The International Data Centre (IDC) is designed to collect, process, analyse and report on data received from facilities of the International Monitoring System, including the results of analyses conducted at certified radionuclide laboratories. The data and products are then transmitted to States Signatories for their final assessment. Data and products are received and distributed through the Global Communications Infrastructure.
The IDC is situated at the Headquarters of the CTBTO 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 2009

- Satisfactory performance of the monitoring system demonstrated with reference to the second announced nuclear test by the Democratic People’s Republic of Korea
- Transfer of 16 noble gas systems into IDC operations
- Installation of the state of health system in the Operations Centre

SUPPORT AND BUILD-UP

In 2009, 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.

IDC application software has been converted, as far as possible, to run on open source systems (Linux), and replacement software has been written for parts that could not be converted. The software was implemented and thoroughly tested on the IDC test bed, and by the end of 2009 the majority of the software was ready to be put to operational use in January 2010. Only the interactive radionuclide analysis software has been held back owing to preparations for noble gas processing in operations, but this will be moved to operations in early 2010.

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 one hour after the data have been recorded at the station. 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, four hours after the recording of the data. SEL2 is improved again after six 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.
As the focal point for operational activities, the Operations Centre 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 3800 incidents at facilities were reported and resolved in the Operations Centre in 2009. Key performance indicators (KPIs) based on statistics from data availability, the IMS Reporting System (IRS) and the GCi have been updated in the performance reporting tool (PRTool) and have been made available to authorized users.

IRS Client, a new high performance version of the IRS for use by station operators, was developed and tested and is being delivered to the operators. It employs email for communication between station operators and the PTS, and avoids the use of tokens, VPNs and direct connection to the PTS databases.

A major achievement was the installation of the state of health (SOH) system in the Operations Centre. The system collects and manages SOH information from all components of the IMS, including stations, GCi links, IDC programs and servers and any other source of data that may be relevant to the operation and maintenance of the IMS. A tool for monitoring SOH parameters and triggering reports based on these was designed and a prototype was being tested.

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, enabling them to receive, process and analyse IMS data. In 2009, efforts were devoted to training in the use of the software and to making the package more reliable.

A total of 113 secure signatory accounts, one for each requesting State Signatory, had been established by the end of the year and 1134 users from these States Signatories had been authorized to access IMS data and IDC products and receive technical support.

**INTERNATIONAL NOBLE GAS EXPERIMENT**

The PTS transferred 16 noble gas systems (installed at 15 IMS stations and one cooperating national facility) into IDC operations during 2009. Specific software has been included to enable SOH parameters to be monitored.

Xenon analysis software for automatic and manual spectrum processing has been further developed and is approaching the operational stage. Analysts were trained to use the review software. New procedures for product delivery using XML based techniques were successfully tested with some NDCs.

Distinguishing the civil anthropogenic background level of airborne radionuclides from radiation emissions due to Treaty-relevant events is still a challenging task that involves nuclear physicists, statisticians and meteorologists. The PTS has worked on understanding data collected from the continuously increasing number of IMS noble gas systems in its database and created historical data sets for testing the method of categorization. Site
specific descriptive parameters have been developed for use in attaching indicators to spectra and for distinguishing abnormal radioxenon concentrations from typical background. This has been done in cooperation with scientists from more than twenty institutions worldwide in the International Noble Gas Experiment (iNGE) and discussed at workshops and scientific meetings.

A project funded by the European Union to support PTS activities to explore the anthropogenic xenon background through field campaigns in several parts of the world was completed successfully. Six campaigns lasting between one week and three months with continuous sampling and spot sampling in Europe, South Africa, the Middle East and South Asia delivered additional insight into civil xenon sources, their mode of operation and the impact of emissions. The findings have substantially refined the picture of the global radioxenon inventory. Additional information on isotopic background levels strengthened source identification capabilities. The outcome of the project serves as a good basis for discussions on how radiopharmaceutical facilities affect CTBT noble gas analysis. In a follow-up project, new transportable systems are under procurement for use in selected locations for longer campaigns, which will thus cover atmospheric variations that better represent real conditions.

**TRACKING RADIONUCLIDES THROUGH THE ATMOSPHERE**

The CTBTO–WMO response system continued into its second year of provisional operation. This system enables 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 respond to these requests, submitting their computations to the Commission with a target response time of 24 hours.

This system is intended to corroborate the backtracking calculations of the Commission, and all centres will benefit from the 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 quarterly and an announced full scale exercise would be conducted annually.

The PTS continued to enhance its capabilities to perform atmospheric transport modelling and reliably deliver high quality products to States Signatories. Atmospheric backtracking calculations are performed daily with near real time meteorological data obtained from the European Centre for Medium-Range Weather Forecasts. Using software developed by the PTS, these calculations are combined with nuclide specific parameters to provide the source–receiver sensitivity, field of regard and potential source region for observations at each of the IMS stations.

**PERFORMANCE OF THE VERIFICATION SYSTEM: THE SECOND ANNOUNCED NUCLEAR TEST BY THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA**

On 25 May 2009, the Democratic People’s Republic of Korea announced that it had conducted its second nuclear test. Since the announcement by this country of its first nuclear test in 2006, the IMS network had grown considerably, with 65 stations having being certified in the meantime.

The event on 25 May was automatically located using 23 primary seismic stations, as reported in the initial list of events (Standard Event List 1) which was issued by the IDC about an hour after the event. This initial location estimate had an ‘uncertainty ellipse’ with an area of 860 square kilometres, which overlapped with that of the event of 2006. The IDC produces three automatic bulletins, which are produced one, four and six hours after the event. The second and third bulletins incorporate additional data for 20 minute intervals. These later bulletins included observations from the 23 primary seismic stations and from 16 auxiliary seismic stations, which reduced the uncertainty ellipse to 582 square kilometres. The infrasound and hydroacoustic monitoring networks of the IMS did not observe any signals which could have been associated with this event.

![Overall Distribution of Treaty-Relevant Radionuclide Occurrences in 2009](image)

Most detections refer to three nuclides, sodium-24, caesium-137 and cobalt-60, which are primarily due to cosmic radiation, to resuspension of fallout from the Chernobyl accident in 1986 or to historical atmospheric tests.

![Occurrence of Anthropogenic Nuclides by Station in 2009](image)
Location and uncertainty ellipse for the 2009 event in the Democratic People’s Republic of Korea (“DPRK2”) based on IMS seismic data. The final estimate obtained after analyst review of all data was issued in the REB within two days.

Evolution of the detectable radioactive plume from the nuclear test of 25 May 2009 in the Democratic People’s Republic of Korea according to the level of containment of the assumed immediate venting. Snapshots of the plume originating from the “DPRK2” event are shown at the times when it would have been at its maximum xenon-133 activity concentration, and therefore most easily detected, at radiocycle noble gas monitoring station RN58 (Ussuriysk, Russian Federation) and subsequently at RN38 (Takasaki, Gunma, Japan) and RN22 (Guangzhou, China). The size of the detectable plume (whose activity concentration must therefore exceed the minimum detectable concentration of 0.2 millicurie per cubic metre) is colour coded on a logarithmic scale against possible values for the degree of containment of the DPRK2 test – the stronger the containment the smaller the extent of the plume. An entirely uncontained test corresponds to an immediate release of 40 000 terabecquerels of xenon-133. This source strength is consistent with the seismic signals that were associated by the IDC with the DPRK2 event. The noble gas stations operating at the time of the test are indicated by blue dots. At the time of the first announced nuclear test by the Democratic People’s Republic of Korea, on 9 October 2006, the only noble gas station operating in the region was RN45 (Ulaanbaatar, Mongolia); this is indicated by a yellow circle around the dot.
Owing to the interest in this event, the IDC expedited the production of the REB of waveform data for the events of 25 May. The REB included observations from 31 primary seismic stations and 30 auxiliary seismic stations and was issued on 27 May, in accordance with the bulletin production schedule envisaged for operation after entry into force of the Treaty. The REB reduced the uncertainty ellipse further to 264 square kilometres.

After the REB becomes available, the IDC applies experimental event screening procedures to exclude events which are “consistent with non-detection at the radionuclide noble gas monitoring stations RN58, RN38 and RN22. The red line denotes an immediate release, with 0% containment, of 40 000 terabecquerels of Xe-133 – the blue bars show that such an event would have been detectable. The green line denotes the minimum required release sensitivity (baseline) against which the IMS global monitoring coverage is evaluated – the blue bars therefore show that the actual monitoring capability in the region exceeds this minimum.

Radionuclides are transported through the atmosphere much more slowly than seismic waves travel through the earth. Consequently, radionuclides generated by an event can only be observed several days, or even weeks, after the event, depending on atmospheric conditions and the distance between the source and the observing stations. Atmospheric transport modelling can be performed in a forecast mode to simulate how radionuclides produced by an event with an assumed release scenario will disperse in the atmosphere. This forward modelling was used to predict when the IMS radionuclide stations in the region could expect to observe radionuclides relevant to the event of 25 May.

During the weeks after the event, the IMS radionuclide stations in the region worked well, with the three closest noble gas stations and seven closest radionuclide particulate stations providing good quality data. Both noble gas and particulate data were reviewed daily, including at weekends, and processing and reviewing tools worked with no significant problems. More than five hundred noble gas spectra were reviewed after the event and data were accessible to States Signatories through the IDC secure web site within 24 hours of spectrum analysis. Despite a detection capability of neighbouring noble gas detectors during this time of 0.2 millibecquerel per cubic metre or lower (where 1 becquerel is 1 radioactive disintegration per second), there was no noble gas detection that could be associated with the event of 25 May. Similarly, particulate data did not show any trace related to the event.

Objective criteria based on multiple xenon-133 measurements and atmospheric backtracking were used to determine the corresponding detection threshold across the area of the event. A consistently good
detection threshold was encountered. This implies that if there had been a xenon-133 release of the order of 10 terabecquerels, several detections would have been made by the noble gas network. This finding confirms that the event did not have a substantial immediate release (i.e. over 0.1% of the total yield), nor was there a substantial, slow seepage.

Although there were no radionuclide observations which could be associated with the 2009 event in the Democratic People’s Republic of Korea, the observed data could be used to place a constraint on the level of containment of noble gases. The lack of indicative radionuclide observations in the IMS noble gas network also shows the importance of on-site inspection (OSI) as a component of the verification regime, since local noble gas signatures may be detectable up to four to six months after an underground nuclear test in the case where there is venting or seepage.

**TSUNAMI EARLY WARNING SYSTEMS**

In November 2006, the Commission endorsed a recommendation to provide continuous IMS data in real time to relevant tsunami warning organizations. The PTS subsequently entered into agreements and arrangements with a number of tsunami warning centres approved by the United Nations Educational, Scientific and Cultural Organization (UNESCO) to provide data for warning purposes. In 2009, an agreement was finalized with the tsunami warning centre in Thailand. This brought to seven the number of such agreements and arrangements that the PTS has entered into: with Australia, Indonesia, Japan, the Philippines, Thailand and the USA (Alaska and Hawaii). Additional agreements or arrangements were being developed with Malaysia, Myanmar and Sri Lanka. Approximately 1.2 gigabytes of data were being sent in near real time each day to the warning centres. To facilitate these efforts, during its Thirty-Third Session the Commission approved a memorandum of understanding between the Commission and UNESCO.
International Scientific Studies

The CTBT verification system relies on the latest advances in science and technology and it is of strategic importance for the Commission to stay attuned to scientific developments and to attract competent scientists to work for it. 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, and is a follow-up to the “Synergies with Science” symposium held in August–September 2006.

The ISS Conference was held at the Hofburg Congress Centre in Vienna from 10 to 12 June. Over five hundred scientists from about one hundred countries joined diplomats and journalists for the meeting. There were eight panel discussions with some sixty contributors and about twenty invited presentations. The global community contributed more than two hundred scientific posters. The meeting was summarized in a publication, which was distributed worldwide and made available on the CTBTO public web site, entitled Science for Security: Verifying the Comprehensive Nuclear-Test-Ban Treaty.

The poster sessions at the conference covered eight themes: the three waveform technologies (seismology, hydroacoustics and infrasound), radionuclide monitoring, atmospheric transport modelling, system performance, OSI and data mining. The presentations were generally of a high scientific quality and drew useful conclusions regarding the overall verification capabilities of the IMS as well as recommendations about new directions that may be fruitfully pursued.

As a follow-up to the ISS meeting, a workshop on multi-sensor data fusion was held in Vienna in November. This meeting included presentations on applications of data fusion by PTS scientists and experts from the global research community. Special emphasis was placed on new results from active data mining research projects.
Panellists in the discussion on atmospheric nuclear explosions.

Andreas Stohl (Norway), speaker on atmospheric transport modelling.

Hugo Yepes (Ecuador), speaker on capacity building.

Raymond Jeanloz (USA), speaker on science for security.

Dmitry A. Storchak (International Seismological Centre), speaker on seismology.

Alexis Le Pichon (France), speaker on infrasound technology.

From left to right: Michael Spindelegger (Minister for European and International Affairs of Austria), Tibor Tóth (Executive Secretary of the CTBTO Preparatory Commission), Wolfgang Hoffmann (Executive Secretary Emeritus) and Ola Dahlman (Chairperson of the ISS Conference).