

Main VNIIA Focus Areas Related to the CTBT Technologies

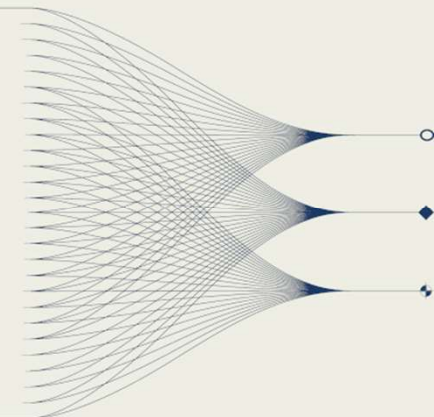
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..... INTRODUCTION AND MAIN RESULTS

The presentation presents a description and results of VNIIA ongoing research on CTBT-related areas: scientific-methodological support and hardware/software for on-site inspections activities; analysis of a possible CTBT non-compliance events; data analytics system for CTBT monitoring; seismic complex for technical support development; seismic/infrasound data processing.

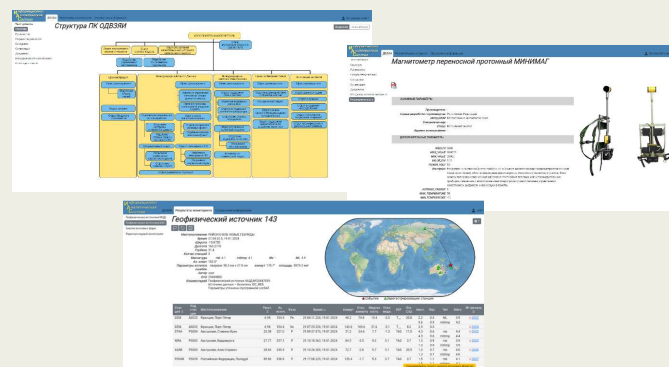


Development of Methodological, Hardware and Software Support of CTBT On-Site Inspection, Enhancement of Information Analytical System

VNIIA develops methodological support for inspection activities and the negotiation process of the Russian Federation related to the CTBT.

As a part of these efforts, the Information Analytical System (IAS) has been upgraded. It is used in applied research to ensure that Rosatom implements its functions related to the CTBT.

The IAS is developed using WEB-technologies and ensures:



Analysis of IMS Monitoring Data Published by IDC

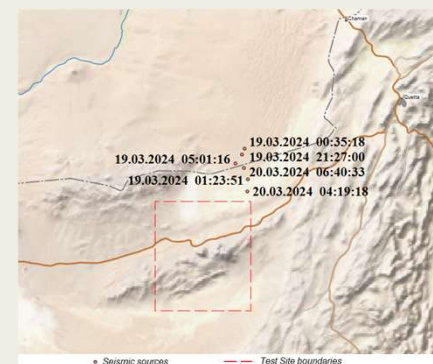
VNIIA analyses data published by the IDC to identify seismic and infrasound events, as well as the radiation environment on the globe.

North Korea Punggye-ri Test Site



No.	Date, time	Latitude	Longitude	Depth	mb	Ms	ML
1	08.01.2024 03:22:58.1	42.16	129.35	0.0	-	-	2.2
2	07.02.2024 18:15:42.5	41.34	129.52	0.0	-	-	2.7
3	27.03.2024 00:43:07.8	41.34	129.16	0.0f	3.4	2.5	3.1
4	27.03.2024 02:14:26.9	41.22	129.44	0.0f	3.2	-	3.0
5	27.07.2024 03:50:55.9	41.29	129.10	0.0	3.5	2.7	3.1
6	09.11.2024 04:23:11.7	41.29	129.10	0.0	3.7	2.3	3.4

Pakistan Chagai Test Site



No.	Date, time	Latitude	Longitude	Depth	mb	Ms	ML
1	19.03.2024 00:35:18.3	29.7694	65.3848	0.0	5.2	5.1	4.7
2	19.03.2024 01:23:51.8	29.4916	65.4194	0.0	3.7	-	3.8
3	19.03.2024 05:01:16.1	29.6348	65.2894	0.0	3.7	2.3	-
4	19.03.2024 21:27:00.2	29.7158	65.3574	0.0	5.3	4.6	4.7
5	20.03.2024 04:19:18.4	29.3812	65.4137	0.0	3.8	2.6	3.8
6	20.03.2024 06:40:33.1	29.5938	65.3776	0.0	3.5	-	-

Seismic Recording System for Carrying out CTBT OSI by the Aftershock Passive Seismic Monitoring and Passive Resonance Seismic Methods

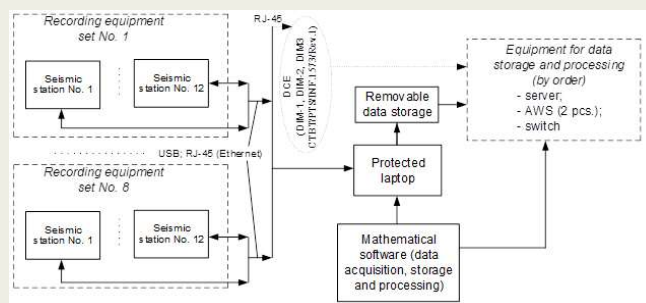
VNIIA develops the seismic recording system (SRS).

The SRS is designed to carry out CTBT OSI by the aftershocks passive seismic monitoring (PSM) and passive resonance seismic (RES) methods. It ensures:

- independent recording of a microseismic background and signals from natural and anthropogenic sources, including signals from aftershocks, by a regular network of three-component digital seismic stations;
- transfer of recording data from seismometers to removable data storages for subsequent processing;
- transmission of recording data via Ethernet using the SeedLink or CD1.1 protocol;
- processing of recording data using developed mathematical software.

The recording functions of the SRS are implemented by a suite of recording equipment sets (one to eight), each of which contains 12 three-component digital seismic stations.

There are two SRS variants – on the base of broadband or short-period seismic stations. The specifications of the analog and digital components of seismometers meet the requirements for seismic equipment specified in the draft List of OSI Equipment (CTBT/PTS/INF.1573/Rev.1) in terms of the PSM and RES equipment.



Software and Hardware Complex for Monitoring Compliance with CTBT

VNIIA develops a software and hardware complex to monitor compliance with the CTBT that implements a complete cycle of the seismic and infrasound continuous geophysical data (CGD) processing, including receiving data from seismic and infrasound stations, automatic data processing to detect signals and their sources, and interactive analysis of automatic data processing results to determine the reliability of the recorded events and identify them.

Table 1 lists the largest international seismic networks (ISN), the data from which is planned to be used in the SHCMC.

Code	Web – site	Name
IRIS	http://ds.iris.edu	United States Geological Survey
GEOFON	http://geofon.gfz-potsdam.de	German global seismological broadband network
GEOSCOPE	http://geoscope.ipgp.fr	French global network of seismological broadband stations (IPGP)
IDC	https://swp.ctbto.org	Vienna International data center

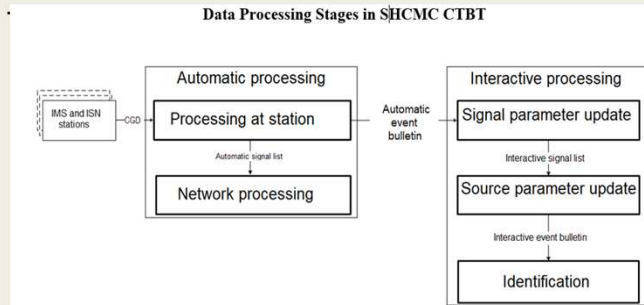
Software and Hardware Complex for Monitoring Compliance with CTBT

The developed software components for automatic detection of seismic and infrasound events include station and network processing of geophysical data [Coyne, 2012].

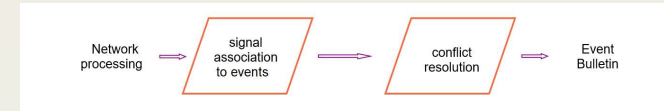
The **station** processing consists of the automatic detection of signals, calculation of their parameters, and quantitative estimation of these parameters' determination errors, as well as preliminary determination of signal phase types.

The network processing of geophysical data consists of automatic association of seismic and infrasound signals to the event and calculation of their parameters (time of occurrence, coordinates, depth and magnitude for seismic events), as well as quantitative estimation of the event parameters' determination errors.

Station processing of infrasound data differs from seismic data processing by the type of the signal detector used. The progressive multichannel cross-correlation (PMCC) algorithm [Cansi, 1995] based on cross-correlation analysis between the array elements is used to detect infrasound signals and measure their parameters on the basis of data from the IMS infrasound arrays.



The association is a generation of all possible event hypotheses. Since the same signal can belong to different hypotheses, a conflict shall be resolved to generate an event bulletin.



The identification parameters (discriminants) are as follows [O.K. Kedrov, 2005]: maximum amplitudes ratios (S/P and LR/P) in form of:

$$D(S/P) = \lg(S/P) - a_m m_b - b_D \lg \Delta$$

$$D(LR/P) = \lg(LR/P) - a_m m_b - b_D \lg \Delta$$

2) magnitude differences ($m_b - M_S$) in form of:

$$D(m_b - M_S) = \lg(m_b - M_S) - a_m m_b - b_D \lg \Delta$$

3) ratios of sums, $S_{i,j}$, of the spectral wave amplitudes, P , in three frequency bands 0.3–0.6 Hz (S_1), 1.3–3.0 Hz (S_2), and 3.0–6.0 Hz (S_3) in form of:

$$D(G_{1,2}) = \lg S_1 - a_{m1} m_b - \lg S_2 + a_{m2} m_b - b_D \lg \Delta$$

$$D(G_{1,3}) = \lg S_1 - a_{m1} m_b - \lg S_3 + a_{m3} m_b - b_D \lg \Delta$$

where a_m and b_D are coefficients estimated for the Eurasia region on the base of the underground nuclear explosions (UNE) and earthquakes records.

Thank you for your attention!

