from the surface up to an altitude of 180 km.

The new models should help to better understand signal waveforms detected at IMS infrasound stations and refine the location of events built with infrasound data. Testing and validation will be needed before any real time dynamic atmospheric models can be used in IDC operations.
The PTS has developed a plan for a smooth and steady transfer of the 20 noble gas systems in the IMS into IDC operations during 2009. The plan includes the definition of the acceptance criteria and SOH parameters of the systems to be monitored as well as outlining the necessary training for relevant staff.

Distinguishing the civil anthropogenic background level of airborne radionuclides from radiation emissions due to Treaty-relevant events is a challenging task that involves nuclear physicists, statisticians and meteorologists. The PTS is currently putting emphasis on obtaining a comprehensive understanding of possible sources, atmospheric transport and variability of the noble gas radioxenon over time. This is possible through cooperation with scientists from more than twenty institutions worldwide in the International Noble Gas Experiment (INGE).

In June 2007, the European Union (EU) approved a joint action to support PTS research activities to explore the anthropogenic xenon background and to fund a PTS field campaign for studying and measuring the xenon background in several parts of the world. The results gained during the last nine years from INGE have clearly shown that the radioxenon background is much more complex than was first thought. Indeed, initially unforeseen anthropogenic sources have been identified, such as radioisotope production facilities for medical applications. Measurements with a transportable detector unit are being carried out at various locations worldwide where radioxenon background data are currently absent.

The EU joint action project successfully collected data at three different sites in 2008 and will continue at another four sites in 2009. Valuable information has been acquired on radiopharmaceutical production, which has recently been identified to be the principal civil source of radioactive xenon isotopes. The data are complemented with measurements directly in the stacks of the radiopharmaceutical facilities. In this way, the PTS can obtain a unique insight into source characteristics and therefore a much better understanding of the extent to which these facilities can influence the sensitivity of the CTBT verification system.
Since 1 September 2008, the CTBTO–WMO response system has been in provisional operation. This system strengthens the atmospheric backtracking capabilities of the verification regime by enabling the Commission to send requests to the World Meteorological Organization for assistance in the case of suspicious radionuclide detections. Nine WMO Regional Specialized Meteorological Centres or National Meteorological Centres located around the world – in Beijing, China; Exeter, United Kingdom; Melbourne, Australia; Montreal, Canada; Obninsk, Russian Federation; Offenbach, Germany; Tokyo, Japan; Toulouse, France; and Vienna, Austria – respond to these requests by submitting their computations to the Commission as fast as is technically feasible, with a deadline of 24 hours.

This system is intended to corroborate the backtracking calculations of the Commission, and both organizations will benefit in terms of feedback and evaluation of the backtracking systems and methods in use. In order to maintain the response system at a high level of preparedness, it was agreed that unannounced, limited-scope system tests would take place every quarter and an announced full scale exercise would be conducted annually.

In the first full scale exercise, the Commission used the radionuclide scenario that it had generated in support of the October 2008 NDC Preparedness Exercise (NPE08). The scenario was based on a seismic event of 27 October recorded in SEL1, which was chosen by the NDCs but not disclosed to the data fusion staff of the IDC or to the WMO centres. The PTS then applied atmospheric transport modelling to predict which IMS stations would, in theory, detect potentially relevant radionuclides in their air samples if the event had been a nuclear test.

**TRACKING RADIONUCLIDES THROUGH THE ATMOSPHERE**

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For the first six days of predicted detections, hypothetical sampling times and the locations of the relevant stations were used to trigger request messages to the WMO centres. Immediate venting of nuclear debris from a nuclear test equivalent in yield to a chemical explosion of 1 kilotonne of TNT and having a radiation source strength of \(1 \times 10^{15}\) becquerels (where 1 becquerel is 1 radioactive disintegration per second) was assumed as the basis for modelling.

The results from all WMO centres and the PTS for each of the six days were analysed and a daily Data Fusion Bulletin combining waveform and radionuclide data was produced with the aid of WEB-GRAPE, an analysis tool used in atmospheric transport modelling. The interactive analysis process revealed that the possible source region was sufficiently well confined for the SEL1 event to be identified as the only plausible source. This meant that the issuance of further request messages to WMO centres could be suspended and the data fusion mission had been a success.

### TSUNAMI EARLY WARNING SYSTEMS

Following the tragedy caused by the tsunami in the Indian Ocean in December 2004, the Commission tasked the PTS to test the provision of data for the purpose of tsunami warning.

A number of tsunami warning institutions began receiving IMS data in near real time on a test basis. During this test phase, which lasted over a year, tsunami warning centres confirmed the usefulness of IMS data. In comparison with data from other existing monitoring networks, IMS data were found to arrive at these tsunami warning centres with less delay and higher reliability. This provides potentially vital additional warning time in which to activate alerts in the event of a possible tsunami threat. Consequently, in November 2006, the Commission endorsed a recommendation to provide continuous data in real time to relevant tsunami warning organizations.

**Detection of Signals from Explosions in Water at Distances up to 16 000 km**

The plots show recordings by the north hydrophone triplets of hydroacoustic station HA3 in the Juan Fernández Islands (Chile) for one of a series of signals recorded in September 2008. The colour-shaded image shows the spectrogram of the signal recorded on hydrophone number 1. The large amount of high frequency energy associated with the signal suggested that the source might have been an underwater explosion. This hypothesis was further supported by the presence of horizontal bands of alternating high and low energy in the spectrogram. These bands are due to interference between the signal transmitted at the time of the explosion and subsequent signals arising from oscillations of the gas bubble produced by the explosion.

Signals recorded at both hydrophone triplets of station HA11 on Wake Island (USA) in the middle of the Pacific Ocean showed a very similar band structure, indicating that they were associated with the same explosive event. Arrival time and azimuth information from the three recording triplets allowed the source of the signals to be located off the east coast of Japan, a distance of some 16 000 km from the Juan Fernández hydrophones.

The signals have been identified as originating from a marine seismic survey. In total, more than thirty explosions from the survey were detected and located by the IDC and reported in the Reviewed Event Bulletin.
In 2008, agreements or arrangements were made between the PTS and tsunami warning centres in Australia, Indonesia, Japan, the Philippines and the USA (Alaska). Additional agreements or arrangements were being developed with Malaysia, Myanmar, Sri Lanka and Thailand. About 2.1 gigabytes of data were being sent in near real time each day to the warning centres.

While the purpose of the global verification regime is to verify compliance with the CTBT, the use of IMS data to mitigate the catastrophic consequences of tsunamis is an example of the wide range of potential civil and scientific applications for which these data could be used.

INTERNATIONAL SCIENTIFIC STUDIES

As an organization responsible for establishing and operating a verification system that relies on the latest advances in science and technology, it is of strategic importance for the Commission to stay attuned to defining events in the scientific community, to benefit from new developments and to attract competent scientists to work for it. In this way, it can also ascertain whether its activities and products meet international standards. The International Scientific Studies (ISS) project, initiated in 2008, is a PTS-wide long term effort to further develop connections and cooperation with the scientific community. It is a follow-up to the “Synergies with Science” symposium held in August–September 2006.

The decentralized work method of the ISS project involves many different scientific groups. The project has engaged some twenty senior scientists who coordinate contacts and activities with the scientific community in eight fields of key importance to the Commission: system performance, seismology, hydroacoustics, infrasound, radionuclide monitoring, atmospheric transport modeling, on-site inspection and data mining.

The project includes active participation in scientific conferences and joint studies with scientific institutions on how to apply modern analytical methods to improve the efficiency of data analysis by the PTS and the quality of its data products. A specific ISS activity begun in 2008 was to evaluate the capability and readiness of the IMS and OSI elements of the CTBT verification regime. The results of this evaluation will be presented at a conference in Vienna on 10–12 June 2009.

A workshop on data mining was held at the Headquarters of the Commission on 15–16 September. It addressed how methods and procedures developed within this new area of science can be used to improve the analysis of verification data. The workshop was attended by some forty experts and proved important in boosting dialogue and cooperation between the data mining community and those engaged in developing tools for analysis of verification data. As a direct result of the workshop, an expert meeting was held at the Lawrence Livermore National Laboratory near San Francisco, California, on 18 December to discuss how data mining methods might create a new paradigm for the analysis of seismic data. To develop the issue further, it was planned to convene the next expert meeting in Vienna on 23–27 March 2009.

The Center for Strategic and International Studies and the American Association for the Advancement of Science invited members of the ISS project to brief scientists at a meeting in Washington, D.C., on 12 December. The meeting was well attended, not only by scientists but also by representatives of the US administration.