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THE FEDERATION OF DIGITAL SEISMOGRAPHIC NETWORKS

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During the 1970's a number of institutions developed digital seismographs and deployed these in sparse global networks to address specific scientific or technical problems. The very long period (100 sec to 1 hour) International Deployment of Accelerographs (IDA) network was an important example providing much useful information on gross earth structure and the nature of earthquake sources, (Agnew et al., 1976). Other examples include the SRO network and the more recent RSTN, deployed to further research in discrimination between earthquakes and explosions, (Peterson and Orsini, 1976). Although developed for a specific purpose these networks have also proved invaluable in providing information on earth structure and earthquake sources. Using the SRO network as a major component, the United States Geological Survey has now operated its Global Digital Seismograph Network (GDSN) for over a decade, and has made the data from the GDSN generally available to the research community.

In the 1980's, with the development of stable well calibrated very broad-band seismometers with high linear dynamic range by Wielandt and Streckeisen (1982), and parallel developments leading to the availability of mass storage devices and powerful economical computers, several institutions began to plan for and to deploy broad-band digital networks. Most notable was the early development of the GEOSCOPE network by the Institut de Physique du Globe with 8 stations in place by the end of 1984, and with plans for more than doubling the network later, (Romanowicz et al., 1984). Also at this time, a consortium of U.S. institutions, IRIS, developed a comprehensive plan for a global network of 100 stations and an associated data centre to ensure that the data from the network would be readily available to its members, (IRIS, 1984).

Several other countries, recognizing the significance of the new technology, began to plan for new broad-band seismographic networks on their territories, and some banded together to develop ambitious plans for regional networks, e.g., the European ORFEUS network.

During 1985 it became clear to many seismologists that there was an important opportunity for the seismological community to coordinate its efforts in order to develop an optimum global seismograph network. Under the sponsorship of the Interunion Commission on the Lithosphere, representatives of 20 institutions met in Karlsruhe in the spring of 1986. During two days of meetings the participants agreed to found a Federation of Digital Broad-Band Seismographic Networks, with the following statement of purpose.

FORMATION OF A "FEDERATION OF DIGITAL BROAD BAND SEISMOGRAPHIC NETWORKS

The international seismological community recognizes new opportunities within its field for improved understanding of the internal structure and dynamical properties of the Earth provided by recent developments in seismographic network technology.

The developments include greatly improved broad-band seismographic systems that capture the entire seismic wave field with high fidelity, efficient and economical data communications and storage, and widely available, powerful computing facilities. It also recognizes that rapid access to seismic data from arrays of modern broad-band digital instruments, wherever they might be, is now possible.

In view of the above, and to take advantage of existing and developing global and regional networks it is considered that a Federation should be formed to provide a forum for:

- developing common minimum standards in seismographs (e.g. bandwidth) and recording characteristics (e.g. resolution and dynamic range);

- developing standards for quality control and procedures for archieving and exchange of data among component networks;

- coordinating the siting of additional stations in locations that will provide optimum global coverage.

The Federation will welcome the participation of all institutions committed to the development of broad-band seismographs and willing to contribute to establishment of an optimum global system with timely data exchange.

In the following August, the Federation held its founding meeting in Keil, when it elected officers and set up four working groups to consider:

- digital broad-band seismographic specifications
- siting plans
- data collection and exchange formats
- data centres.

The Federation met again, briefly in San Francisco in December 1986, and during the Assembly of the IUGG in August 1987. In December 1987 the working group on data formats met in Albuquerque and the Federation will hold its 1988 annual meeting in June in Blanes, Spain.

Digital Broad-Band Seismograph Specification

The Federation has adopted as its primary objective the development of a "global" network of very broad-band high dynamic range digital seismographic stations having similar system response. The 'global' response is shown in Figure 1 and represents what is currently possible with state-of-the-art technology. Seismographs built to these specifications can faithfully record the signals from small M_L 3 earthquakes at .1° and great M_W 9 events at 30° without distortion.

Twelve very broad-band (VBB, 5 Hz - 250s minimum) 'global' and 96 broad-band (5 Hz - 20s) seismographic stations are now operating around the globe. In addition, members of the Federation have reported plans and proposals for a further 91 VBB stations by either converting existing stations or by installing new ones. Thus the community can look forward to a substantial global network of stations meeting the 'global' standard within approximately five years.

The Federation recognizes that for many 'regional' studies, stations with more limited capability will be entirely adequate, and the response for such stations is also shown in Figure 1. While regional stations will not faithfully record the longer period (greater than 250 sec) signals from large earthquakes, they will nonetheless be entirely adequate for recording body waves and intermediate period surface waves. Besides providing excellent high quality data for regional studies, they will provide a higher density distribution of stations than would otherwise be possible with the higher cost global stations.

Siting Plans

The distribution of existing planned and proposed Federation stations of both global and regional type is shown in Figure 2. Undoubtedly not all the planned and proposed stations will be deployed; however, it is now clear that the seismological community can confidently anticipate a network of broad-band stations distributed about the earth by the early 1990's. The distribution of course is not and will not be ideal. In particular the majority of stations are necessarily on the continents leaving the oceans, a significant proportion of the earth's surface, unmonitored. Stations sited on oceanic islands will

provide much useful data especially in the West Pacific, but large areas will remain unmonitored unless ocean-bottom systems are deployed. Of the continental areas, the territory of the USSR is notable for its lack of stations contributing to the Federation network.

Data Formats

In 1985, the International Association of Seismology and Physics of the Earth's Interior, Commission on Practice formed a working group on Digital Data Exchange to develop a 'standard' to enable the efficient exchange of digital data from the digital seismograph networks then rapidly developing, (Halbert et al., 1988). Shortly after this, as explained above, the Federation was formed and, by agreement with the Commission on Practice, accepted responsibility for developing the standard. A preliminary meeting in August 1987 of the Federation Working Group on Data Collection and Exchange Formats considered a draft that had been developed by the U.S. Geological Survey and IRIS for distributing data from their own and cooperating digital stations. In the light of these discussions and others, Halbert et al. of the U.S.G.S. developed a complete draft for discussion in December where representatives of eight Federation Member Networks critically reviewed the standard in detail. The Standard for the Exchange of Seismic Data (SEED) will be considered for adoption by the Federation in Blanes, Spain, on June 19, 1988. It is hoped that it will be accepted widely and become de facto the international standard for the exchange of digital earthquake data. Some organizations plan to use the formats of the standard right at their seismograph stations as well as for archive and exchange purposes.

Data Centres

It is highly probable that by the mid-1990's there will be well over 100 broad-band digital stations operating around the globe - each with a system response meeting at least the minimum specification of the FDSN. The task of collecting, archiving and distributing all of these data to the international research community will be a major task, that may be beyond the resources of any one institution. The FDSN has therefore decided that the only practical approach is to coordinate the activities of existing and developing data centres into a network that will allow a sharing of costs and workload for the benefit of the research community. The conceptual model is shown in Figure 3.

National Centres and Institutions are responsible for the installation and operation of their seismograph stations, and for the collection and archiving of the complete waveform data from their own network. By agreement with the FDSN they will contribute full and event waveform data from a selection or from all their stations to a specified Global Network Data Centre. In addition to contributing their data to the FDSN, they will also be responsible for distributing FDSN data to their particular research community. Examples of National Centres include those operated by Federation Members in Australia, Canada, China, FRG, Italy and the UK.

Global or Major Regional Centres may install and operate global or regional networks of seismograph stations. They will act as regional data centres for member national networks. They will be responsible for the collection and archiving of their own data and that contributed to them by member (national) networks. They will collate their data and make full wave form available to

the Federation Archive, and event wave-form data available to the Federation Event-Data Centre. In addition to contributing their data to the FDSN, Global Data Centres will be responsible for distributing FDSN data to National Centres and depending upon circumstances to individual seismologists.

Federation Data Centres

The U.S. Geological Survey (World Data Centre A - National Earthquake Information Centre) has agreed to act as the Federation Event-Data Centre, and is now accepting digital data from the Global (GEOSCOPE and IRIS), major Regional Data Centres (ORFEUS), and some national networks. Event data will be distributed in the SEED format on CD-ROM's through the Federation data network.

In the future the Federation will consider the need for a Federation Archive that will collect and archive complete waveform data from all Federation stations. The task is of such a magnitude however that careful consideration will have to be given to the nature of the service provided by such an Archive. Clearly unlimited access by the international research community will likely not be possible. However, the rapidly developing technologies of mass digital storage and data communication will probably be of significant assistance, making a reasonable compromise solution practicable.

Summary

Since its formation in the spring of 1986, the Federation of Digital Seismographic Networks has attracted 11 Members representing approximately 20 institutions. It has adopted standards for the system response of Federation seismographic stations and for the data formats to be used in the exchange of

earthquake data. The siting plans of member networks have been adjusted by detailed discussion between members, resulting in a significantly improved collective global network. An event-data centre has been established by the U.S. Geological Survey on behalf of the Federation. Thus the Federation has met its initial goal of coordinating the efforts of its Members so as collectively to deploy and to operate an optimum global network of digital broad-band seismograph stations. The stage is now set for Members to deploy a significant number of seismographic stations meeting Federation standards in the near future. If current plans and proposals are executed, the Federation's Global Network should be comprised of at least 90 stations by the early 1990's.

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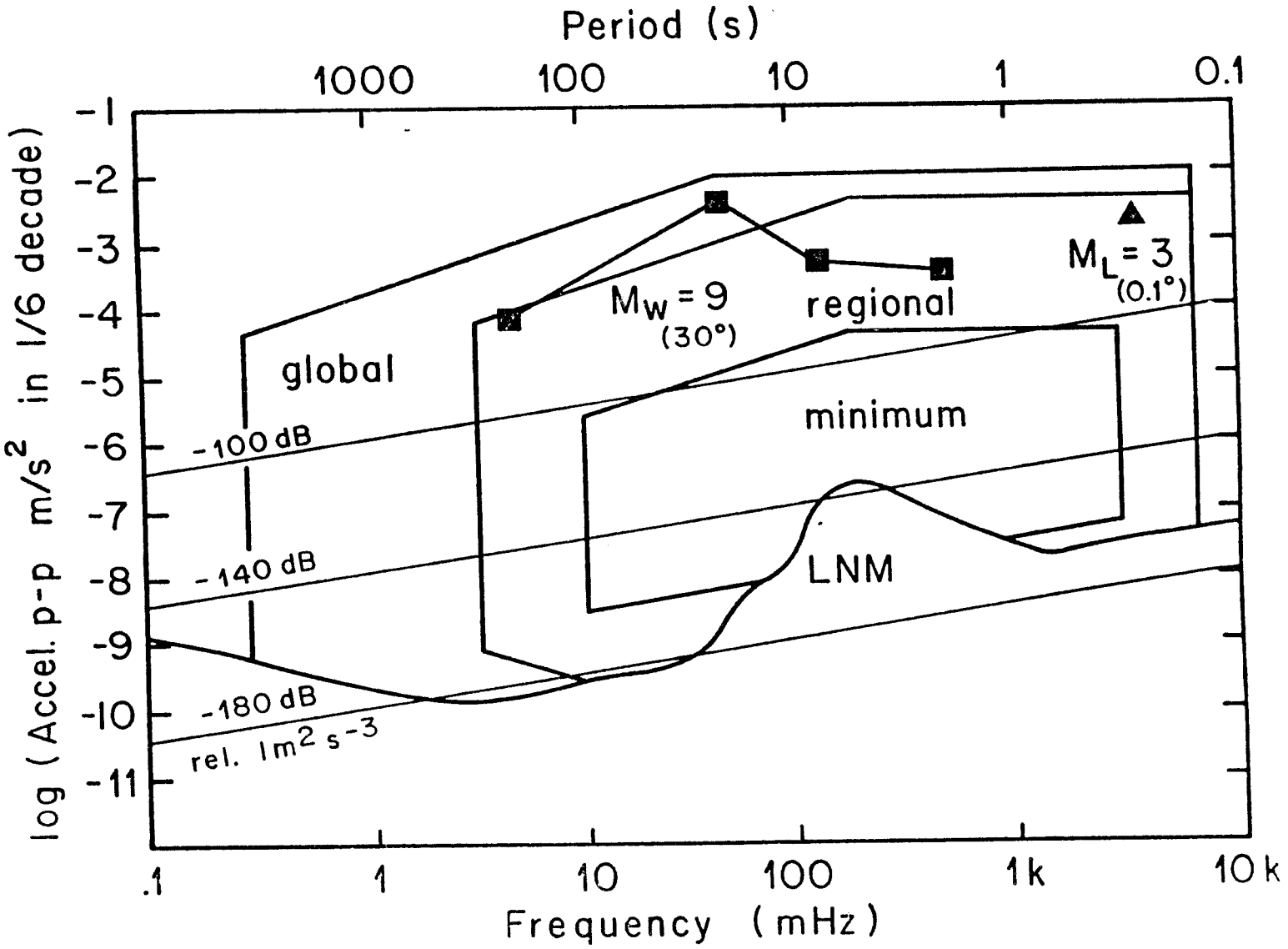

FIGURE 1: Federation Seismographic Response

DIGITAL BROADBAND SEISMOGRAPH STATIONS
APRIL 6, 1988

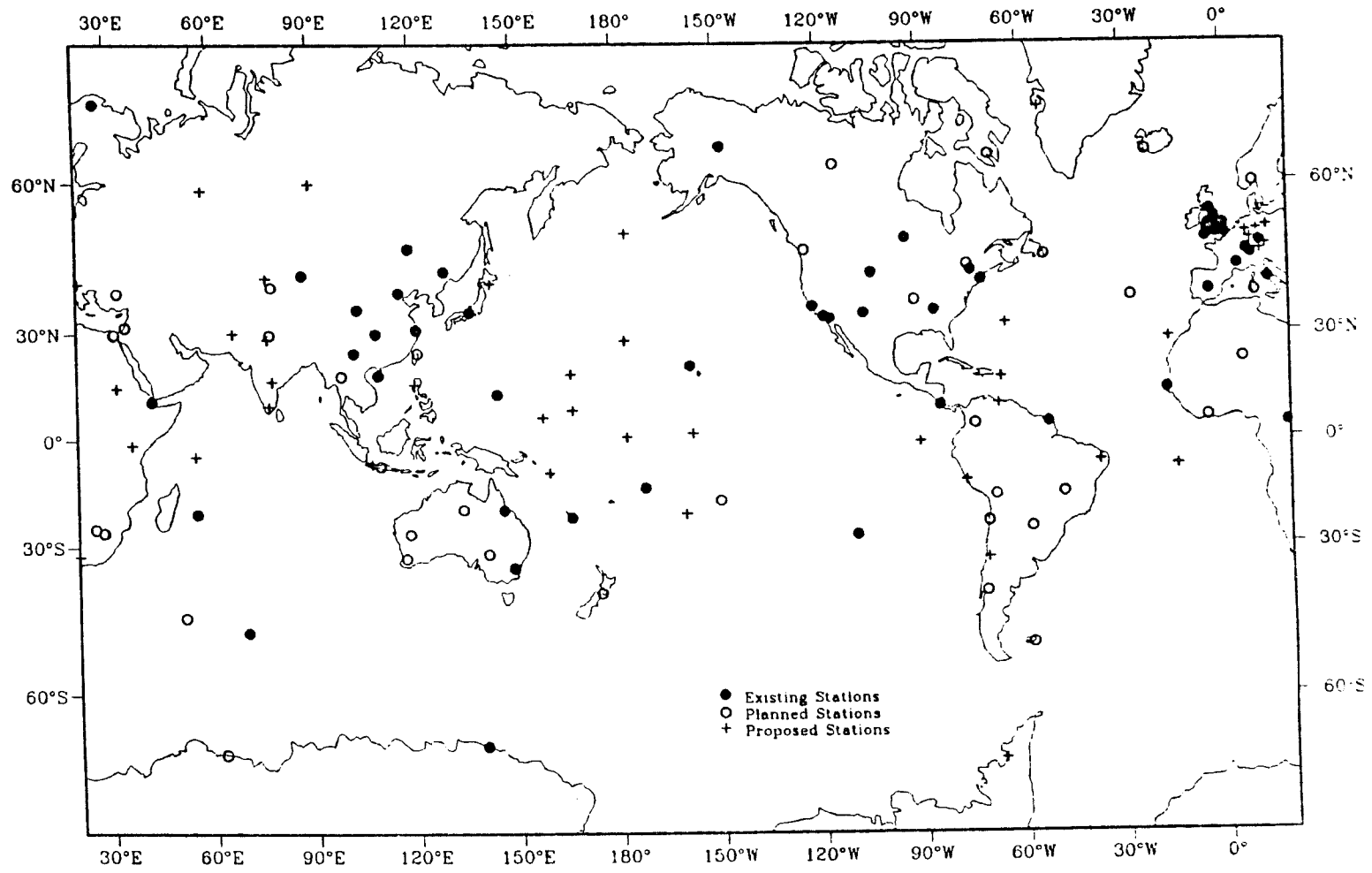

FIGURE 2

FDSN DATA DISTRIBUTION

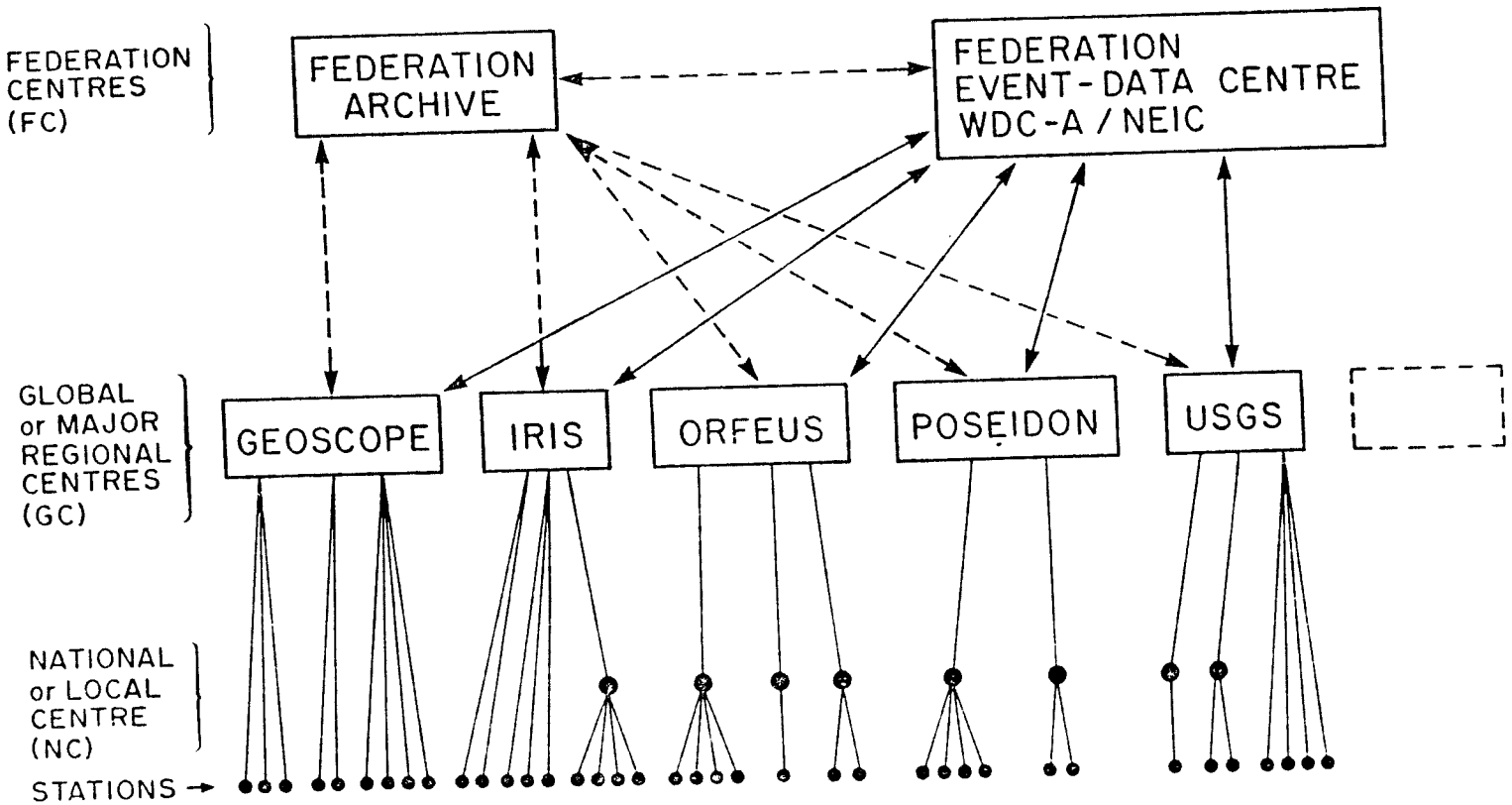

FIGURE 3

Doc 2633T
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