The International Data Centre

Highlights in 2015

Further steps taken in IDC progressive commissioning

Implementation of Public Key Infrastructure at 110 IMS facilities

Holding the CTBT Science and Technology 2015 conference

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 the States Signatories.

The Commission has created full computer network redundancy at the IDC in order to ensure a high level of availability of its resources. A mass storage system provides archiving capacity for all verification data, which now cover more than 15 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.

The IDC’s 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). 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 2 days.

Radionuclide Spectra 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 (ARR) within the 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 (RRR) 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; these are appended to each particulate RRR. Using software developed by the Commission, States Signatories can combine these calculations 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 the 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.
Services

A National Data Centre is an organization in a State Signatory that has technical expertise in the Treaty verification technologies and has been designated by the State’s national authority. 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.

The Commission provides an ‘NDC in a box’ software package that enables NDCs to receive, process and analyse IMS data. In 2015 it provided additional functionality in the package that allows users to read and process waveform data in additional standard formats and to work with an open source database (PostgreSQL). This enables users to more easily combine data from the IMS network with data from other stations and global networks.

Build-up and Enhancement

IDC Commissioning

Build-up, continuous enhancement, and 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 the Secretariat has developed.

During 2015 the organization drafted a detailed road map for Phase 5b of the IDC Progressive Commissioning Plan for review by Working Group B (WGB) in 2016. It also updated its validation and acceptance test plan and detailed plans for the first full scale experiment contained in the road map.

Security Improvements

The Commission continued to identify and evaluate risks to its operational environment and to strengthen security controls on information technology (IT). These measures to safeguard IT assets included mitigating risks of malware attacks and a phased implementation of network access control to prevent unauthorized access to the resources of the Commission.

To ensure an effective information security programme, the Commission developed an awareness and training programme to educate the staff of the organization on security best practices and to serve as a foundation for organization-wide security policies. The training course focuses on the key tenets of information security: protection of confidentiality, integrity and availability of information assets. The Commission also developed a framework for security policies with a phased implementation of security best practices.

Software Enhancements

As part of the first phase of the IDC re-engineering programme, the Commission has developed a new distributed application control system (DACS) to manage the entire automatic waveform processing.

Another project that neared completion during 2015 under the first phase of IDC re-engineering was the development of new software for waveform quality control and a related data model. The software preserves waveform quality control information, thus capturing more complete information on data provenance, which helps to reproduce processing results. The new software also captures more complete information on waveform quality and improves the identification of some waveform quality problems, in particular for single point spikes. The software is now undergoing final pre-release testing.

The Commission continued to make progress with the new regional seismic travel time (RSTT) software and model that have been provided as a contribution in kind by the United States of America. It derived travel time correction files for a total of 150 primary and auxiliary IMS seismic stations. In 2014 the Commission initiated an operational test to compare automatic processing results across all stages of the processing pipeline. This test was completed in 2015 and the results were made available to experts of States Signatories for independent evaluation.

The Commission continued to develop new automatic and interactive software that uses state of the art machine learning and artificial intelligence. It also enhanced the NET-VISA software to be able to process infrasound data in addition to seismic and hydroacoustic data. In 2015 the testing of NET-VISA at the IDC focused on determining the effect of running NET-VISA in all stages of the network processing pipeline. The preliminary results of the inclusion of a model for infrasound technology, as evaluated by experts from States Signatories, were positive.
For three years, the Commission has been developing jointly with the Commissariat à l’énergie atomique et aux énergies alternatives (CEA) of France a toolkit for infrasound station processing and interactive review, DTK-PMCC/DTK-GPMCC. This toolkit is undergoing continuous enhancement to meet IDC and CEA criteria. When ready, it will be included in the extended NDC in a box software package and delivered to NDCs and will be used by the Commission for field activities. In 2015 the toolkit was deployed in the development area of the IDC. It is going through validation testing and is being compared against the current processing software using the results from the framework for the detector evaluation project. The toolkit is expected to be easier to use and to provide more accurate detection parameters for IDC operational activities.

The Commission also continued to develop the verification data messaging system (VDMS) and released two major versions of this software. Since March 2015 all data and products disseminated through the VDMS have been digitally signed. A new product that provides information on the results of calibration activities at seismic stations was released in 2015 and the waveform data quality products underwent significant upgrades.

A first release of the extension of the alternative radionuclide analysis system (ARAS) pipeline to SPALAX from IMS stations. The results for five selected Treaty relevant radionuclides were presented in August 2013. The new categorization approach, which reduces the number of unusual detections by up to 90%, was promoted to IDC operations.

The Commission’s investigation of an alternative method for the categorization of particulate samples was completed during 2015. It had studied a long term distribution, quartile based filtering algorithm using 13 years of released samples from IMS stations. The results for five selected Treaty relevant radionuclides were presented in August 2013. The new categorization approach, which reduces the number of unusual detections by up to 90%, was promoted to IDC operations.

Efforts to enhance the IDC software for operational radionuclide processing focused on two areas: increasing the level of consistency between automatic and reviewed categorization of particulate spectra; and reducing the workload of analysts. Important enhancements carried out in the second half of 2015 included the optimization of key
aspects of the radionuclide library; automatic assignment of comments to false positives; and the implementation of a software tool for automatic discrimination of technetium and germanium isotopes ($^{99m}$Tc and $^{75m}$Ge) in particulates samples.

Interactive review tools for particulate and noble gas data were enhanced with new features to provide analysts with further details on radionuclide sample spectra. As a result of these software enhancements, the IDC exceeded its target of 50% consistency between the results of automatic and reviewed categorization for most of 2015.

The existing version of the UniSampo-Shaman software of the ARAS pipeline was upgraded to process daily data from all certified particulate radionuclide stations of the IMS. A new feature to support a Monte Carlo based isotope response function for particulate samples has been implemented. This is expected to further enhance analysis results based on the ARAS pipeline.

The Commission is making a longer term exploration of alternatives to the net count calculations method for beta–gamma analysis in the framework of the alternative for beta–gamma analysis method (ABGAM) project. Specifically, ABGAM studies the applicability of multidimensional peak search and peak fitting techniques to automatic

**Correctly Categorized Automatically Processed Radionuclide Spectra**

(The dotted line shows the target performance of 50%.)

**Radionuclide Events Recorded by IMS Stations in IDC Operations in 2015**

<table>
<thead>
<tr>
<th>Number of Categorized Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARP01</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

Note: An event is level 4 if the sample contains an anomalously high concentration of a relevant anthropogenic radionuclide; it is level 5 if the sample contains a number of anthropogenic radionuclides at anomalously high concentration and at least one is a fission product.

**Treaty Relevant Radionuclides Detected in 2015**

- Cs-137: 36.57%
  - Cs-134: 15%
  - Co-60: 0.37%
  - Tc-99M: 1.82%
  - Na-24: 47.43%
  - I-131: 5.56%
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processing of beta–gamma spectra. It also studies the applicability of these techniques to the prototyping of interactive review tools for the results of such automatic processing.

During 2015 the Commission further optimized a software tool for providing automatic multidimensional peak search and peak fitting, including deconvolution and decomposition methods and basic interactive graphical visualization. The results that this tool produces are being benchmarked against the results of recent radionuclide laboratory PTEs for noble gas samples. A feasibility study was initiated to define options for the integration of these novel methods into the IDC processing pipeline.

It is a complex task to discriminate between background radioxenon from civil nuclear applications and radioxenon from nuclear testing. The scientific challenge is to develop algorithms and tools that facilitate background assessment in order to provide adequate understanding of the background for use as an event screening parameter. A longer term vision is to be able to predict the impact of civilian sources on the radioxenon detections at IMS stations. With the goal of gaining initial experience and scientific insight, the IDC developed a prototype software application, Simulated IMPAct of Xenon (SIMPAX), to calculate hypothetical radioxenon concentrations at IMS stations. SIMPAX is based on a combination of source–receptor sensitivity (SRS) fields and estimated civilian radioxenon releases as published in peer reviewed papers.

In 2015 the Commission implemented an automatic suite for high resolution simulations of regional meteorological and atmospheric transport modelling (ATM). The suite also creates animations to illustrate ATM simulations and the relevant meteorological information. The suite can be triggered on demand to support an analysis of an event of interest influenced by regional factors. It can be configured for any region on the globe. Both forward and backtracking ATM simulations are enabled.

The organization also released a new version of the WEB-GRAPE software that allows the possible source region to be calculated and displayed for several nuclides.

The organization initiated a second phase of IDC reengineering in 2014 with support from a contribution in kind from the United States of America. This project aims to specify a unified architecture for all waveform software, across processing stages, to pave the way for further development and future sustainment of the software. The project’s inception phase, which focused on requirements definition, was completed in February 2015. The elaboration phase, targeted at system design, then began. Experts from States Signatories reviewed the project deliverables at technical meetings in Vienna in June 2014 and June 2015.

The International Noble Gas Experiment and Atmospheric Radioxenon Background

The 31 noble gas systems that are in provisional operation at IMS radionuclide stations continued to send data to the IDC during 2015. The 24 certified systems and 1 system that is in the process of certification sent data to IDC operations, while data from the remaining 6 non-certified systems were processed in the IDC testing environment. 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 34 locations as part of the International Noble Gas Experiment (INGE), they are still not understood in all cases. A good understanding of the noble gas background is crucial for the identification of signs of a nuclear explosion.

"It is a complex task to discriminate between background radioxenon from civil nuclear applications and radioxenon from nuclear testing"

An initiative funded by the EU (under Council Joint Action III and Decision V) to improve understanding of the global radioxenon background, which started in December 2008, continued in 2015. The objective of this project is to supplement knowledge on the global radioxenon background over longer periods. By performing measurements for at least six months, this project will provide more representative periods at selected sites. This will provide empirical data for validating network performance, for testing xenon equipment, for data analysis, and for training local experts.

EU Council Decision V supported a three year project that ended in December 2015 to further measure the noble gas background using mobile measurement systems. This work was also supported by a contribution in kind from the United States of America, through which the
Pacific Northwest National Laboratory conducted background measurements using an additional mobile detection system. The Commission installed a mobile system in Manado, Indonesia, in February 2015 that operated during the year. The mobile noble gas system in Kuwait experienced successive hardware problems in various modules that necessitated a series of maintenance visits. The system restarted in August 2015 and the subsequent sporadic failures were solved with the assistance of local operators. The mobile system now automatically sends data to the Commission on a regular basis. After processing and review by the IDC, the data from both campaigns are made available to radionuclide experts for further analysis.

The Commission plans to use the results and conclusions from this campaign to further develop its noble gas categorization scheme and to gain a better understanding of the inventory, transport and time variation of radioxenon in the atmosphere.

**Civic 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 (UNESCO) to provide data for tsunami warning purposes. In 2015 the Commission finalized the negotiations on an agreement with the Instituto Português do Mar e da Atmosfera (IPMA), Portugal. Such agreements or arrangements have now been made with 15 organizations, in Australia, France, Greece, Indonesia, Japan, Malaysia, Myanmar, the Philippines, Portugal, the Republic of Korea, the Russian Federation, Thailand, Turkey and the United States of America (Alaska and Hawaii).

IMS infrasound data and IDC products can provide valuable information on a global scale regarding bodies entering the atmosphere. As a consequence of the 2013 meteor airburst in Chelyabinsk, Russian Federation, infrasound technology continued to attract interest beyond the verification regime. The IMS infrasound network observed several airbursts, such as one in Thailand on 7 September 2015, and these appeared in the IDC Reviewed Event Bulletin.

Quick detection of a volcanic eruption can reduce the hazard to air traffic of ash clouds clogging jet engines. The eruption of the volcano Calbuco in Chile on 22 April 2015 was the largest eruption registered by the IMS network in 2015. The Commission reported detections at seven IMS infrasound stations, at distances up to 5000 kilometres, while extended infrasound processing allowed signals to be detected at IS32 (Kenya), 12 000 kilometres away.

The Commission is collaborating with international organizations such as the WMO and the International Civil Aviation Organization (ICAO), and with the scientific community of the Volcanic Ash Advisory Centres (VAACs) and the Atmospheric dynamics Research InfraStructure in Europe (ARISE) project to develop an infrasound volcanic notification system. The Commission extended its commitment to the ARISE community by accepting the invitation to serve on the ARISE2 advisory board for the duration of the project (2015–2017).
CTBT: Science and Technology 2015 Conference

To keep abreast of scientific developments, the Treaty verification regime relies on the latest advances in science and technology as well as interaction with the global scientific and technological community. The ongoing interaction allows the Commission to build partnerships with the scientific communities engaged in various aspects of test-ban monitoring. Against the backdrop of a dynamic technological landscape, the process is one of collaboration, support and sharing insights. This helps to maintain the relevance of the verification regime by understanding and overcoming challenges. It also means that required improvements in the verification regime benefit from cutting edge research.

CTBT: Science and Technology 2015, the fifth conference in the series, was held on 22–26 June in Vienna. Keynote speeches were given by Ms Naledi Pandor, Minister of Science and Technology of South Africa; Mr Ahmet Üzümcü, Director-General of the Organisation for the Prohibition of Chemical Weapons (OPCW); and Mr Des Browne, former Secretary of State for Defence of the United Kingdom and vice-chairman of the Nuclear Threat Initiative (NTI).

Panel discussions on diverse topics of interest to the monitoring community were held throughout the conference. These topics included enhancing governmental, industry and scientific engagement on nuclear non-proliferation and disarmament; citizen networks and the promise of technological innovation; and scientifically credible scenarios for OSI integrated field exercises.

Over 850 participants from 99 States drawn from scientific and technology communities, academia, civil society and governments attended the conference and engaged in its deliberations. In addition, a significant effort to engage young scientists was made in the citizen science panel and through the young scientists evening as well as in the Academic Forum sessions.

One of the goals of the conference was to promote the wider scientific application of data that are used for test-ban verification. This goal was pursued by the Listen to Our Earth exhibit – a three dimensional multimedia installation – and the significant number of oral presentations and posters on civil and scientific topics.

The conference also sought to enhance the exchange of knowledge and ideas between the Commission and the broader scientific community. During the conference, arrangements were made for interactions among participants during the oral presentations and poster sessions, demonstrations, exhibits, field trips and associated workshops. The 2015 CTBT Academic Forum, which took place alongside the conference, identified ways to integrate Treaty related topics into existing policy- or science-based academic curricula and to develop educational resources.

A comprehensive public and media outreach strategy promoted the conference. A global media campaign, including a short film “Nothing Escapes the Global Ear: Nuclear Tests, Volcanoes, Earthquakes or Meteors”, reached an estimated audience of 600 million through television, radio, print, the Internet and social media.

Over 40 newspaper, online or radio reports on the conference were published, including by The Wall Street Journal, Nature, Science, the BBC World Service, Bloomberg and Austrian ORF radio. Professional branding, video, photographic and online coverage significantly raised the profile of the conference, as well as innovative exhibitions such as Listen to Our Earth and a hands-on display of OSI equipment. With over 6 million impressions on Twitter for the conference hashtag #SnT2015, the conference was well covered on social media.

A significant share of the work of the Commission is exploring new and improved verification methods and implementing promising technologies and methods introduced at Science and Technology conferences. Among these are self-calibrating microbarometers, network performance tools, improved velocity models of the earth and atmosphere, waveform association routines and cross-correlation techniques.