

## **Improvements of the Technical Capability of the Verification Regime Since 2000**

### **Improvements in the Verification System**

The first IMS stations were certified in the summer of 2000. The number of certified IMS stations and laboratories has moved from zero to 250 as of today. Such an exponential increase in the number of stations installed and certified has been a source of improvement for coverage and network resilience. Station design, especially infrasound, has also evolved, resulting in an increased capability of detection.

Operational experience with the systems has increased over time. Monitoring software, including the State Of Health tools, has been developed. Those tools have enabled more precise troubleshooting. Concerted sustainment efforts have resulted in developing and implementing more effective preventive maintenance, supportability and logistical strategies. There has been an improvement in reliability as measured by downtime and data availability. Such a sustained improvement should be measured against the continuous and exponential growth of the system.

### **Seismic**

The average daily number of events contained in the Reviewed Event Bulletin increased from 50 in 2000 to nearly 100 in the year preceding October 2009. This increase in event numbers reflects the build-up of the IMS seismic network in the intervening years. This number will continue to increase as the network is expanded and the global detection threshold is reduced.

Based on threshold monitoring, seismic events as small as magnitude 2.75 can be detected in Europe and Asia. In the northern hemisphere, overall detection threshold is about 3.5. The threshold is not as good in the southern oceans. On average, the global detection threshold is about 4.

During the buildup of the IMS network, the legacy stations were used to begin the task of developing optimal operational procedures as well as calibrating and optimizing data processing. From the late 1990s until 2003, a series of studies led to improved event detection and location performance by characterizing the seismic observations from the IMS stations. The studies assembled a large set of ground-truth data from known explosions and locally-constrained earthquakes. They resulted in a set of corrections to be applied to the observations during processing to account for observed variations in the wave propagation phenomena. An important feature of the operational software used at the IDC is the ability to accommodate these corrections to improve performance as additional knowledge is acquired.

Under the Treaty the IDC is to summarize observational features that may be related to the nature of an event, whether it is man-made or natural. A subset of these features is used routinely and automatically to screen out events that are clearly consistent with natural phenomena. The regional variation discriminant initially used has been upgraded to higher resolution by a factor of five and a more accurate detection algorithm was put in place.

The timelines for the production of the waveform automatic bulletins have been decreased to those that are envisaged at the time of Entry Into Force of the Treaty; SEL1 – 1 hour, SEL2 – 4 hours, and SEL3 – 6 hours. New analyst tools have been introduced by the PTS to improve the quality and completeness of the final bulletins.

### **Infrasound**

Infrasound processing was introduced into provisional operations at the IDC in 2001, but the methods for automatic detection, signal characterization, association and interactive review were not sufficiently mature. During the buildup of the network, the small number of installed IMS infrasound stations limited the contribution of infrasound data to the IDC Reviewed Event Bulletin to occasionally complement existing seismic events. The first atmospheric event built only from infrasound arrivals was reported in 2003. The growing amount of infrasound data and detections produced by the automatic system challenged the station and network processing at the IDC, which required the organization to redesign the way infrasound data are processed. In 2004, the IDC discontinued routine network processing of infrasound data.

Subsequently, the IDC focused on better understanding infrasound propagation and developing new processing methods and tools to realize an operational processing scheme. An improvement of signal to-noise ratios of up to 50% at many infrasound stations has been achieved. Five years later, the infrasound automatic and interactive processing has reached the desired level of capability and maturity and the IDC is now re-introducing infrasound into routine operations.

The capability of the infrasound network depends on station distribution and current weather conditions, which are variable.

Recent studies have shown that the infrasound network will be capable of detecting and locating atmospheric explosions down to a level of tens of tons of TNT where station coverage is favourable, as in the northern hemisphere. Explosions of approximately 500 tons of TNT would be detected by at least 2 infrasound stations at any time of the year.

### **Hydroacoustic**

The IMS hydroacoustic network is significantly more capable than it was ten years ago. In the year 2000, the only station installed was HA8. Since 2000, five hydrophone stations and five T-phase stations have been installed (and, apart from one half of HA3 and all of HA4, are currently contributing data to the IDC.) Years of operations since 2000 have demonstrated that that the design and installation of underwater systems are mature and reliable. The network has exceeded its anticipated performance by being able to locate occasional in-water explosive events down to tens of kilograms of TNT as a primary sensing technology.

### **Radionuclide Particulate**

The overall quality of radionuclide particulate analysis has improved since 2000 due to:

- More reliable equipment,
- Detector modelling providing an isotope response function that allows reliable identification and quantification of relevant isotopes
- Objective peak review criteria
- Graphical visualization tools help to resolve special cases
- Background radiation is more precisely considered.
- The radionuclides relevant to CTBT verification are better understood.

### **Radionuclide Noble Gas**

The System Performance Indicator figures achieved during Phase III/c (involving 17 noble gas systems in IMS locations over a period of 4 years) show that all three system types (SAUNA, ARIX AND SPALAX) have no problems in meeting the IMS requirements for collection, measurement, acquisition, reporting and Minimum Detectable Concentration (MDC).

The IMS requirement for Xe-133 Minimum Detectable Concentration is 1 mBq/m<sup>3</sup>. For SAUNA and ARIX, the MDC for Xe-133 can reach as low as 0.1mBq/m<sup>3</sup>, indicating an improvement by about a factor of 10 from their prototypes. For SPALAX, the MDC has improved by a factor of about 2. Further technological development can lead to even higher detection capability of these systems.

### **Radionuclide Laboratories**

There were no certified radionuclide laboratories in 2000. Since then ten laboratories have been certified. The PTS has developed and implemented a Quality Assurance/Quality Control (QA/QC) programme to monitor the performance of the radionuclide particulate network, i.e. to ensure that data produced are of acceptable quality.

### **Atmospheric Transport Modelling**

Since 2002, the PTS has been routinely applying atmospheric transport modelling (ATM) to backtrack dispersed radioactive material. The most recent advances in the domain of transport as well as the most comprehensive meteorological data sources have been integrated into the PTS operations. A layered scheme applied in these operations allows for a clear separation of computationally demanding data acquisition and modelling, relieving the Member States from product generation and visualization.

To further increase the confidence in the ATM results, independent backtracking calculations have been triggered by each anomalous radionuclide detection (Level 5). Since September 2008 the requests for such supplementary calculations have been submitted to 9 regional specialized meteorological centres under the auspices of a CTBTO-WMO cooperative agreement. In addition, the system is routinely tested quarterly and with an additional multi-day scenario during the year.

## **OSI Regime Development Since 2000**

Since 2000 we have made steady progress in developing the OSI regime in accordance with the Resolution Establishing the Preparatory Commission. In 2004, the OSI Strategic Plan (CTBT/PTS/INF.677) was developed. It defined a strategic goal to achieve full OSI readiness at entry into force. It established the intermediate goal of conducting a near full scale OSI field experiment and the final goal of establishing the capability to conduct two simultaneous OSIs at EIF.

In 2006, the new Revised OSI Strategic Plan (CTBT/PTS/INF.793) was issued consisting of two phases to establish the readiness of the OSI regime. The goal of the first phase was to establish provisional OSI capability, namely, to develop, test and refine, to the extent possible, the procedures and tools which are necessary for the eventual conduct of OSIs, by conducting field exercises periodically. The goal of the second phase is the preparation for the rapid completion of the OSI regime, which includes finalizing the OSI Operational Manual, the preparation of training courses for inspectors and the procurement of OSI equipment.

### **2008 Integrated Field Exercise**

In September 2008, the PTS conducted an Integrated Field Exercise (IFE) at the former nuclear test site at Semipalatinsk in Kazakhstan. The IFE was the largest and most complex exercise conducted by the PTS since its inception, involving over 200 participants 51 tons of equipment operating for a month in the most remote area totaling 1000 km<sup>2</sup>.

The conduct of the IFE contributed greatly to the further development of the OSI regime, serving as a basis for the preparation of the 'Action plan developed as a result of the review and follow-up process for the 2008 integrated field exercise' (CTBT/PTS/INF.1020) which was presented at the last session of WGB in August/September 2009.

The transfer of equipment and all logistical tasks, although challenging and complex in nature, were accomplished as foreseen in the planning process without a single activity needing to be cancelled. Testing nearly all OSI techniques and procedures in an integrated manner showed the functionality of large scale exercises as milestones for following up on the progress made on various elements of the OSI regime.

Additionally, the conduct of the exercise provided a unique opportunity to test the equipment for an extended period under realistic conditions. All this contributed to the collection of valuable lessons for the future learned with respect to the procedures, techniques, inspectorate, logistics, use and maintenance of equipment.

In accordance with the revised OSI Strategic Plan the PTS has just started the second cycle of Phase I, with the aim of finalizing it in 2013 in accordance with the 'Action plan'. The Action Plan corresponds to the Medium Term Plan and covers the period 2009-2013.