

GSETT-3: a test of an experimental international seismic monitoring system

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Abstract

The UN Conference on Disarmament's Group of Scientific Experts (GSE) was established in 1976 to consider international co-operative measures to detect and identify seismic events. Over the years, the GSE has developed and tested several concepts for an International Seismic Monitoring System (ISMS) for the purpose of assisting in the verification of a potential comprehensive test ban treaty. The GSE is now planning its third global technical test (GSETT-3) in order to test new and revised concepts for an ISMS. GSETT-3 will be an unprecedented global effort to conduct an operationally realistic test of rapid collection, distribution and processing of seismic data. A global network of seismograph stations will provide data to an International Data Center, where the data will be processed and results made available to participants. The full-scale phase of GSETT-3 is scheduled to begin in January 1995.

Key words *seismology – earthquakes – nuclear explosions – seismic network – seismic monitoring – nuclear test ban*

1. Introduction

Seismology provides an efficient tool for detecting and locating underground nuclear explosions and distinguishing them from earthquakes. For this reason, the science of seismology has had a central position throughout the discussions of verification procedures for a comprehensive nuclear test ban treaty.

A nuclear explosion detonated underground generates vibrations (seismic waves) that propagate through the interior of the Earth and can be detected at great distances by modern seismograph stations. In particular, highly sensitive so-called array stations are effective in providing detection and identification of such explosions even down to very low magnitudes.

An international seismic system designed

to exchange and analyze seismic data recorded globally would form a crucial element of the verification regime for a nuclear test ban agreement. Such a system would build upon modern technology and make use of all achievements in seismology in order to deter violations and instil confidence that a test ban is adhered to by all parties.

2. The Group of Scientific Experts (GSE)

Under the auspices of the United Nations Conference on Disarmament in Geneva, a Group of Scientific Experts (the GSE) has, since 1976, conducted extensive work with the mandate to develop international cooperative measures to detect and identify seismic events. The GSE is composed of Government-appointed experts from participating countries and is open to Member States as well as non-Member States of the Conference on Disarmament.

The GSE holds its plenary sessions in Geneva, usually twice a year. A progress report to the Conference on Disarmament is submitted after each session, and in addition, the Group has produced six comprehensive reports dealing with detailed scientific and technical matters relevant to its mandate.

The GSE participants also conduct extensive work in between sessions, both in the form of informal technical workshops and through national or multinational technical and scientific cooperative studies and experiments. Results of these national and multinational investigations are presented as informal working papers and discussed at the GSE plenary sessions. Over the years, several hundred such papers have been introduced, many of them of considerable impact and volume.

3. Proposed global system

The GSE has proposed the establishment of a global International Seismic Monitoring System (ISMS) for the purpose of assisting in the verification of a comprehensive nuclear test ban treaty. Such a cooperative international effort would have three main elements:

1) A network of highly sensitive seismological observatories distributed around the globe. These stations would belong to the host countries and be operated according to internationally agreed rules;

2) National Data Centers (NDCs) established in participating countries. NDCs (or cooperative regional facilities, in some cases) would be responsible for the operation of stations in the global network and for ensuring that the data are made available expeditiously, in an agreed manner, to a specially established International Data Center (IDC);

3) Processing of data according to agreed procedures at the International Data Center and transmission of analysis

results back to participating countries for national assessment.

An integral part of the proposed global system is high quality data communication links connecting the IDC with the regional and national facilities. This would comprise both high-speed continuous links to selected seismograph stations and on-demand links as required.

The essential features of the global system are:

- rapid acquisition and processing of data from a global network of stations at a central processing facility;

- prompt and convenient provision of reliable data to all participating States for their national verification purposes;

- as much automation as possible in the collection, processing and distribution of data;

- permanent archive of all data collected or generated by the system;

- security and quality control;

- an architecture which will permit modifications and improvements as they are judged desirable.

The primary purpose of such a system would thus be to provide analysis results and data collected on a global scale in a timely manner to all States parties to a test ban treaty in order to assist them in their national verification effort.

While the emphasis of the GSE work over the years has been on seismic monitoring, the envisaged system (ISMS) is flexible enough to incorporate the collection, archiving and distribution of data from non-seismic techniques, for example, radioactivity, hydroacoustics and infrasound.

4. The GSE First and Second Technical Tests (GSETT-1 and GSETT-2)

In 1984 the GSE conducted its first global technical test (GSETT-1). With the

participation of 75 seismic stations in 37 countries, the emphasis of GSETT-1 was on the rapid global exchange and analysis of basic parameter data (Level I data) of seismic events detected by the participating stations. Data exchange was achieved using the Global Telecommunication System of the World Meteorological Organization.

Based on the experience from GSETT-1, the GSE conducted its second technical test (GSETT-2) in 1991. This time, the scope was more ambitious, with global exchange and analysis of both Level I data and the far more voluminous Level II data, comprising complete waveform segments of detected seismic events. In spite of the much greater technological capability required by participants compared to GSETT-1, the test succeeded in attracting the participation of 60 seismograph stations from 34 countries.

5. The GSE Third Technical Test (GSETT-3)

Following the successful conduct of GSETT-2, and with experience gained from that test, the original concept for an ISMS has been revised. This revision has also taken into account emerging new technologies, some of which were tested during GSETT-2.

The GSE is now planning its third technical test (GSETT-3), which will comprise the development, testing and evaluation of an experimental ISMS. The GSETT-3 exercise has three primary objectives that distinguish it from previous tests. These objectives are to:

- a) develop and test new concepts for an experimental International Seismic Monitoring System, building upon previous experience;
- b) provide a practical basis upon which to furnish the Conference on Disarmament with timely technical information;
- c) develop an experimental system that

can evolve and adapt to support future requirements.

GSETT-3 will be an unprecedented global effort to conduct an operationally realistic test of rapid collection, distribution and processing of seismic data. It will incorporate the most advanced seismic sensors, global communications, data management and data processing technologies currently available. The initial phase of GSETT-3 has already started, with full-scale operation scheduled to begin in January 1995.

6. Station network during GSETT-3

The global seismograph network envisaged for GSETT-3 is a two-tiered network comprising the so-called Alpha and Beta seismograph stations.

The Alpha stations consist primarily of arrays, with some three-component stations, and are designed and located to provide detection of seismic events throughout the world. The station waveform data are telemetered continuously to the International Data Center (IDC), either directly or through an NDC.

The Beta stations provide data supplementary to that provided by the Alpha stations, so that events can be located with improved accuracy. The Beta stations are primarily three-component stations, with some arrays. Though not telemetered continuously to the IDC, waveform segments can be retrieved automatically by the IDC or by NDCs from continuous data archives at NDCs or at the individual stations.

The GSE has proposed that the experimental system to be tested during GSETT-3 should contain a network of about 50 Alpha stations distributed globally and more than 100 Beta stations.

The GSE has defined the minimum technical specifications that should be met by the so-called «ISMS-standard» stations. This does not necessarily mean that these facilities must consist of identical technical components, but the components of these

systems must meet basic functional and technical requirements. During GSETT-3 as many participating stations as possible should conform to these ISMS standards.

For the instrumentation of such systems the following general design requirements should be taken into consideration: modularity, flexibility, reliability, robustness, incorporation of widely used components, and low power consumption.

Participating countries may also make available supplementary data (Gamma data) from national and regional networks that are not formally part of the ISMS. Stations in such networks are maintained to national standards. Gamma data are available on request, although rapidity of responses may vary from one network to another. The IDC will make use of these data according to standard procedures agreed to by the GSE.

7. National Data Centers (NDCs)

NDCs (or in some cases regional data centers) will be established in participating countries. During GSETT-3 the NDCs will be responsible for the maintenance of the Alpha and Beta stations, maintenance of communications links, coordination and submission of Gamma bulletins from their country, and feedback and research that improve the function of the IDC.

Requirements for other work and responsibilities at NDCs will vary depending on the conditions within each country. For example, national responsibilities may include the detailed interpretation of IDC products, retrieval of additional data from Alpha, Beta and Gamma networks, and provision of results to national authorities.

An important function of NDCs during GSETT-3 will be to participate in the evaluation activities. Thus, NDCs might contribute to the assessment of event location accuracy within their geographical region, assist the IDC in verifying the integrity of the data and transmission links and so on.

8. The GSETT-3 International Data Center (IDC)

The International Data Center for GSETT-3 will be located near Washington, D.C. The products and services of the experimental IDC will include:

- an automatically produced event list based on Alpha station data within 1 h;
- an automatically produced event list based on Alpha and Beta station data within 4 h;
- a final, analyst-reviewed event bulletin within 2 days.

The IDC will be an open facility, and all data and processing results will be available to participants for automatic and easy access. Data and processing results not older than 15 days should be available for on-line access, requests should be responded to automatically and promptly, and data older than 15 days should be available within 24 hours.

The IDC should function as a service facility for participating countries, providing data, user support and agreed data analysis functions. The IDC must conform to strict requirements regarding procedures, documentation, data authentication, reliability and data base management.

9. Future plans

Most of the Alpha stations which the GSE considers should form part of the experimental network existing today. A number of new stations will have to be established through national or cooperative international efforts. Modern, high-speed communication links will be established for both the Alpha and Beta stations in the experimental network. The GSE foresees a gradual establishment of the network by adding stations when they are completed or made available (see Harjes *et al.*, fig. 1, page 384, this volume).

The introduction of the Beta stations will also be by a step-by-step procedure and the GSE will make further decisions as to the Beta network once it is clear which stations participating countries will contribute to this network.

Both Alpha and Beta stations will be subjected to acceptance tests prior to being incorporated into the experimental system. An acceptance test of the International Data Center will also be carried out. Furthermore, the GSE will conduct an ongoing

assessment during GSETT-3. Results will be continually incorporated into the system to improve its performance so that the system will be capable of supporting future requirements by the Conference on Disarmament relating to the monitoring of a comprehensive nuclear test ban treaty.

More detailed descriptions of the planning and status of various GSETT-3 activities can be found in the individual contributions in this volume of «Annali di Geofisica».