Seismograph stations from across Canada relay data to a central laboratory at the Geological Survey of Canada in Ottawa.

esses them to produce a global bulletin of seismic events, and dispatches this bulletin within an agreed time frame to the national participants; and

3) an efficient global communications system that connects these facilities together. The IDC will maintain an archive of all of the relevant seismic data, any parts of which would be made available for analysis to the national agencies of the parties when the latter find "interesting" seismic events in the bulletins.

The ISMS Improves with Advances in Technology

Although the overall concept has not changed, the technology available to the ISMS has improved dramatically in the past 30 years. In the system described by the GSE in its first report to the CD in 1978, most of the world's seismograph stations were producing data on paper recordings, although some of the first digital seismographs were in operation, and national data centres were responsible for extracting parameters (e.g., arrival times and amplitudes of recorded seismic waves) from these recordings and transmitting them by telex-based communication systems to a number of IDCs. More than one IDC was required to cover the various regions of the globe and to address concerns about data tampering.

The GSE conducted an international experiment of this concept in 1984 called GSETT-1 (for GSE Technical Test Number One). GSETT-1 was a success, but it showed the shortcomings of the data communications systems in many parts of the globe (many of the data messages got lost), and the restrictions placed on the IDCs, which had only the derived parameter data with which to work and not the original recordings, or "waveforms." Making better use of the latter could improve the seismic event bulletins.

By the late 1980s, technological advances had been made in many of the components required for the proposed system: seismographs had improved significantly and become computerized; computers had become much more powerful and less expensive, for both national and IDC seismic data processing; and international data communications by satellite, fibre optic cables and commercial networks had become much more efficient and reliable. The first of three GSE workshops that Canada was to host met in Ottawa in 1986, allowing the GSE to consider the implications of these modern means of data communications for the ISMS.

Canada was also instrumental in developing modern seismograph technology. Through a joint EAITC/Energy, Mines and Resources initiative, a major ($3.5 million) refurbishment of the Yellowknife Seismic Array, the principal research tool used by the seismologists at the Geological Survey of Canada to conduct research on the detection and identification of underground nuclear explosions, was undertaken. Thirty members of the GSE met in Yellowknife in September 1989 (the second Canadian GSE workshop) to attend the opening of the Array and to review plans for a second data exchange experiment (see *The Disarmament Bulletin* No. 11, Fall 1989). The Verification Research Program of EAITC is also supporting research, through Professor K.-Y. Chun at the University of Toronto, to improve the ability to distinguish underground explosions from naturally occurring earthquakes. Professor Chun and his team are using data from the new Yellowknife Array and other stations of the Canadian National Seismograph Network to improve techniques for detecting and discriminating small seismic events.

The second data exchange experiment (GSETT-2), completed in 1991, was designed to take advantage of recent technical improvements. In particular, it was established that the seismograph stations would transmit the original digital waveform recordings of each detected seismic event, rather than only parameters derived from these waveforms, to enable the IDC to make much better judgements during its processing of the seismic event bulletins. Four IDCs were operated for this experiment (in Washington, Moscow, Stockholm and Canberra) in order to establish whether different systems, using similar procedures could produce similar results. Canada's GSE delegates, Peter Basham and Robert North of the Geological Survey, coordinated GSETT-2 on behalf of the GSE.

The GSE spent 18 months evaluating GSETT-2, aided by the third Canadian GSE workshop held in Montebello, Quebec in November 1992. Two important changes were made to the system, due mainly to the continuing improvements in global data communications. First, it is now agreed that the ISMS can operate with only one IDC. Global data communications to a single IDC are feasible and any concerns about tampering with data can be alleviated with sophisticated authentication devices. Second, data from the primary network of seismograph stations will be transmitted directly, in real time, to the IDC. This innovation transfers responsibility for the seismic event detection processing from the national facility