THE FEDERATION OF DIGITAL BROAD BAND SEISMIC NETWORKS

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Introduction

The design and deployment of the STS-1 instruments (Wielandt and Streckeisen, 1982) marked a turn in the history of modern seismology just at the time, when the first spectacular tomographic maps of the earth's interior based on the first generation digital seismological networks (IDA, Agnew et al., 1976; GDSN, Peterson and Orsini, 1976) were beginning to appear. The potential of the new instruments, together with improved recording technology and computer storage space and power, to provide data of unequaled quality in bandwidth, dynamic range and noise level, was soon realized in several countries, mainly owing to the examples provided by the Graefenberg array in western Germany (Harjes and Seidl, 1976). Several national initiatives were then taken to deploy global or large scale regional networks of new generation stations, with associated data centers for the collection and distribution of waveform data. By the end of 1985, the global Geoscope network of France (Romanowicz et al., 1984) counted 10 operational stations with plans for at least another 10, the IRIS consortium in the U.S. was announcing the deployment of a 100 station global broad band network (Smith, 1986), while in Europe, the ORFEUS project of a european data center for broadband waveforms was taking shape (Nolet et al., 1986) and also other countries were taking first steps in similar directions. Since no one country was in the position to deploy by itself a dense enough global network that would satisfy the needs of research in global seismology, it then appeared that some coordination on the international scale would be necessary to optimize the station distribution and the worldwide exchange of data. A meeting in Karlsruhe was organized in April 1986, under the sponsorship of I.C.L., to which representatives of all countries involved in global seismology were invited. The outcome was the decision to form a Federation of Digital Seismic Networks, and its terms of reference were formulated. The F.D.S.N. was then officially

founded a few months later in Kiel (August 1986) with 9 founding member programs.

Organisation, goals and achievements of the F.D.S.N.

The terms of reference of the F.D.S.N. are given in Appendix I, together with its affiliations. Table I gives the composition of the two executive committees that have been active so far. Three major areas of effort were identified: standardisation of instrumentation, siting coordination and data exchange and 4 working groups were formed (Table II). Since its foundation in 1986, the F.D.S.N. has met regularly once a year (Table III), and several additional meetings of some working groups, have met more often especially Working Group 3 on the standardisation of formats. There were 9 founding members to the FDSN (Table III), soon joined by Italy, U.K. and the USSR. A number of meetings related to FDSN activities have also taken place (Table IV).

Instrument specifications

Working Group 2 (E. Wielandt) defined the instrumentation standards for the FDSN. An optimum and a minimum standard were identified (Figure 1 and Appendix II). The optimum standard , that of "global" stations", corresponds to specifications which are presently achieved, for example, by the very broad band version (VBB) of the STS-1 seismometers (Wielandt and Steim, 1986). Minimum standards correspond to the needs and philosophy of networks of regional coverage.

Data Centers

Just as the installation and maintenance of more than one hundred broad band stations distributed around the world cannot realistically be achieved by a single institution, so the collection, verification and distribution of data can be most efficiently realized if tasks are shared and coordinated at different levels. The Federation has identified three levels among existing or developing data centers (figure 2): national, regional and Federation data centers. The national, or network data centers collect and archive complete data from their own national, regional or global network. Regional data centers, such as Orfeus, collect data from

individual stations or networks and collate subsets of data (events) for distribution to the community and other data centers (Berry, 1988). On the third level, no practical solution yet exists for a data center specifically dedicated to the Federation. However, the USGS (NEIC, Golden , Col.) offered early on to serve as the "event FDSN data center" and distribute , on a Federation CD-ROM, broad band data from events recorded at FDSN stations, as well as continuous long period (1 sps and or .1 sps) data. These data will be distributed in the adopted standard SEED format. As a first step, a CD-ROM containing event data from the period October-December 1989, from as many FDSN stations as possible, will be produced by the next IUGG meeting in Vienna in August 1991. On the other hand, the IRIS Data Center in Austin (Texas) has offered to become the first Federation archive, which will collect and make available to the international community continuous data from the FDSN stations.

The problem of rapid access to data following an "interesting" event has led to the concept of ten or so Federation open stations, that could be freely accessible by dial up. Some member networks, such as Geoscope, prefer to eventually open up their data center on line archive for rapid access to data from a whole group of stations. These concepts are presently being discussed within the Federation and the possibility of establishing rapid communication links among data centers is being examined.

Station Siting

Working Group 1 (R. Engdahl) regularly produces listings of existing and planned broad band stations, with network affiliations and specifications (bandwidth, dynamic range, sampling rates) as well as associated maps (figure 3). A subset of 100 stations, operational, or in the course of installation, optimally distributed around the world, was identified in Istanbul (1989) as the "Federation Network", which would contribute data to the FDSN CD-ROM (Figure 4). These stations all comply, or will comply in the near future to the "global station" standard as defined by Working Group 2. While the hole in the global distribution due to lack of stations in the U.S.S.R. is being gradually filled, many oceanic regions, especially in the southern hemisphere, will never be covered, unless ocean bottom installations are deployed (Figure 5). This

is why simultaneous efforts have begun in several countries (Japan, U.S., France) to conduct pilot experiments to test the opportunity and feasability of placing semi-permanent broad band digital stations on the ocean floor or down oceanic boreholes, using recently developed re-entry technology. While many technological problems, related for example to power supply and means of data retrieval. are yet to be solved, it is clear that progress in many aspects of global seismology, is dependent on our ability to instrument the ocean floor. Since, for noise considerations, down hole instrumentation is likely to be recommended, a community of interests has naturally been identified with the ODP program, materialized by the formation of a joint FDSN/ODP task group.

Standardisation of exchange formats

Working Group II (J. Scheimer and later R. Buland, chairmen) has so far had the most complicated task of proposing, and then polishing, to meet every member's critical appraisal, a standard format for the exchange of FDSN data. This format, SEED, was originally developed at A.S.L. (Halbert et al., 1988) as a new format for the distribution of USGS global station data. It is now at the point of reaching a final form and several member networks (e.g. IRIS, GEOSCOPE, ORFEUS) are already distributing data coded according to the SEED standard. Several programs for writing and reading SEED data have been developed in different institutions and the CD-ROM experiment, the burden of which will fall on USGS/NEIC, will represent the final test on the user's satisfaction with accessing data from different networks on a single volume.

Conclusions

After four years of existence, the FDSN can praise itself as having achieved most of its original goals: defining standards of instrumentation and a standard data exchange format, and providing a forum for coordinating siting plans of individual member programs. Since the foundation of the FDSN in 1986, it has appeared more and more clearly that there is pressure from the community of users to have not only convenient and open access to the FDSN data sets, but also rapid sometimes even real-time access. The next challenge for the Federation is

to establish rapid links between its member data centers and standardise access protocoles to on-line databases, were they complete network collections or individual station most recent recordings. Another development is that which concerns the deployment of ocean bottom stations, a formidable task which can only be achieved through international cooperation and in which the FDSN is bound to play an important coordination role.

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Table I

FDSN Executive Committees

1986-89

M. Berry	Canada	Chairman
A. Dziewonski	U.S.A.	Vice Chairman
B. Romanowicz	France	Vice Chairman
R. Engdahl	U.S.A.	

1989-

A.Dziewonski	U.S.A.	Chairman
Y.T. Chen	China	Vice Chairman
H.P. Harjes	F.R.G.	Vice Chairman
B. Romanowicz	France	
R. Engdahl	U.S.A.	
D. Giardini	Italy	Secretary

Table II

F.D.S.N. Working Groups

Working Group I :	Siting plans	(chair: R. Engdahl)
Working Group II:	Instrumentation	(chair: E. Wielandt)
Working Group III:	Data Exchange Formats	(chair: J. Scheimer 1989- R. Buland)
Working Group IV:	Data Centers	(chair: E. Husebye)

Table III

FDSN CHRONOLOGY

1986	April 10,11	Karlsruhe (F.R.G.)	Mid Term ILP Symposium	Preparatory Meeting
1986	Aug 21,30	Kiel (R.F.A.)	EGS	Founding Meeting
1986	Dec 10	San Francisco	AGU	
1987	Aug 9,13	Vancouver (Canada)	IUGG	U.K. and Italy join FDSN USGS to produce FDSN CD-ROM Instrumentation Stand. adopted
1988	June 20,25	Blanes,Spain	Mathematical Geophysics	USSR joins FDSN
1989	Aug 24,29	Istanbul, Turkey	IASPEI	Election of new Exec. Com. SEED adopted FDSN Network designated
1990	Aug 1,3	Golden (Col)		IRIS first FDSN archive Statement of Support to ODP
1991 (planned)	August	Vienna	IUGG	

Table IV

F.D.S.N. members (1990)

Australia	National Net.
Canada	Candis
China (People's Republic)	C.D.S.N.
France	Geoscope
Germany (F.R.G.)	National Net.
Japan	Poseidon
Orfeus	European Data Ctr.
U.S.	IRIS GSN
U.S.	USGS Nets.
U.K.	National Net.
Italy	Mednet
USSR	National Net.

Table V

Related Meetings

1988, August Tokyo (Japan)	"Global Seismology and the POSEIDON Project"
1988, April Woodshole (U.S.)	"Workshop on broadband downhole seismometers in the deep ocean"
1989, Dec. Tsukuba (Japan)	"POSEIDON Symposium II"
1990, Sept. Erice (Italy)	"MEDNET"

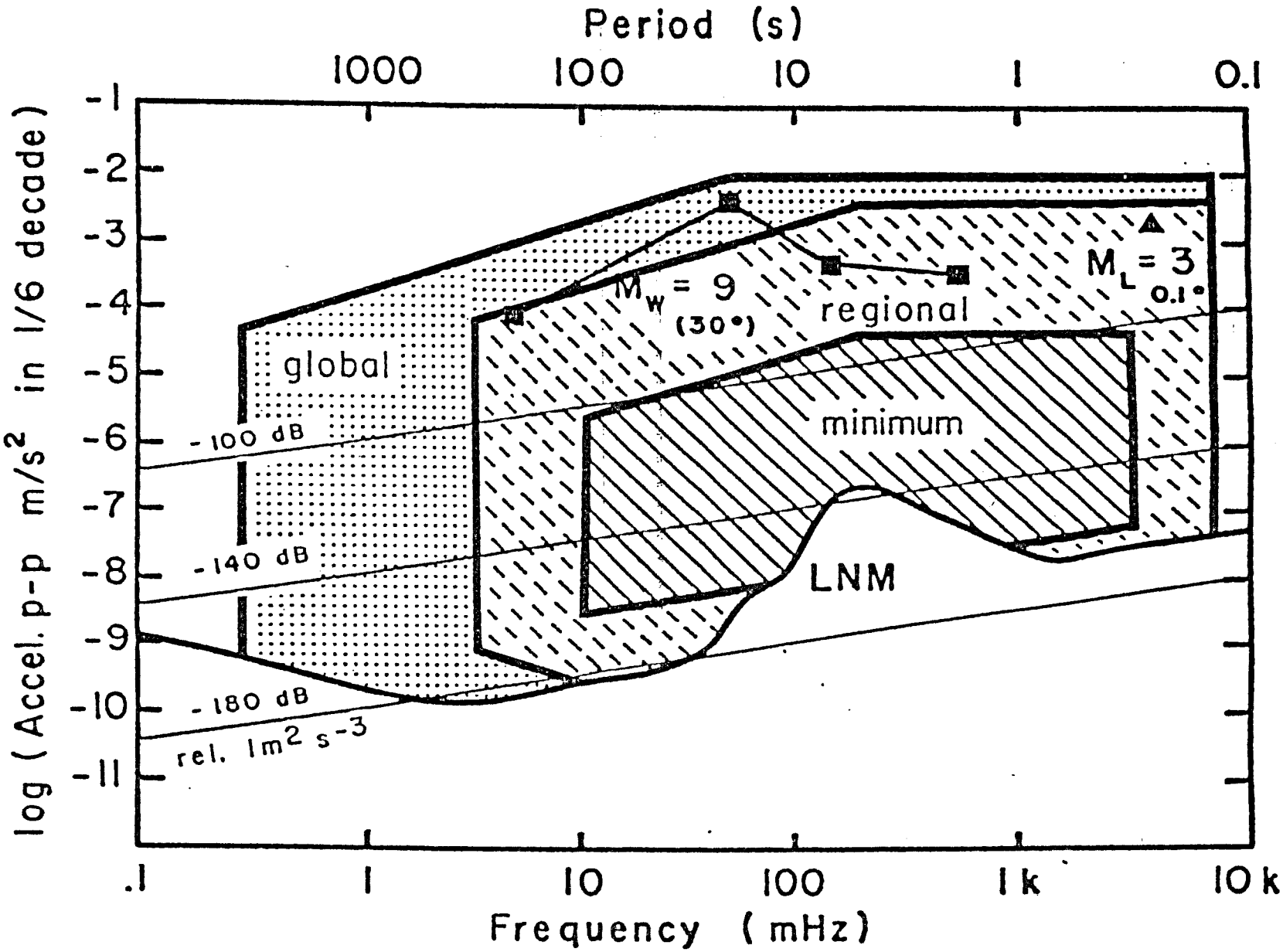


Figure 1. Standards of instrumentation for the F.D.S.N.

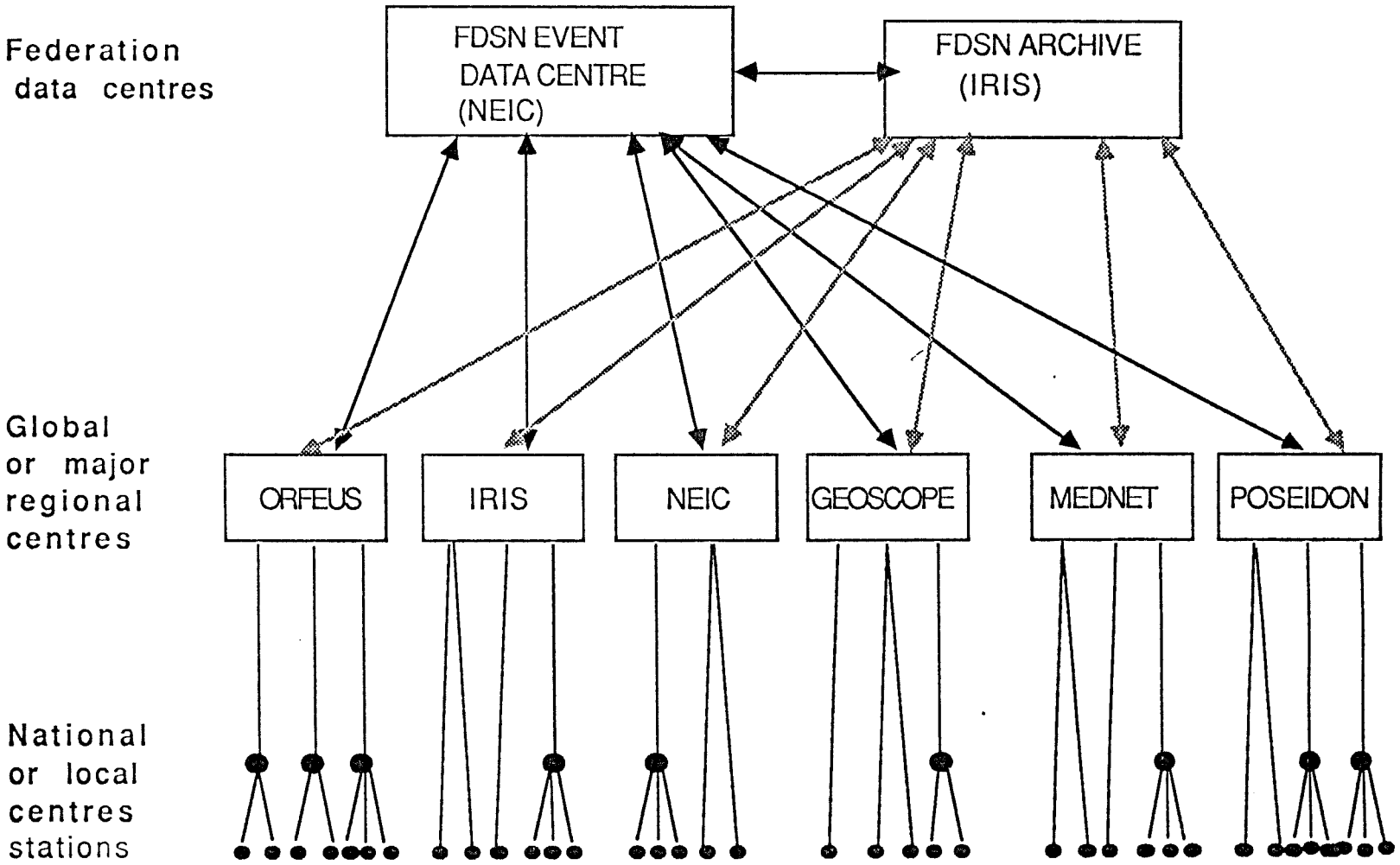


Figure 2. Relations between different FDSN data centers

Figure 3. DIGITAL BROADBAND SEISMOGRAPH STATIONS
August 1990

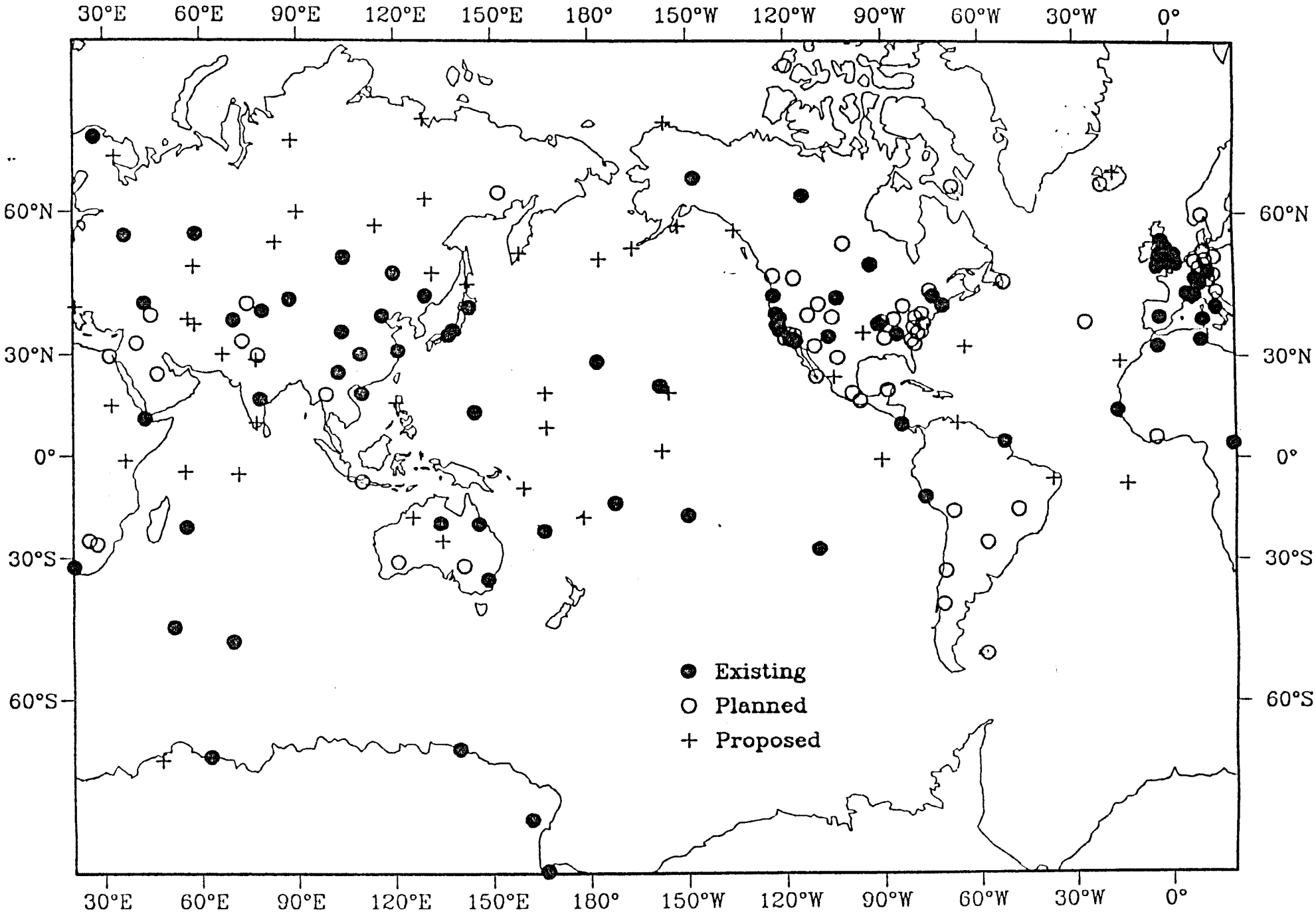
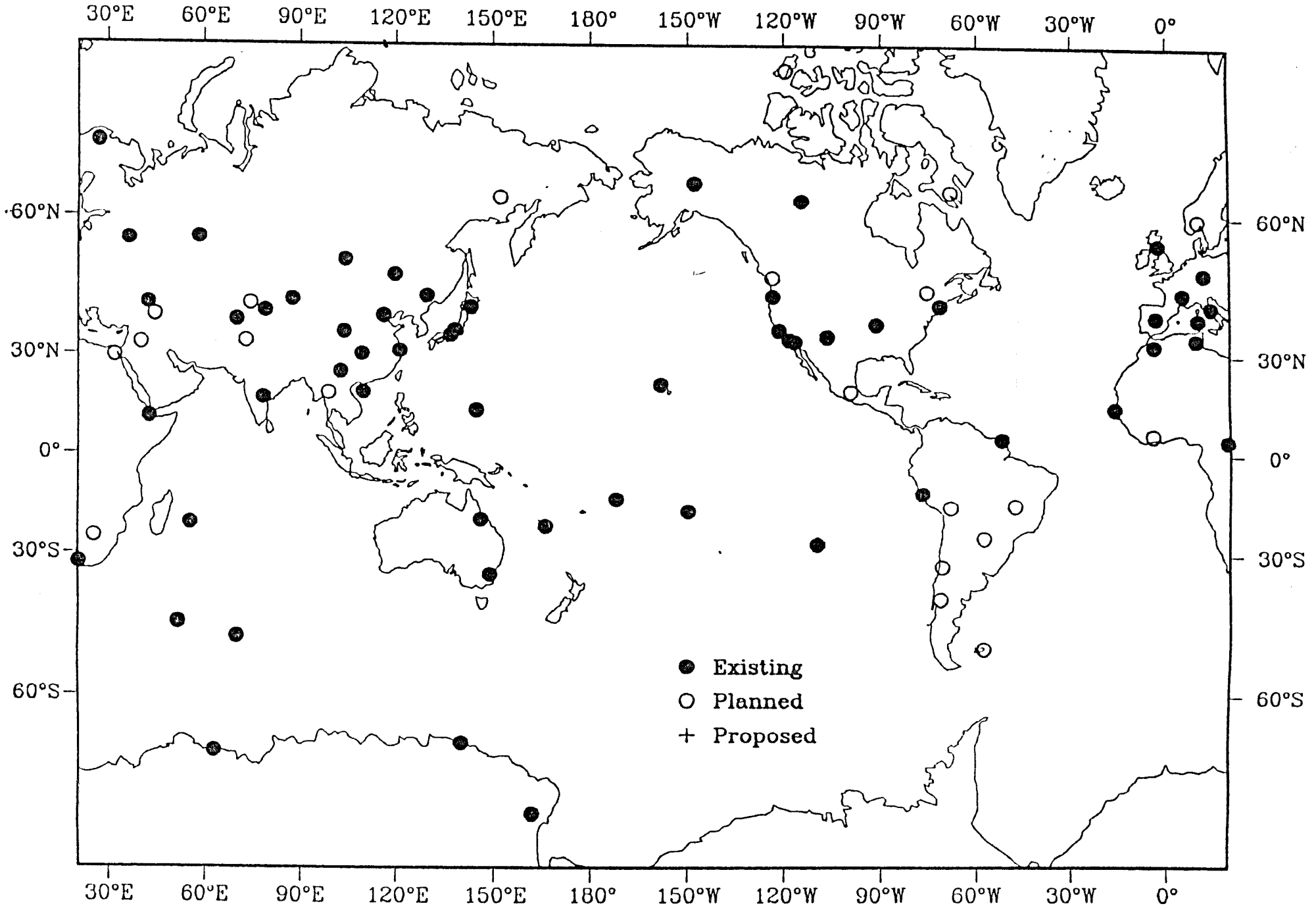
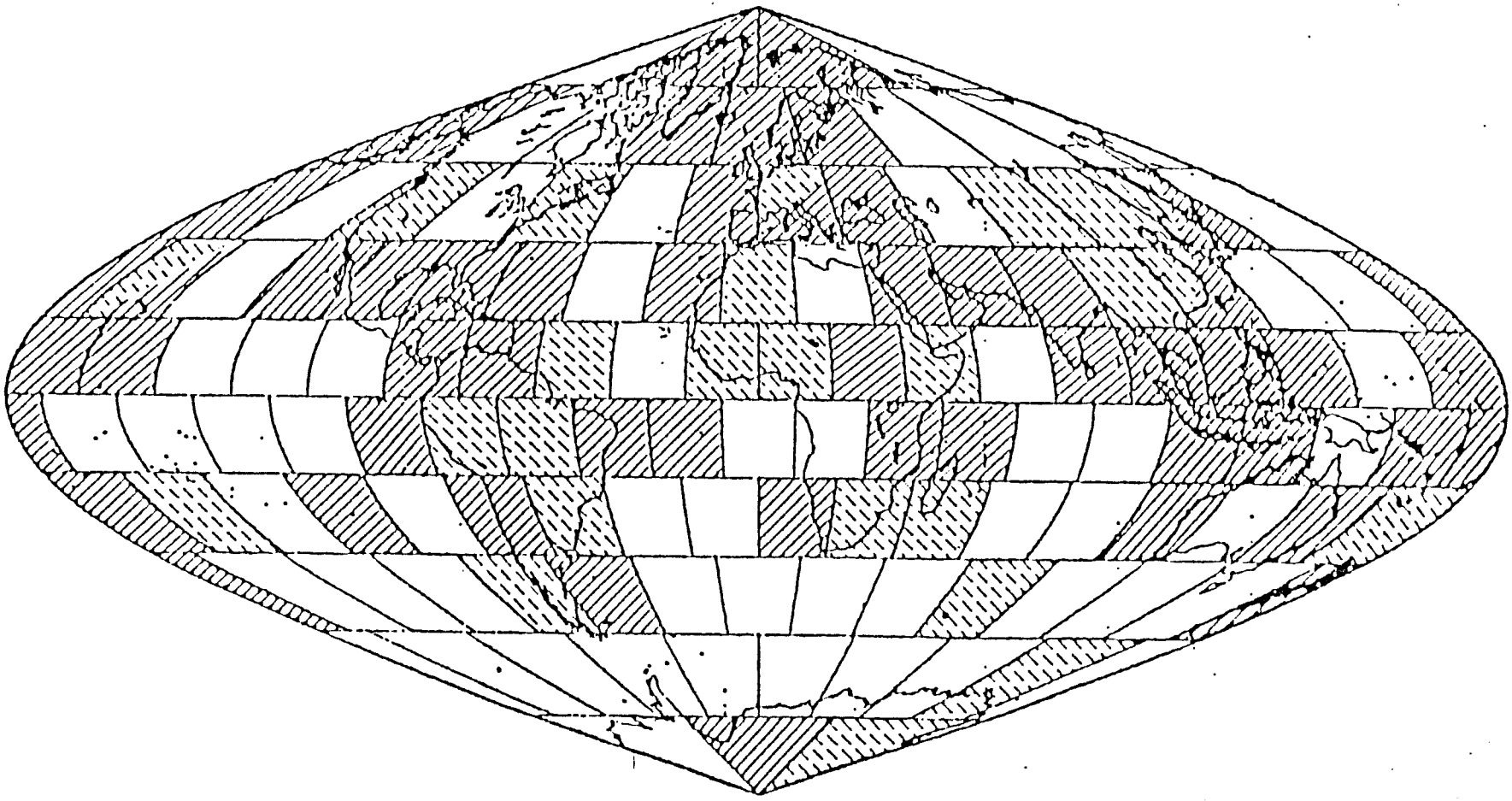


Figure 4. FEDERATION NETWORK
August 1990



GSN AT THE END OF 5-YEAR PLAN



Other Networks

IRIS 5-year Plan

Figure 5. Coverage of the earth by broad band digital stations by the early 1990's

APPENDIX I

TERMS OF REFERENCE

Federation of digital Broad-Band Seismograph 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 seismograph network technology.

It also recognizes that rapid access to seismic data networks of modern broad-band digital instruments wherever they might be. is now possible.

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.

The federation is open to all national and international programs committed to the deployment of broad-band seismographs and willing to contribute to the establishment of an optimum global system with timely data exchange.

I. Goals

In view of the above. and to take advantage of existing developing global and regional networks the "Federation of Digital Broad-Band Seismograph Networks (FDSN)" is 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 archiving and exchange of data among component networks ;
- coordinating the siting of additional stations in locations that will provide optimum global coverage.

II. Institutional Frame

The Federation is an independent international association and is affiliated with two international organisations : the Inter Union Commission on the

Lithosphere (ICL) and the International Association for Seismology and Physics of the Earth's Interior (IASPEI).

III. Membership and Organization

- Membership in the FDSN is open to national and international programs committed to both the development and operation of broad-band digital networks and complying with the goals of the federation.

- The activities of the federation will be coordinated by a steering committee whose membership may not exceed one representative from each of any national or international program.

- The members of the steering committee will be appointed or selected from within the country or the organization they represent

- The steering committee will be headed by a chairman elected for a two year term, assisted by two vice-chairmen.

- The steering committee will form all necessary working groups or special technical committees as required to reach the objectives of the FDSN.

- The steering committee will meet at least once a year.
  Special meetings may be called by the chairman as appears necessary for the progress of the FDSN.

- Concerning all recommendations made and actions to be taken, each member of the FDSN will have one vote, and an affirmative vote by 2/3 of members present at a steering committee meeting will be required.

- A majority of members of the FDSN will constitute a quorum for the steering committee meetings.

- No fees are imposed but voluntary contributions may be requested to cover costs for communications.

- Any member may resign at any time by giving written notice to the chairman.