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7.4 Monitoring a CTBT: Lessons learned from the GSETT-3 experiment

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Introduction

An effective, permanent International Monitoring System (IMS) will form a crucial part of the future global verification regime of a CTBT, currently being negotiated by the Conference on Disarmament (CD). The IMS is expected to include global networks designed to monitor the seismic, radioactive, infrasound and hydroacoustic effects of possible nuclear explosions, and will be supported by an International Data Center.

Seismic monitoring is today the most well developed of the four mentioned technologies. This is due in a large part to the work of the CD's Ad Hoc Group of Scientific Experts to Consider International Co-operative Measures to Detect and Identify Seismic Events (the GSE). Over the years, the GSE has developed and tested the basic principles for an international seismic monitoring system, culminating with the GSE Third Technical Test (GSETT-3) which began full-scale operation on 1 January 1995.

GSETT-3 objectives

The primary objectives of GSETT-3 are to:

- Develop and test new concepts for an experimental International Seismic Monitoring System (ISMS), building upon previous experience;
- Provide a practical basis upon which to furnish the CD with timely technical information;
- Develop an experimental system that can evolve and adapt to support future requirements that may be specified for an ISMS.

GSETT-3 is an unprecedented global effort to conduct an operationally realistic test of rapid collection, distribution and processing of seismic data. It incorporates the most advanced seismic sensors, global communications, data management and data processing technologies currently available. The GSETT-3 system needs to process and disseminate a volume of data about 10 times greater than that of any existing seismic monitoring system.

Overall GSETT-3 experience

The first year of GSETT-3 experience has demonstrated a number of technical and scientific results, which could be useful in the development of an International Monitoring System for a CTBT. It has served to validate the effectiveness of the GSE concept for a seismic monitoring system comprising a single centralized International Data Center (IDC), a specifically designed high-quality seismographic network consisting of about 50

primary stations and 100-150 auxiliary stations, National Data Centers (NDCs) in participating countries, and a modern communications system to support data exchange among these elements. Sustained operation of the GSETT-3 system during a full year has been achieved. At present, 45 countries are providing data from 42 primary and 85 auxiliary stations world-wide to the GSETT-3 network.

While the scope of GSETT-3 is limited to seismic monitoring, the GSETT-3 system design has proved flexible enough to incorporate the collection, archiving and distribution of data from other technologies considered for the IMS (Figs. 7.4.1 and 7.4.2).

IDC experience

GSETT-3 has demonstrated that a single International Data Center, of the structure and size established during GSETT-3, can acquire and archive the volume of seismic data that is anticipated from the IMS to be established under a CTBT. It has been shown that a single IDC can routinely analyze this large volume of data in a timely manner and produce and distribute a set of defined products that are usable and useful for seismological monitoring and system evaluation. Additional work is needed, however, to further develop methods to provide characterization parameters and for providing user-friendly reporting products.

Full redundancy of key equipment at the IDC is essential for reliable operations and to avoid loss of data. Key elements of the ISMS must be improved in terms of robustness and, often, redundancy in order to provide the 99% or higher reliability specified in CD/1254.

The IDC experience has shown that successful development and evolution can be combined with efficient routine operation. During the first year of GSETT-3, invaluable experience has been gained at the IDC on organization, staffing, costs, development and training.

NDC experience

NDCs play a critical role in the operation and maintenance of reliable stations and communication links, and form an effective interface between the IDC and participating States through which data and products can be accessed and evaluated. NDCs can also serve a useful role in providing backup storage capability to the IDC, if equipped with sufficient redundancy.

During GSETT-3, the NDCs have comprised a wide range of size, equipment and technical capabilities. GSETT-3 has contributed significantly to improving the operation and competence at the participating NDCs, and has benefited from a number of national evaluation efforts.

Participating NDCs have made available to the IDC supplementary information on seismic events based on analyzing data from national networks, which are maintained to individual national standards. These supplementary data have proven useful in evaluating the performance of the GSETT-3 network and should be useful in improving the capability of the network by calibration.

Station network and communications

Seismic arrays at low-noise sites will be the most valuable type of installation in the primary network of the seismic component of the envisaged IMS. The GSETT-3 has shown the value of upgrading stations from three components to arrays. Digital data from stations with high operational capability and reliability are essential.

GSETT-3 has proven to be a valuable impetus to countries participating in the experiment for the installation of high-quality seismic equipment and communications equipment.

The GSETT-3 experience has shown that a seismic monitoring system comprising a mixture of different types of seismic instrumentation and communication links can function well. However, this requires that basic minimum standards are satisfied with regard to functionality, formats and instrument calibration. There is a need for further developments of technical facilities at many seismograph stations and NDCs. Likewise, some existing data communication links are inadequate and must be improved. There is also a need for further development and testing of authentication procedures and data and system security.

International participation

To reach the envisaged GSETT-3 participation has been more difficult and taken much more time than expected. Bilateral cooperation and financial/technical support has been essential in enlisting new participants. Practical training of international staff at the IDC and national staff at the NDCs has proved important during GSETT-3. This training should be continued and expanded to encompass other technologies as the transition to IMS begins.

The international participation at the IDC has been crucial to the success of GSETT-3, with respect to both development efforts and regular operation. GSETT-3 has demonstrated that an international technical staff can work efficiently together at the IDC.

GSETT-3 structure/organization

During GSETT-3, the Group of Scientific Experts (GSE) has acted as an international supervising body, meeting regularly in Geneva. A considerable amount of work has taken place between sessions, coordinated by three working groups for Planning, Operation, and Evaluation, each headed by a Convenor.

The IDC has had a main "executive" function, with responsibility for development and operations in accordance with GSE guidelines. The NDCs have appointed technical "points of contact", who have acted as the main responsible people to interface with the IDC in the daily operation.

Regular working group Convenors' meetings have been held, with participation also by the GSE Chairman and Scientific Secretary, as well as an IDC representative, in order to coordinate their work. The GSETT-3 has also benefited from a number of informal technical workshops arranged by participating countries.

In summary, GSETT-3 has successfully achieved a balance between international coordination and practical day-to-day execution/development. This experience could be useful in the transition to IMS.

Evaluation

Evaluation has been an essential component of and prerequisite for the success of GSETT-3. Experience from previous tests has shown that evaluation procedures must be carefully planned before system development begins. Both on-going and day-to-day evaluation and periodic comprehensive evaluation are important in this connection, and have in fact been carried out during GSETT-3. GSETT-3 has shown the advantages of having the evaluation performed by experts not directly involved in the operation, but still with close knowledge and understanding of the system and its purpose.

The global station coverage during the first year of GSETT-3 has been uneven, and many of the conclusions drawn are based on observational data from selected regions only. These are regions with station coverage corresponding to the original GSETT-3 plan, and the observational results are supplemented by theoretical modelling and are continuously evaluated.

The GSETT-3 experience has confirmed the validity of theoretical 90% detection/location capabilities for well-covered areas. This gives confidence that the theoretical estimates are achievable for other areas as well. However, considerable work remains on calibrating the network in order to obtain the envisaged location accuracy of 1000 km^2 or better in all continental areas.

Concluding remarks

There has been a considerable and lengthy effort to establish the infrastructure needed for GSETT-3, including the stations, NDCs, the IDC and communications links. GSETT-3 has demonstrated the value of careful preparation and planning, including several limited small-scale tests. A step-by-step approach has led to a steadily improved performance at all levels as operational experience has been gained.

Continuous experimental operation over an extended period of time has been the key to developing and demonstrating the viability of the GSETT-3 concept for a seismic monitoring system. However, many important system components require further development and evaluation. It is therefore essential to maintain key elements of the GSETT-3 structure that could contribute to the future IMS established under a CTBT.

F. Ringdal

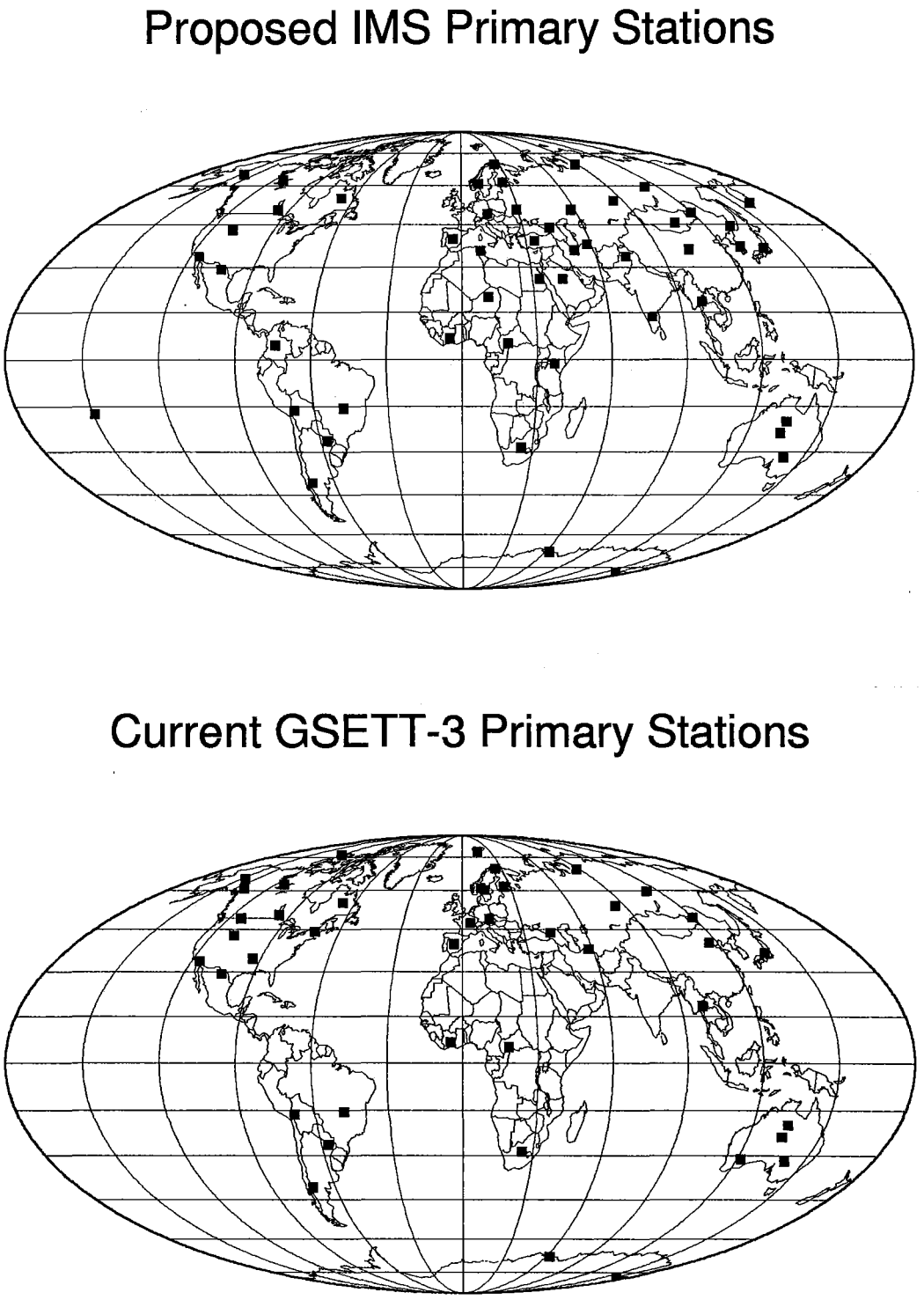

Fig. 7.4.1. Comparison between the primary seismic network proposed for IMS (top) and the GSETT-3 primary network as of January 1996. Note that the majority of IMS primary stations are already taking part in the GSETT-3 experiment.

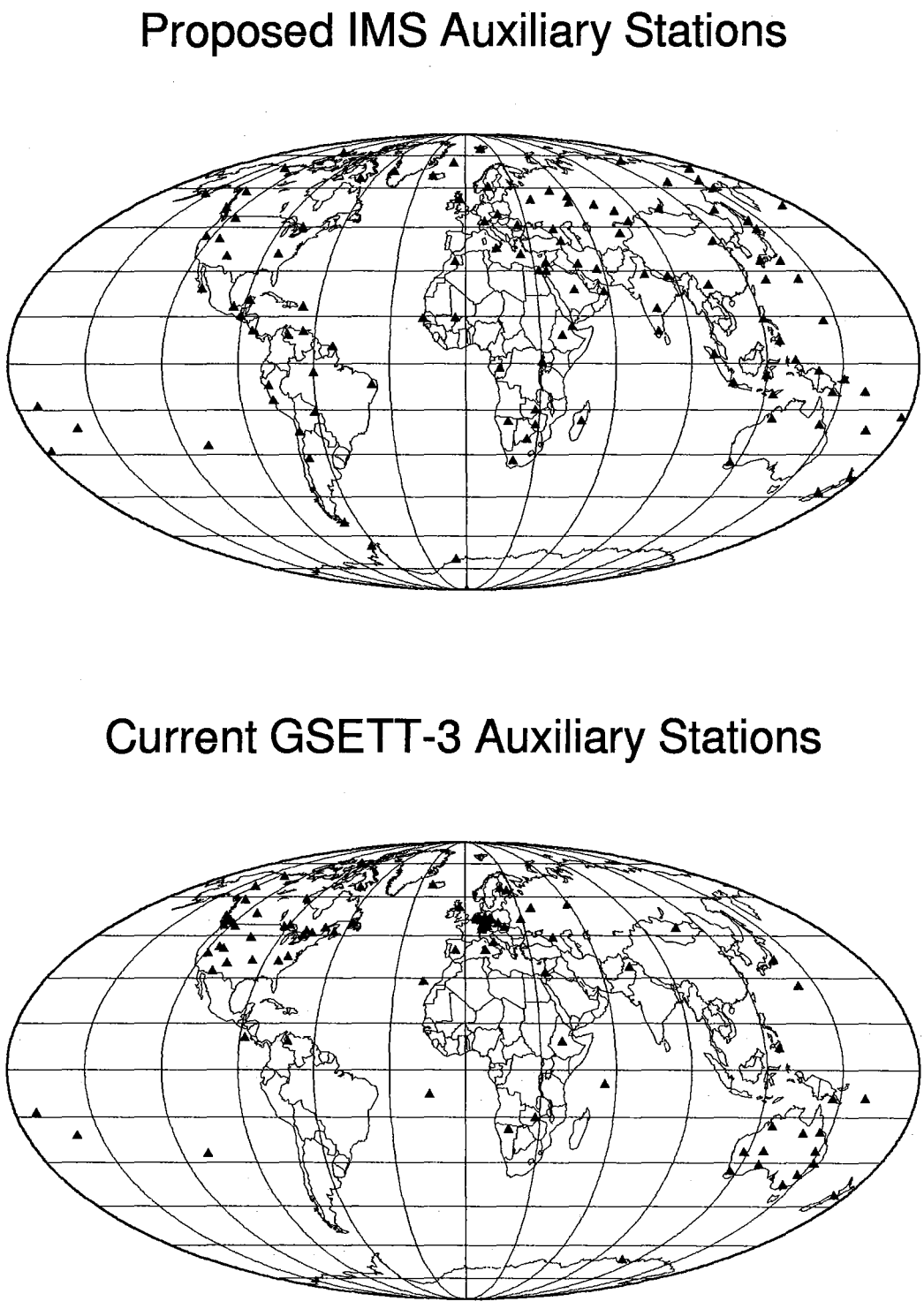

Fig. 7.4.2. Comparison between the auxiliary seismic network proposed for IMS (top) and the GSETT-3 auxiliary network as of January 1996. Note that the GSETT-3 auxiliary stations are much less homogeneously distributed than the IMS stations. Nevertheless, in selected regions the GSETT-3 network has provided an excellent data base for evaluation purposes.