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LETTER DATED 9 MARCH 1984 FROM THE CHAIRMAN OF THE AD HOC GROUP OF SCIENTIFIC EXPERTS TO CONSIDER INTERNATIONAL CO-OPERATIVE MEASURES TO DETECT AND IDENTIFY SEISMIC EVENTS TO THE PRESIDENT OF THE CONFERENCE ON DISARMAMENT TRANSMITTING THE THIRD REPORT OF THE AD HOC GROUP

I have the honour to forward to you, in your capacity as President of the Conference on Disarmament, the Third Report to the Conference on Disarmament of the Ad Hoc Group of Scientific Experts to Consider International Co-operative Measures to Detect and Identify Seismic Events. This Report was prepared pursuant to the decision of the Committee on Disarmament of 7 August 1979.

The Ad Hoc Group would like to note, with appreciation, the assistance which the Secretariat of the United Nations provided to it.

The Ad Hoc Group of Experts requested me, as its Chairman, to transmit on its behalf, the report which was adopted unanimously.

(Signed) OLA DAHLMAN
Chairman

GE.84-60684

THIRD REPORT TO THE CONFERENCE ON DISARMAMENT OF THE AD HOC GROUP OF SCIENTIFIC EXPERTS TO CONSIDER INTERNATIONAL CO-OPERATIVE MEASURES TO DETECT AND IDENTIFY SEISMIC EVENTS

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Summary

1. The Ad Hoc Group of Scientific Experts to Consider International Co-operative Measures to Detect and Identify Seismic Events, so as to facilitate the verification of a comprehensive nuclear test ban treaty, was established in 1976 by the Conference of the Committee on Disarmament (CCD) and has later been maintained by the Committee on Disarmament (CD), which, as of February 1984 has become the Conference on Disarmament (CD). Government appointed experts from 30 States 1/ and representatives from the World Meteorological Organization (WMO) have participated in the work during the Group's present mandate. Names of the participants are listed at the end of this report.

2. In its consensus reports CCD/558 of 14 March 1978 and CD/43 of 25 July 1979 the Ad Hoc Group described how seismological science could be applied, in international co-operation, for a global exchange of seismological data, so as to assist States in their national verification of a comprehensive nuclear test ban.

The proposed system for global data exchange will, it is expected, operate on the basis of a number of provisions to be worked out within the framework of a treaty prohibiting nuclear weapons tests covering nuclear explosions for peaceful purposes in a protocol which would be an integral part of the treaty.

3. The proposed global system has three main elements:

(a) a network of more than 50 existing or planned seismological stations around the globe, with improved equipment and upgraded procedures for the extraction of data;

(b) an international exchange of these data over the Global Telecommunication System (GTS) of the World Meteorological Organization (WMO);

(c) processing of the data at special International Data Centres (IDCs) for the use of participant States.

4. The data to be reported from each station or observatory would be in standard form and on two levels:

Level I */ with the routine reporting, with minimum delay, of basic parameters of detected seismic signals and

Level II */ with detailed records of waveforms provided in response to requests for additional information.

Compared to current seismological practice, increased emphasis would be laid on parameters relevant to event identification and generally strict operational requirements would be set forth as to scope, consistency, reliability and promptness in the reporting. Where applicable, internationally agreed scientific practices would be followed.

1/ Algeria, Australia, Austria, Belgium, Bulgaria, Canada, Czechoslovakia, Denmark, Egypt, Finland, German Democratic Republic, Germany, Federal Republic of, Hungary, India, Indonesia, Italy, Japan, Kenya, Mexico, Netherlands, New Zealand, Norway, Peru, Poland, Romania, Sweden, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland, United States of America and China (participating as observer).

*/ In CCD/558 and CD/43, Level 1 and Level 2 were used, respectively.

5. The present consensus report, which is the third report overall of the Ad Hoc Group, contains detailed, preliminary instructions for the comprehensive experimental testing of the global system, which might be established for the international exchange of seismological data under a future treaty. In addition the report contains the results of national investigations submitted to the Group by its members, concerning questions relating to the further development of scientific and technical aspects of the global system described in CCD/558 and CD/43. More than 200 national contributions have been submitted to the Group as informal working papers, some of them of considerable impact and volume. These contributions, which are listed in Appendix 2 to this report, have been reviewed and analysed at nine plenary sessions held by the Group.

6. Dr. Ulf Ericsson of Sweden served as Chairman of the Ad Hoc Group from 1976 until his death in November 1982. During these years, he guided the work of the Group with great skill and dedication. The significant results that the Ad Hoc Group has achieved must to a large extent be attributed to the Chairmanship of Dr. Ericsson.

7. On 10 February 1983, the Ad Hoc Group unanimously elected Dr. Ola Dahlman of Sweden as its new Chairman.

8. Upon invitation by the CD, representatives of the WMO have attended the Ad Hoc Group's sessions, and have provided valuable advice and assistance with regard to transmission of seismic data on the WMO/GTS. The Ad Hoc Group takes note of the letter addressed to the Chairman of the CD from the Secretary-General of the WMO (CD Working Paper No. 99 of 20 June 1983), in which he informed the Committee of the decision by the WMO Executive Council, at its thirty-fifth session, to approve Recommendation 18 (CBS-VIII) of the WMO Commission for Basic Systems concerning the "Inclusion of seismic bulletins in the global exchange programme". Thus the formal approval now exists to regularly exchange Level I seismic data through the WMO/GTS, starting 1 December 1983.

9. The present report has eight chapters, each dealing with different aspects of the Group's work. In addition, eight appendices containing detailed and technical material are annexed as an integral part of the report. Consensus was reached on the entire main part of the report, and also on those appendices (4B, 7 and 8) containing recommendations and preliminary technical instructions. Appendices 1, 2, 4C, 5A and 5B contain factual information on various organizational and technical matters. The remaining appendices (3, 4A, 4D, 4E, 5C and 6) contain summaries of national investigations, and thus reflect the viewpoints of individual countries on various technical problems.

10. The contents of the chapters of the report are summarized in the following paragraphs.

11. Chapters 1 and 2 are introductory chapters, giving the background for the establishment of the Ad Hoc Group, its terms of reference as given by the CD, and its organization and method of work.

12. Chapter 3 describes recent developments in seismograph stations and networks. In summary, significant technical developments have taken place in the past few years with regard to seismograph facilities worldwide, and some of these are described in this chapter and its associated appendices.

The many advantages of digitally recording seismograph systems are now widely recognized, and in consequence many such systems have been installed. While a significant number of stations of interest for the global network still are of the analog recording type, the Ad Hoc Group recommends that conversion of analog stations to digital systems be given high priority.

The Ad Hoc Group maintains its recommendation from CCD/558 and CD/43 that all network stations be equipped with modern seismograph systems capable of continuous recording of data in digital form, and operated in a standardized way. However, progress toward such a standardization has been slow, and the attainment of an agreed specification of standards for the network is an important aim that deserves further study.

National experiments have demonstrated the usefulness of data that can be obtained from array stations, even if these array stations are of very small aperture.

In CCD/558 it was noted that the large majority of high quality seismic stations were located in the northern hemisphere. The situation is essentially unchanged today. The Ad Hoc Group considers it essential that more high quality stations be established in the southern hemisphere, especially in Africa and South America. The Ad Hoc Group considers as very valuable the efforts that are currently under way to establish the feasibility of ocean-bottom seismograph systems. The Group notes that the inclusion of such instruments would significantly improve the capabilities of the global system.

The Ad Hoc Group notes that significant changes have occurred since the theoretical capabilities of a network selected to model a global system were considered in CCD/558. A new method for network capability estimation, using simulated earthquake data, has been introduced to the Ad Hoc Group, and is of methodological importance. However, the Group agrees that an accurate evaluation of the capabilities of a global network will only be possible in conjunction with a comprehensive experimental exercise of the global system, as first proposed in CCD/558. The need for such an experimental exercise continues to be recognized.

13. Chapter 4 discusses Level I data extraction at the seismograph stations of the global network. In summary, the Ad Hoc Group has reviewed several national investigations addressing the Level I parameter lists proposed in CCD/558 and CD/43. As a result of these studies, the Group believes that a number of new parameters could be added as being useful for an international seismic data exchange. However, the final list of parameters will be established only after a comprehensive experimental exercise as proposed in CCD/558.

National investigations have shown that existing methods for Level I data extraction can impose a heavy work load on participants in an international data exchange. The Ad Hoc Group notes that promising results, which might lead to a reduction in the work load, have been achieved using automatic procedures, but recognizes that this is a difficult problem. The Group considers that further research in this area is needed. Here it is understood that the participating stations in the proposed global system would be equipped with digital recording devices.

Interactive processing has proved very valuable in the analysis of seismic records, and further studies should be conducted. A reasonable aim is to attempt to minimize the number of intermediate decision points in the interactive process, thus approaching the goal of automatic parameter extraction. The Ad Hoc Group believes that standardization of the interactive process is important and should be investigated.

The Ad Hoc Group takes note of the recommendations adopted by the International Association of Seismology and Physics of the Earth's Interior (IASPEI) during its assembly in Canberra, Australia, in 1979 regarding instructions for measuring amplitudes and periods for magnitude determinations (Appendix 4C). The Group recommends that these standards should

form the basis for such measurements within the global system, and that automatic procedures to analyse signals be designed according to these standards.

Promising results have been reported on the use of techniques for Level I data extraction such as polarization filtering and high-resolution wavenumber analysis of data from small arrays. The Ad Hoc Group recommends that studies of these and other advanced methods be pursued further.

14. Chapter 5 deals with exchange of Level I data through the WMO/GTS. Two trial exchanges of abbreviated Level I data using the WMO/GTS have been conducted with broad participation of countries represented in the Ad Hoc Group. Although some technical problems have been encountered, the results from the experiments have shown that the WMO/GTS has the potential of fully satisfying the aims of rapid and undistorted transmission of Level I data for the proposed global system. At many remote places, the WMO/GTS offers the only practical communication mechanism for rapid transmission of Level I data.

An additional technical test which has been conducted between five countries has shown that the GTS can handle large volumes of Level I data without problems.

The Ad Hoc Group sees the need for additional technical tests using the WMO/GTS to test further aspects of the possible international exchange of data, especially the complete set of Level I parameters. The dissemination of seismic bulletins from data centres also needs further testing. Noting that no significant experience has been obtained regarding transmissions from Africa, Antarctica and South America, the Group considers it important that additional experiments include participation from these continents.

The WMO has authorized the use of the GTS for the exchange of Level I seismic data on a regular basis from 1 December 1983. The Ad Hoc Group considers it essential that up-to-date information on improvements and changes to the GTS be readily available; therefore, it is recommended that the Secretariat of the Conference on Disarmament make arrangements with the Secretariat of the WMO to receive regular advice on this matter.

The Ad Hoc Group has noted the advice of the WMO that significant improvements in transmission can be expected only if the GTS is used on a more regular basis. Some countries are already doing so. However, the Group notes that regular use or participation in more extensive tests of the GTS poses organizational problems for some potential participant States.

The Ad Hoc Group considers it important that the format of Level I data be kept consistent with the International Seismic Code currently in use, and recommends that a close liaison be maintained with international seismological agencies in order to co-ordinate future elaborations on the format for Level I parameters.

15. Chapter 6 concerns format and procedures for the exchange of Level II data. In the proposed global system, Level II data will be exchanged, upon request, between government-authorized National facilities through International Data Centres. Some national investigations have shown that rapid exchange of Level II data in digital form can be achieved using modern telecommunications facilities without any particular restriction on the amount of such data that might be requested.

In the proposed system for global data exchange, any Level II data from individual stations designated as participating in the global network should be exchanged upon requests made from a government-authorized National facility through an International Data Centre.

The Ad Hoc Group agrees that a precise estimate of the amount of Level II data that might be requested can be given only after sufficient experience has been acquired from a comprehensive experimental exercise as proposed in CCD/558.

Preliminary formats for digital Level II seismic data on magnetic tape have been considered. In future consideration of such formats, possible IASPEI recommendations should be taken into account. Formats for the exchange of such data by telecommunications channels need to be further developed, but should follow the magnetic tape standard as closely as possible.

Level II data should be exchanged as rapidly as practical, the rapidity will depend on precise procedures which have to be agreed upon. The Group notes that it will be necessary to take into consideration the practical telecommunications conditions particular to each participating country.

The Ad Hoc Group recommends that further investigations be made of possible formats and methods for Level II data exchange at the request of participants in connection with the preparations for the comprehensive experimental exercise proposed in CCD/553.

16. Chapter 7 deals with the topic of International Data Centres (IDC's) for the envisaged global system. A number of national investigations have been conducted regarding the organization of such centres and the data processing that would be performed. Experimental data centres have been established by some countries and some large-scale experiments have been conducted to test and develop procedures for data handling and analysis. These efforts and their implications for a global system are summarized in this chapter. A "Preliminary Operations Manual for International Data Centres" has been developed, giving a detailed outline of the operational procedures to be followed at such centres. The manual is annexed as an integral part of this report (Appendix 7). Certain aspects of the procedures developed in this annex should be tested and updated further.

Preliminary results have been obtained using automated procedures for Level I seismic data analysis in the International Data Centres to be established for the proposed global system. The experts of the Ad Hoc Group agree that automatic Level I data processing in the IDCs is one of the most complex problems for the proposed global system. Results of national investigations indicate, however, that in principle it is possible to solve this problem. The Ad Hoc Group recommends that further research into automatic processing at data centres be given high priority.

National investigations carried out by some countries have shown the effectiveness of the use of Level II data at national centres in obtaining more accurate focal parameters of events presenting an interest.

Some modifications to the procedures described in the Group's earlier reports have been agreed to. The procedure to be used for event definition should take into account a large number of seismic phases than suggested in CCD/553 and CD/43. Further research efforts are needed to improve the accuracy of epicentre location and, most urgently, of event depth estimation. This might be achieved by using globally compiled local travel time data and also by using joint hypocentre estimation techniques. An increased use of depth phases seems, however, to be the most important step here.

Certain national investigations have shown that the more detailed analysis of information at stations of the global network (Level II data), for example with the help of polarization analysis, provides greater effectiveness in the identification of depth phases.

Procedures and formulas should be established to estimate short period and long period magnitude from local recordings. Magnitude estimation procedures should include individual station corrections and the use of noise data for non-detecting stations. Increased effort should be given to the reporting and analysis of long period surface waves, since experiments have shown that surface wave observations can be obtained to a much greater extent than previously experienced.

Efforts should be made to increase the amount of preliminary location data from array stations and of estimates of arrival directions for long period surface waves.

Effective procedures need to be developed for receiving, copying, storing and distributing copies of Level II data to participating States which have made a request in connection with an event of interest.

17. Chapter 8 contains conclusions and recommendations for further study. As observed in this report, significant and rapid developments have taken place in recent years regarding seismology and data processing techniques, and th se developments are continuing.

The Ad Hoc Group notes that these results can turn out to be useful and thus could be considered for the further development of the scientific and technical aspects of the co-operative global system described in CCD/558 and CD/43 as well as for the further elaboration of a comprehensive experimental exercise of that system.

The Ad Hoc Group has noted areas in which additional scientific and technical progress is needed, as discussed in Chapters 3 through 7 of this report and the most important such topics are summarized in Chapter 8.

The Ad Hoc Group notes with appreciation the recent decision by the WMO Ninth Congress that the WMO/GTS may be used for regular transmission of Level I data from 1 December 1983. The Group sees the need to conduct further technical tests, in co-operation with the WMO, to establish the operational performance of the WMO/GTS for seismic data exchange on a global basis. The Group has worked out a preliminary plan for such a test of the WMO/GTS transmission channels for Level I data to be carried out in 1984.

The Ad Hoc Group maintains its recommendation from CCD/558 and CD/43 that a comprehensive experimental exercise of all aspects of the eventual global system be conducted.

CHAPTER 1

Introduction

Summary

The background for the establishment of the Ad Hoc Group is reviewed, and the terms of reference for its continued work are presented.

1.1 Background and terms of references for the Ad Hoc Group

On 22 July 1976, the Conference of the Committee on Disarmament (the CCD) established an Ad Hoc Group of Government-appointed experts to consider and report on international co-operative measures to detect and identify seismic events, so as to assist in the verification of a comprehensive test ban. The Group submitted its consensus report (CCD/558) in March 1978, describing how seismological science can be applied in a co-operative international effort to achieve this purpose. In this sense, the co-operative measures would have three main elements:

- a systematic improvement of the observations reported from a network of more than 50 seismological observatories around the globe
- an international exchange of these data over the Global Telecommunication System of the World Meteorological Organization (WMO/GTS)
- processing of the data at special International Data Centers for the use of participant States.

The report also considered some steps, such as a comprehensive experimental exercise, which could be taken initially to assist the establishment of such a co-operative international data exchange system.

On 9 May 1978, the CCD decided that the Ad Hoc Group should continue its work by studying the scientific and methodological principles for a possible comprehensive experimental exercise of a global network of the kind described in CCD/558. The Committee on Disarmament (the CD), in its decision of 15 February 1979, maintained the arrangements for the Ad Hoc Group. Subsequently, in July 1979, the Group submitted its second report (CD/43).

On 7 August 1979, the CD decided (CD/PV.48) that the Ad Hoc Group should pursue its work further, under the following terms of reference:

"1. Recognizing the valuable and important work carried out by the Ad Hoc Group in elaborating instructions and specifications for International Co-operative Measures to Detect and Identify Seismic Events, as presented to the CD in its report of July 1979, the CD decides that the Ad Hoc Group should continue its work on such measures, which might be established in the future for the international exchange of seismological data under a treaty prohibiting nuclear weapon tests covering nuclear explosions for peaceful purposes in a protocol which would be an integral part of the treaty.

2. This work should, inter alia, include:

- further elaboration, with the second report of the Group as a basis, of detailed instructions for an experimental test of the global system for international co-operative measures to detect and identify seismic events;

- further development of the scientific and technical aspects of the global system;

- co-operation in the review and analysis of national investigations into relevant matters such as:

  - the conditions for using the WMO Global Telecommunication System for seismic data exchange;

  - procedures to obtain desired data at individual stations under a range of conditions;

  - the analysis and data handling procedures at the envisaged data centres; and

  - methods of rapid exchange of waveform data.

3. The organization and procedures of work of the Group should remain the same as defined by the decision of the CCD on 22 July 1976 and maintained by the Committee on Disarmament by its decision of 15 February 1979. The Ad Hoc Group will hold its first meeting under its new mandate late in January or early in February 1980.

4. The Committee on Disarmament invites WMO to continue its co-operation with the Ad Hoc Group."

CHAPTER 2

Organization and Method of Work of the Ad Hoc Group

Summary

The organization and composition of the Ad Hoc Group is described and its programme and method of work is outlined.

2.1 Organization and composition of the Ad Hoc Group

The Ad Hoc Group is open to all Member States of the Conference on Disarmament as well as to other States Members of the United Nations upon invitation by the CD. Altogether, scientific experts and representatives from twenty-five Member States of the CD and five other States have participated in the work of the Ad Hoc Group under its current mandate.

Upon invitation by the CD, representatives of the World Meteorological Organization (WMO) have attended the Ad Hoc Group's sessions, and have provided valuable advice and assistance with regard to transmission of seismic data on the Global Telecommunication System (GTS) of the WMO.

Dr. Ulf Ericsson of Sweden served as Chairman of the Ad Hoc Group from 1976 until his death in November 1982. During these years, he guided the work of the Group with great skill and dedication. The significant results that the Ad Hoc Group has achieved must to a large extent be attributed to the Chairmanship of Dr. Ericsson.

On 10 February, 1983, the Ad Hoc Group unanimously elected Dr. Ola Dahlman of Sweden as its new chairman.

Dr. Frode Ringdal of Norway has served as Scientific Secretary for the Ad Hoc Group. Mr. P. Csillag, United Nations Centre for Disarmament,*/New York, Mrs. L. Waldheim-Natural, Chief, Geneva Unit, United Nations Centre for Disarmament, and Mr. M. Cassandra, United Nations Department for Disarmament Affairs, Geneva Branch, have served as Secretary for the Group at its different sessions.

The names of the participants are listed at the end of this report.

In the course of its work under its present mandate, the Ad Hoc Group agreed to establish five Study Groups in order to achieve an appropriate compilation, summarization and assessment of the experience acquired through national investigations and co-operative studies in areas relevant to its work. These open-ended Study Groups have each dealt with a specific issue as follows:

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*/ As of 1 January 1983, the United Nations Centre for Disarmament was transformed into the United Nations Department for Disarmament Affairs.

Study Group 1 Seismological stations and station networks

Study Group 2 Data to be regularly exchanged (Level I data)

Study Group 3 Format and procedures for the exchange of Level I data through the WMO/GTS

Study Group 4 Format and procedures for the exchange of Level II data

Study Group 5 Procedures to be used at International Data Centres

Each of these Study Groups has been headed by a convenor and co-convenor as listed at the end of this report.

2.2 Programme and method of work

Under its present mandate, the Ad Hoc Group has met in nine sessions at Geneva (its ninth through seventeenth sessions) on the following dates:

9th session:	11-15 February 1980
10th session:	7-16 July 1980
11th session:	3-12 February 1981
12th session:	3-12 August 1981
13th session:	1-12 March 1982
14th session:	9-20 August 1982
15th session:	7-18 February 1983
16th session:	11-22 July 1983
17th session:	27 February-9 March 1984

The Group has submitted a progress report to the CD after each of the sessions and prepared an extended progress report following the thirteenth session in order to assist the Committee on Disarmament in reporting to the Secretary-General of the United Nations in preparation for the second special session of the General Assembly devoted to disarmament (CD/260).

The method of work has been informal, with presentation of reports on national investigations from participating experts, review and assessment of these contributions during the plenary sessions, and compilation and summarization of the conclusions between sessions by the convenors of the five Study Groups. Based on these contributions, a first draft of a report was compiled by the Scientific Secretary prior to the fifteenth session, and the report was then reviewed by the Ad Hoc Group. A second draft was distributed prior to the sixteenth session for further review. Prior to the seventeenth session, a third draft was distributed and was then reviewed and finalized in its present form during that session.

The present report has as its purpose to:

- summarize the experience gained so far from the national and co-operative studies conducted under the Ad Hoc Group's current mandate,

- consider the implications of these new results for the further development of the scientific and technical aspects of the global system for International Co-operative Measures to Detect and Identify Seismic Events as described in CCD/558 and CD/43,

- elaborate detailed instructions for a comprehensive experimental exercise of the global system for International Co-operative Measures to Detect and Identify Seismic Events.

The report reflects the consensus view of the Ad Hoc Group in this regard.

Chapters 3 through 7 discuss the national contributions relevant to each of the five Study Groups, and gives the assessment of the implications for the global system described in CCD/558 and CD/43. Conclusions and recommendations are presented in Chapter 8.

A number of separate appendices, containing detailed and technical material, are annexed as an integral part of this report. Appendix 1 gives a glossary of seismological terms and abbreviations used in this document. Appendix 2 lists the national contributions submitted in the course of the Ad Hoc Group's present mandate. Appendices 3 through 7 contain detailed technical material in connection with Chapters 3-7 of the report. Appendix 8 contains detailed, preliminary instructions for a comprehensive experimental exercise of the proposed global system.

Consensus was reached on the entire main part of the report, and also on those appendices (4B, 7 and 8) containing recommendations and preliminary technical instructions. Appendices 1, 2, 4C, 5A and 5B contain factual information on various organizational and technical matters. The remaining appendices (3, 4A, 4D, 4E, 5C and 6) contain summaries of national investigations, and thus reflect the viewpoints of individual countries on various technical problems.

CHAPTER 3

Recent Developments in Seismograph Stations and Networks

Summary

Significant technical developments have taken place in the past few years with regard to seismograph facilities world-wide, and some of these are described in this chapter and its associated appendices.

The many advantages of digitally recording seismograph systems are now widely recognized, and in consequence many such systems have been installed. While a significant number of stations of interest for the global network still are the analog recording type, the Ad Hoc Group recommends that conversion of analog stations to digital systems be given high priority.

The Ad Hoc Group maintains its recommendation from CCD/558 and CD/43 that all network stations be equipped with modern seismograph systems capable of continuous recording of data in digital form, and operated in a standardized way. However, progress toward such a standardization has been slow, and the attainment of an agreed specification of standards for the network is an important aim that deserves further study.

National experiments have demonstrated the usefulness of data that can be obtained from array stations, even if these array stations are of very small aperture.

In CCD/558 it was noted that the large majority of high quality seismic stations were located in the northern hemisphere. The situation is essentially unchanged today. The Ad Hoc Group considers it essential that more high quality stations be established in the southern hemisphere, especially in Africa and South America. The Ad Hoc Group considers as very valuable the efforts that are currently under way to establish the feasibility of ocean-bottom seismograph systems. The Group notes that the inclusion of such instruments would significantly improve the capabilities of the global system.

The Ad Hoc Group notes that significant changes have occurred since the theoretical capabilities of a network selected to model a global system were considered in CCD/558. A new method for network capability estimation, using simulated earthquake data, has been introduced to the Ad Hoc Group, and is of methodological importance. However, the Group agrees that an accurate evaluation of the capabilities of a global network will only be possible in conjunction with a comprehensive experimental exercise of the global system, as first proposed in CCD/558. The need for such an experimental exercise continues to be recognized.

3.1 Introduction

This chapter summarizes recent national developments of seismograph facilities and special facilities for the extraction and analysis of seismic data that have been reported in the form of working papers and other documentation to the Ad Hoc Group. Summaries of national developments in the two categories are given in Appendices 3A and 3B. The implications of these developments for the global system described in CCD/558 and CD/43 are discussed in the following sections.

In the first report of the Ad Hoc Group (CCD/558) in March 1978 a variety of global seismograph networks were studied. The stations in these networks were selected from the stations of potential interest to the global system, largely

on the basis of seismological considerations. Many of the stations are in countries not represented by experts in the Ad Hoc Group and were selected on geographical considerations from available lists of global seismograph stations.

In CCD/558 and in the second report of the Ad Hoc Group (CD/43), submitted in July 1979, desirable technical standards for stations participating in an eventual global network were described. In particular it was deemed highly desirable to have all participating stations capable of producing digital seismic data.

The national seismological agencies in many of the countries participating in the work of the Ad Hoc Group have been modernizing and expanding their seismograph station facilities; some specifically for development of capabilities to participate in the global system, others to generally strengthen their seismological research capabilities or to improve the capacity to monitor local seismicity. Many of the reported national seismograph developments have been for purposes of studying local seismicity. Although the seismograph stations involved in these types of developments will not necessarily be offered by the host country as part of a global network, the modernization of facilities and development of local data transmission, data management and analysis facilities will put the country in a better position to respond effectively to the eventual needs of the global network.

3.2 Standards for stations in a global network

Over the past few years the many advantages of digitally recording seismograph systems have been widely recognized and advances in technology have made such systems much more economical than was previously the case. Consequently, many such systems have been developed and installed, particularly for the recording and analysis of local earthquakes (see Appendix 3A). Nevertheless, a significant number of stations of interest for the global network are of analog recording type, and participation of these stations in the international data exchange is important. Therefore, it is recommended that conversion to digital systems of analog stations that may be offered by the host country for participation be given high priority.

It was recommended in CCD/558 and CD/43 that all stations in the global network be equipped with modern seismograph systems capable of continuous recording of data in digital form, and operated in a standardized way. However, progress toward such a standardization has been slow and consequently temporary data centre facilities established as part of mulilateral experiments by the Ad Hoc Group have had to handle a wide variety of data from different seismograph systems. The use of standard characteristics for non-standard seismograph systems offers a practical, temporary alternative, but an agreed specification for station standards is an important aim that deserves further study.

National experiments have demonstrated the usefulness of data that can be obtained from array stations, even if these array stations are of very small aperture.

3.3 Distribution of stations in a global network

In CCD/558 it was noted that the large majority of higher quality seismograph stations are located in the northern hemisphere. The situation is essentially unchanged today, and in order for the global system to provide reasonably uniform global coverage of seismic events, it is essential that more high-quality stations be established in the southern hemisphere, especially in Africa and South America.

An illustration of the inadequacy of the short-period detection capability in the southern hemisphere was made with a national experiment using data from the multi-country Common Data Base Experiment carried out in relation to the work by the Ad Hoc Group. (See Appendix 4 A.)

Because much of the southern hemisphere is covered by oceans, a major improvement in this area will come from ocean-bottom seismographs (OBS). National developments have included OBS deployment: (a) for continuous recording in conjunction with land-based stations to improve the recording of local seismicity; and (b) as a research programme in boreholes in the ocean floor to reduce ambient noise levels.

National experiments have also been conducted on the use of "T-phases", i.e., hydroacoustic phases, to detect seismic events in oceanic areas. T-phases can be recorded on short-period vertical seismographs deployed at island or coastal locations. Recording conditions are favourable when there is deep water close offshore. Special sensors deployed for T-phase detection could significantly improve the detection capability in the southern hemisphere.

3.4 Global network capabilities

Technical information collected on existing global seismograph stations was employed in CCD/558 to model hypothetical global networks and then to calculate their theoretical short- and long-period detection capabilities. Significant changes have occurred since these calculations were made, changes that include improved seismic instrumentation (e.g. Appendix 3A), the deployment of new stations, and the closure of other stations including some large arrays. Because of these types of changes, which will continue as national developments continue, the Ad Hoc Group considers it important that the Secretariat of the Conference on Disarmament act as an on-going repository of up-to-date information on the technical and seismological characteristics of global seismograph stations. This applies in particular to those stations of potential interest that are offered by different countries for participation in the global network.

The Ad Hoc Group has not undertaken for this report a new evaluation of the theoretical detection capabilities of selected networks of stations. For the evaluation to be a significant improvement on that presented in CCD/558, it would require comprehensive data on seismic noise c nditions, signal levels, data communications performance and other factors at each of the stations. All countries are being encouraged to assemble this type of information for their stations and deposit it with the Secretariat of the Conference on Disarmament. A list of stations for which comprehensive seismic noise data are now available is given in Appendix 3C. A new method for network capability estimation, using simulated earthquake data, has been introduced to the Ad Hoc Group and is of methodological importance.

The Ad Hoc Group recognizes the value of theoretical network capability estimates, but at the same time agrees that these cannot provide a comprehensive assessment of the capabilities of a global system. Therefore, the need for a comprehensive experimental exercise, first expressed in CCD/558, continues to be recognized.

CHAPTER 4

Level I data extraction

Summary

The Ad Hoc Group has reviewed several national investigations addressing the Level I parameter lists proposed in CCD/558 and CD/43. As a result of these studies, the Group believes that a number of new parameters could be added as being useful for an international seismic data exchange. However, the final list of parameters will be established only after a comprehensive experimental exercise as proposed in CCD/558.

National investigations have shown that existing methods for Level I data extraction can impose a heavy work load on participants in an international data exchange. The Ad Hoc Group notes that promising results, which might lead to a reduction in the work load, have been achieved using automatic procedures, but recognizes that this is a difficult problem. The Group considers that further research in this area is needed. Here it is understood that the participating stations in the proposed global system would be equipped with digital recording devices.

Interactive processing has proved very valuable in the analysis of seismic records, and further studies should be conducted. A reasonable aim is to attempt to minimize the number of intermediate decision points in the interactive process, thus approaching the goal of automatic parameter extraction. The Ad Hoc Group believes that standardization of the interactive process is important and should be investigated.

The Ad Hoc Group takes note of the recommendations adopted by the International Association of Seismology and Physics of the Earth's Interior (IASPEI) during its assembly in Canberra, Australia, in 1979, regarding instructions for measuring amplitudes and periods for magnitude determinations (Appendix 4C). The Group recommends that these standards should form the basis for such measurements within the global system, and that automatic procedures to analyse signals be designed according to these standards.

Promising results have been reported on the use of techniques for Level I data extraction such as polarization filtering and high-resolution wave-number analysis of data from small arrays. The Ad Hoc Group recommends that studies of these and other advanced methods be pursued further.

4.1 Introduction

In CCD/558, Level I data were defined as a set of parameters characterizing a seismic waveform that should be extracted at each station within the global network for all detected seismic events. These data should thereupon be rapidly transmitted to International Data Centers for compilation, processing and dissemination. The set of Level I parameters given in CCD/558 comprises eight measurements in the case of weak events and 52 measurements in the case of strong events.

The experience acquired so far through national investigations and co-operative studies aimed at scientific and methodological principles of a possible comprehensive experimental exercise of a global system in the field of Level I data extraction relates mainly to the following groups of problems:

(a) Improvement of procedures to obtain Level I data and of instructions for a comprehensive experimental exercise

(b) Development of scientific and technical aspects of the automatic extraction of Level I data

(c) Interactive procedures for parameter extraction using graphic systems.

A summary of these contributions is given in the following. Further details on the national investigations are presented in separate appendices.

4.2 Instructions and specifications for Level I data

The procedures to obtain Level I data at analog and digital stations were defined in detail in CCD/558 and CD/43. Several national studies (Appendix 4A) as well as one international experiment have been carried out to elaborate these procedures. The purpose of the international experiment - proposed and organized by one of the participating countries in the Ad Hoc Group - was to create a common comprehensive and high quality data base containing both Level I and Level II data. During this Common Data Base Experiment (CDBE) Level I data were reported from 101 stations for the period 1-15 October, 1980. However, compared to the total number of approximately 50 Level I parameters, it was suggested that the number be reduced to approximately 10 for this first international experiment. In general, the instructions and specifications to obtain Level I parameters proved to be well defined. The presently available experience indicates a heavy work load imposed by the measurement of Level I parameters if carried out manually. However, the experience gained from the limited experiments which have been conducted is not sufficient to estimate the time needed for Level I data extraction as compared with the present standard operation of seismic stations.

At this stage some amendments and revisions of the proposed procedures in the previous report (CD/43 - chapter 3 and corresponding appendix) have been agreed to by the Ad Hoc Group. These technical specifications are given in a revised version of technical instructions for extracting Level I parameters at seismic stations in Appendices 4B and 4C. In particular, inclusion of the T-phase (see Chapter 3) in the parameter list has been agreed.

Furthermore, an abbreviated form of reporting large earthquake sequences has been proposed. However, additional efforts are needed to develop methods for properly reporting the large number of signals which result from strong earthquake sequences and swarms.

4.3 Development of scientific and technical aspects of the automatic extraction of Level I data

In its second report (CD/43) the Ad Hoc Group considered automatic extraction of seismic parameters a desirable goal and recommended further work in this field with the aim to develop standardized procedures. Such automatic extraction requires a data format suitable for computer processing and would therefore in practice only be applicable for seismic stations with digital data recording. Besides the important effect of time reduction, the main advantage of automatic processing of seismic data is a reduction of subjective factors in the evaluation procedure. Any automatic extraction of Level I parameters requires equivalent algorithms at all participating stations. The choice of these algorithms is of great importance in this context.

The Level I parameters are based on the analysis of short- and long-period seismograph records. In automatic processing a prefilter can be applied to generate a set of unified transfer characteristics for various existing seismographs. This results in an improvement of signal-to-noise ratio for small events or in an enhancement of spectral amplitudes in conventional SP- and LP-band for the standardized measurements of periods and amplitudes.

The correction for the amplitude response used in the determination of spectral parameters in the time domain by manual measurements is only approximate. The same is true for the correction of arrival times due to phase- or group-delay time. In an automatic procedure digital filters can produce precise and compatible results for all seismic stations. Preprocessing of this kind is highly appropriate to standardize the data analysis. In principle most of the Level I parameters can be extracted automatically, but experience in this field is still limited.

Until now no experiments have been reported to the Ad Hoc Group in which the whole set of Level I parameters has been extracted automatically. At the present stage, interactive procedures using graphic systems (section 4.4) appear to be more practicable. However, promising experiments have been conducted at some stations regarding the automatic extraction of a few basic parameters (Appendix 4D).

4.4 Interactive procedures using graphic systems

Interactive processing provides an analyst with efficient means to comprehend his data base, to direct a computer in its operations upon that data base, and to examine the results - all within a short time interval. The principal advantages of interactive processing are:

(1) it reduces the waiting time between intermediate processing steps, thus increasing productivity;

(2) it provides an efficient means to retain human judgement in the analysis loop, and thus avoids problems inherent in fully automating analytical decisions.

Interactive processing is particularly suited for applications characterized by a series of sub-processes with intermediate decision points. The seismic signal analysis associated with Level I parameter extraction belongs to this class of problems. Typical intermediate decision points are:

(a) data quality control, elimination, or correction of bad data segments;

(b) rapid visual control of detection/non-detection decisions on individual signal traces;

(c) alignment of signal traces in a location procedure;

(d) selection of bandpass filters or matched filters;

(e) selection of signal peaks for amplitude and period measurements;

(f) selection of a time window for computing parameters such as seismic noise level, signal complexity and spectral ratios.

In addition, several more sophisticated Level I parameters can be extracted by interactive processing. Examples include the spectral analysis (measurement of amplitudes at 10, 20, 30, 40 seconds) and the identification of later phases.

As part of national investigations Interactive Remote Seismic Terminals (RST's) have been developed. The RST's are microprocessor-based systems which, in addition to providing data communications with an international data centre can be used in the preparation and interactive analysis of data from seismic stations. It is clear that using an interactive terminal for seismogram analysis is different from those procedures discussed in earlier reports of the Ad Hoc Group. However, this concept represents an example of the new technical opportunities available for the automatic extraction of Level I data under visual control of a seismologist.

National investigations reported to the Ad Hoc Group, as summarized in Appendix 4E, have confirmed that interactive processing is indeed a useful tool in the Level I data analysis at seismograph stations.

4.5 Implications for the global system

Level I parameters

The Ad Hoc Group believes that a number of new parameters could be added as being useful for an international seismic data exchange. However, the final list of parameters will be established only after a comprehensive experimental exercise as proposed in CCD/558.

Mode of processing

The Ad Hoc Group maintains the goal that automatic procedures, supplemented by visual inspection, should be developed for parameter extraction at the stations. However, no satisfactory automatic processing system has as yet been demonstrated, and further research in this area is therefore needed.

Interactive processing has proved very valuable in the analysis of seismic records, and further studies should be conducted. A reasonable aim is to attempt to minimize the number of intermediate decision points in the interactive process, thus approaching the goal of automatic parameter extraction. The Ad Hoc Group believes that standardization of the interactive process is important and should be investigated.

The Ad Hoc Group takes note of the recommendations adopted by the International Association of Seismology and Physics of the Earth's Interior (IASPEI) during its assembly in Canberra, Australia, in 1979, regarding instructions for measuring amplitudes and periods for magnitude determinations (Appendix 4C). The Group recommends that these standards should form the basis for such measurements within the global system, and that automatic procedures to analyse signals be designed according to these standards.

Additional analysis techniques

Promising results have been reported on the use of techniques for Level I data extraction such as polarization filtering and high-resolution wavenumber analysis of data from small arrays. The Ad Hoc Group recommends that studies of these and other advanced methods be pursued further.

CHAPTER 5

Exchange of Level I Data through the WMO/GTS

Summary

Two trial exchanges of abbreviated Level I data using the WMO/GTS have been conducted with broad participation of countries represented in the Ad Hoc Group. Although some technical problems have been encountered, the results from the experiments have shown that the WMO/GTS has the potential of fully satisfying the aims of rapid and undistorted transmission of Level I data for the proposed global system. At many remote places, he WMO/GTS offers the only practical communication mechanism for rapid transm ssion of Level I data.

An additional technical test which has been conducted between five countries has shown that the GTS can handle large volumes of Level I data without problems.

The Ad Hoc Group sees the need for additional technical tests using the WMO/GTS to test further aspects of the possible international exchange of data, especially the complete set of Level I parameters. The dissemination of seismic bulletins from data centres also needs further testing. Noting that no significant experience has been obtained regarding transmissions from Africa, Antarctica and South America, the Group considers it important that additional experiments include participation from these continents.

The WMO has authorized the use of the GTS for the exchange of Level I seismic data on a regular basis from 1 December 1983. The Ad Hoc Group considers it essential that up-to-date information on improvements and changes to the GTS be readily available; therefore, it is recommended that the Secretariat of the Conference on Disarmament make arrangements with the Secretariat of the WMO to receive regular advice on this matter.

The Ad Hoc Group has noted the advice of the WMO that significant improvements in transmission can be expected only if the GTS is used on a more regular basis. Some countries are already doing so. However, the Group notes that regular use or participation in more extensive tests of the GTS poses organizational problems for some potential participant States.

The Ad Hoc Group considers it important that the format of Level I data be kept consistent with the International Seismic Code currently in use, and recommends that a close liaison be maintained with international seismological agencies in order to co-ordinate future elaborations on the format for Level I parameters.

5.1 Introduction

In its reports CCD/558 and CD/43, the Ad Hoc Group recommended the use of the Global Telecommunication System (GTS) of the World Meteorological Organization (WMO) for the rapid exchange of Level I data within the proposed global system. These reports also specified the parameters to be exchanged as well as the format - the "International Seismic Code" - suitably expanded to handle many additional parameters. Some basic features of the WMO/GTS are presented in Appendix 5A, and additional information relevant to the Group's work is contained in Appendix 5B.

In view of the large number of Level I parameters to be transmitted and the short time delays imposed, the Ad Hoc Group has considered it essential to conduct practical tests in order to obtain familiarity with the use of the WMO/GTS for this purpose. Two trial exchanges have been conducted with broad participation of countries represented in the Ad Hoc Group. An additional test with limited participation has also been carried out. Results and recommendations from these technical tests are presented in the following, and summaries of national contributions are presented in Appendix 5C.

5.2 Review of results from co-operative technical tests

5.2.1 The first GTS trial exchange, October-November 1980

Fourteen countries participated in the first trial exchange, which took place from 6 October to 28 November 1980. The exchange was planned from the outset to impose minimal strain on national seismological stations and GTS centres, as in some places the addition of extra loads could cause problems. Therefore no attempt was made to impose Level I type loads or to invoke special error-detection techniques in the communication system.

The main objectives of the first trial were to extend the transmission of messages globally, in order to expose more seismological centres to the GTS and vice versa. The results may be summarized as follows:

- The trial met its general objectives, and has led to permanent improvements in facilities in some countries. On the other hand, this first trial caused some unexpected strains in existing systems for the routine exchange of seismic data.

- Access to and use of the WMO/GTS for the transmission of seismic messages were achieved without problems except in a few places; however, messages were lost in many transmissions, and altered in a few.

- Messages were often received more than once, thereby increasing the load. This arises in the GTS because seismic messages are broadcast, and some places are at the ends of loops in the GTS.

- The first trial exposed some deficiencies which should be eradicable by including elementary checking procedures on the seismic side. The error-detection safeguards in the GTS cannot be used in this connection because they are applied only in periodic system tests and not in day-to-day operations.

5.2.2 The second GTS trial exchange, November-December 1981

Twenty-one countries took part in this trial, which was conducted between 2 November and 11 December 1981. However, two of the countries were not included in the list given to the WMO Secretariat and so GTS nodes were not notified, and most of their messages were not circulated globally. Nearly all messages from one other country also failed to circulate, so the results reported here are based on only 18 countries.

To avoid some of the problems encountered in the first trial, objectives and procedures were laid down during informal workshops and recorded in a set of guidelines on the experimental use of the WMO/GTS.

The objectives were:

- To obtain further experience with GTS procedures and to establish the necessary local connections and practices.

- To determine the effectiveness of the GTS as a communications medium, in terms of successful message transmissions and of error-rates in the characters within messages.

- To determine the transit-times for messages between seismological centres.

The principal findings of the trial were:

- Detailed arrangements with both the WMO/GTS Secretariat and local GTS centres must be made at least three months, and preferably six months, in advance. GTS procedures and instructions must be adhered to exactly.

- Messages were received at a 95 per cent success rate on a few long distance circuits, but the result over-all was lower. Some losses occurred because of seismic or GTS operator errors at the internal (national) level; others could be attributed to manual procedures; a few were traced to actual outages of GTS channels; but a significant number of messages disappeared at or between GTS hubs for undetermined causes.

- Future trials or regular operations should invoke procedures for immediate checking of outgoing messages (at the national level), and for requesting repeat transmissions (at the international level).

- The error rate was about 1 in 2,000 characters but this needs to be determined more accurately in subsequent trials. Some of the errors were obvious (e.g., a letter instead of a number), and the GTS is probably satisfactory in this regard.

- Transit times were generally less than an hour - often only a few minutes - but occasionally up to a few hours on some circuits. These times are mostly satisfactory for an exchange of seismic data.

In assessing the results of this trial it should be borne in mind that some parts of the WMO/GTS do not possess equipment capable of recognizing seismological messages. Consequently transmission failures tend to be higher in these places.

Taking into account all the data received in the course of the trial and the above-mentioned recommendations on the organization of seismological data exchange and on furnishing all the WMO/GTS channels with the necessary technical equipment, in the opinion of the Group the system will be capable of satisfying all the requirements as regards the operational and reliable transmission of Level I data for the purposes of international exchange of seismological data.

5.2.3 The multilateral GTS technical test, October-November 1982

Five countries participated in this limited exchange, which took place from 25 October to 7 November 1982. The objectives were twofold, i.e., to test the performance of the GTS when exposed to a heavy transmission load of seismic data, and, secondly, to develop procedures for data centres to handle large data inflows from the GTS while concurrently engaging in the preparation and transmission back through the GTS of preliminary event lists.

Synthetic Level I data were generated for a network of 68 stations and arrays for a 14-day interval. National seismological centres in three countries transmitted daily messages on the WMO/GTS to experimental data centres in two other countries. Procedures established for the two earlier trials were used.

From the communications aspect, the results were:

- Although the volume of data far exceeded that of the previous trials, no loading difficulties arose on the GTS.

- A much higher percentage of messages (97 per cent) was received, and most losses probably occurred at the origins.

- Only one participating country could respond quickly to retransmit requests made via the GTS, and the need for this capability was re-emphasized.

5.3 Implications for the global system

Format for Level I data

The International Seismic Code approved by the WMO Commission for Basic Systems, can be readily adapted to handle the extra parameters recommended as Level I data. It is likely that many national centres which would provide seismic data for the global system, would also be the national reporting centres for earthquake location services. Therefore, it is worthwhile to devise one code which can be used for both purposes.

With these points in mind the question of formats has been discussed with the International Seismological Centre and the United States National Earthquake Information Service (NEIS) which have been collaborating on an improved seismic code. Some changes in the formats proposed in CD/43 have resulted, and the Ad Hoc Group recommends that a close liaison be maintained with these agencies in order to co-ordinate future elaborations of the formats for Level I parameters.

Organization of Level I data exchange

For the rapid global exchange of Level I data, the WMO/GTS continues to offer the only practical communication mechanism to many places around the globe which are remote. The regional distribution of GTS messages has the advantage of making all Level I data immediately available to all participating States. However, when needed, specific arrangements are possible for channelling seismic data from stations, or national seismic centres, to International Data Centers only.

The trials provided useful practical experience of the use of the WMO/GTS channels, but the success rate for the transmission of Level I data is still not satisfactory. Procedures should be developed independently of the WMO/GTS to ensure that messages leave national facilities in the correct form and that they are received in time by international centres. Certain measures are also necessary within the WMO communications system itself in order to adapt it for the purposes of the transmission of seismological data.

Message transit times were mostly acceptable. Although the error rate seemed to be sufficiently low, this needs further testing.

No significant experience has been obtained from Africa, Antarctica or South America; additional technical tests should include participation from those continents and should also test the transmission of bulletins from data centres.

The WMO has authorized the use of the GTS for the exchange of Level I seismic data on a regular basis from 1 December 1983 (see Appendix 5B). The Ad Hoc Group considers it essential that up-to-date information on improvements and changes to the GTS be readily available; therefore, it is recommended that the Secretariat of the Conference on Disarmament make arrangements with the Secretariat of the WMO to receive regular advice on this matter.

A number of national investigations have indicated that existing technology offers several supplements to the WMO/GTS for rapid transmission of Level I data between national facilities and International Data Centers. As stated in CD/43, the general use of the WMO/GTS for Level I seismic data should not preclude the supplementary use of other communication systems where these can provide efficient means of bilateral data exchange. The Ad Hoc Group notes that the WMO/GTS is in the process of rapid development.

CHAPTER 6

Exchange of Level II data

Summary

In the proposed global system, Level II data will be exchanged, upon request, between government-authorized national facilities through International Data Centers. Some national investigations have shown that rapid exchange of Level II data in digital form can be achieved using modern telecommunications facilities without any particular restriction on the amount of such data that might be requested.

In the proposed system for global data exchange, any Level II data from individual stations designated as participating in the global network should be exchanged upon requests made from a government-authorized National facility through an International Data Center.

The Ad Hoc Group agrees that a precise estimate of the amount of Level II data that might be requested can be given only after sufficient experience has been acquired from a comprehensive experimental exercise as proposed in CCD/558.

Preliminary formats for digital Level II seismic data on magnetic tape have been considered. In future consideration of such formats, possible IASPEI recommendations should be taken into account. Formats for the exchange of such data by telecommunications channels need to be further developed, but should follow the magnetic tape standard as closely as possible.

Level II data should be exchanged as rapidly as practical, the rapidity will depend on precise procedures which have to be agreed upon. The Group notes that it will be necessary to take into consideration the practical telecommunications conditions particular to each participating country.

The Ad Hoc Group recommends that further investigations be made of possible formats and methods for Level II data exchange at the request of participants in connection with the preparations for the comprehensive experimental exercise proposed in CCD/558.

6.1 Introduction

In CCD/558, Level II data were defined as data (mostly waveforms) that would be requested by States participating in the international data exchange for events of special interest. These data, which would be much more voluminous than the Level I data, would be needed for the detailed analysis of such events, and do not depend so critically on rapid communication.

In the proposed system for global data exchange, any Level II data from individual stations designated as participating in the global network should be exchanged upon requests made from a government-authorized National facility through an International Data Center.

Just a few years ago there were no practical alternatives to the postal system as a means for exchanging Level II data. Notable exceptions here were some large aperture seismic arrays and networks where seismic waveform data in digital form were transmitted via telephone lines and/or microwave over

considerable distances as early as in the late sixties. Recent advances in communication and microprocessor technology imply that at least in principle rapid exchange of Level II data in digital form between government-authorized National facilities through International Data Centers within the global seismograph network should now be possible. However, at present few countries have technical facilities available at their seismograph stations to accommodate such Level II data transmission. Furthermore, for the purpose of a comprehensive experimental exercise of the global system, it is not essential that all stations be capable of rapid transmission of Level II data in response to requests.

Recent national investigations regarding Level II data exchange (Appendix 6A) have focused on the formats of the data to be exchanged and on the potential for utilizing recent advances in communications technology to achieve rapid and reliable data transmission. In this chapter the various means presently available for data exchange over large distances will be presented and the question of how best to utilize these systems for Level II exchange will be discussed.

6.2 Specification of Level II data

As earlier reported in CCD/558 and CD/43, the Ad Hoc Group envisages the need for exchanging different types of waveform data, since the global network will be composed of stations with different instrumentation and data recording equipment.

6.2.1 Analog recording systems

Each contributing station of the analog type in the global network should ensure continuous recording of all individual seismograph components. Also, each station should be equipped with a camera in order to obtain microfilm copies of the seismograms. Quite commonly, a seismometer calibration pulse is inserted in the seismogram, so in case of a request for an analog recorded event, it would be necessary to include with the record the appropriate information on calibration and time correction. (More detailed information of calibration standards is given in Appendix 5.2 of CD/43.)

6.2.2 Digital recording systems

Here we differentiate between standard stations, broad band stations and arrays, and the respective recorded data volume would be

- Standard stations: One 3-component short period instrument set with minimum 20 Hz sampling rate. Occasionally, such stations may be equipped with only a vertical seismometer. Additionally, a standard station might include a 3-component long period instrument set with 1 Hz sampling rate.

- Broad band stations: Same data volume per unit time as for standard stations.

- Seismic arrays: Data volume per unit time generally proportional to the number of array elements. By agreement, beams could be transmitted in addition to, or instead of, single sensor traces.

The basic advantage of digital recording in addition to high dynamic range and flexible time resolution is that the data can be fed directly into a computer which in turn permits flexible and sophisticated analysis of the

recorded seismic signals and also easy transfer of such data to other computers in other countries. Only a few years ago digital seismological recording systems were rather uncommon, but recent advances in microprocessor technology are rapidly making such systems more widely available. Within a few years most, if not all, of the stations of potential interest to the global network are likely to have digital recording systems.

6.3 Means of Level II data exchange

There are many well-proven means available for exchange of Level II data, although which to choose may be somewhat dependent on local conditions, that is, the extent of postal, telephone and datalink services available within a specific country. A distinction is made between the exchange of seismic event records in analog and digital form, respectively.

6.3.1 Analog records

Analog records containing the waveforms of a requested event would be in the form of seismograms, or photographic copies of such.

Postal system: Level II data in analog form could conveniently be exchanged by means of the postal system, which has been and is still extensively used for this purpose by the seismological community. While this type of transfer service is globally available, it is not considered particularly speedy as delivery times of letters and small parcels are of the order of at least one to two weeks between countries on different continents. However, in this respect advantages should be taken of express air mail and similar types of special delivery services, as this would reduce delivery times to at most a few days.

Facsimile transmission: The essence of this system is that a "picture" of the seismogram containing the Level II data is sent via ordinary telephone lines, linking appropriate coding devices both at the sender and receiver ends. The service is very speedy compared to mail; just a matter of minutes. New developments here include the possibility of digitizing seismogram traces.

6.3.2 Digital records

Level II data in digital form can be exchanged principally in two ways: either through the postal system or by use of various telecommunication services.

Postal services: The same comments apply here as in the case of exchange of data in analog form. The only difference is that the copy of the original waveform data in digital form would be on magnetic tape, diskette or similar media, for which the postal handling would pose no problem.

The WMO/GTS data transmission network: In addition to Level I data also Level II data can be transmitted over the WMO/GTS network, and this has been demonstrated by national experiments. The Ad Hoc Group takes note of the document submitted to it by the WMO (Appendix 5B), where it is stated, inter alia: "It should be borne in mind that the GTS should not be used to exchange the much more detailed seismic Level II data."

However, as stated by the WMO representative, further study can be done if necessary, on a national level or on a bilateral basis between countries concerned in order to seek a future possibility of the exchange of Level II data on the GTS.

The question of the possibility and feasibility of using the WMO/GTS network for the transmission of Level II data at the request of participants may be reconsidered in co-operation with the WMO. The final resolution of this question would await the results of the comprehensive experimental exercise proposed in CCD/558.

International telecommunications services: A discussion of the various options available for use of international telecommunication for the exchange of digital Level II data is given in Appendix 6B. In summary, these options comprise:

(a) International telephone services: National investigations have shown that Level II data can be exchanged internationally by dial-up telephone connections, using a simple microprocessor-based computer system. In practice, the efficiency of such transmission would depend upon the quality of the telephone lines.

(b) Dedicated data links: Such data links can be established, e.g. by land lines or via existing communication satellites, and are capable of handling large volumes of data with high reliability. Dedicated data links are utilized most effectively for data transfer on a continuous basis.

(c) Digital data networks: Such networks are being established in many countries, and some of these have been connected internationally. Where available, digital data networks would provide an efficient and reliable means of Level II data exchange, but global availability of such services is at present far from being realized.

(d) Special-purpose satellite systems: An example of such a system is INMARSAT, which has been developed for maritime communication, using small receiver/transmitter units with direct transmission to satellites. Such a system would be very suitable for Level II data transmission from remotely located seismic stations, but its use would require special permission from its international governing council.

In summary, there are numerous options available for digital Level II data exchange by telecommunication channels. In this connection, the Ad Hoc Group notes that it will be necessary to take into consideration the practical telecommunications conditions particular to each participating country.

6.4 Requests for Level II data

As stated in CCD/558, any participating State can request Level II data in accordance with agreed procedures. Such requests must be channelled through one of the International Data Centers. The data that might be requested to supplement the Level I data routinely transmitted to International Data Centers would basically comprise:

- Supplementary Level I data confirming a detection or non-detection at a specific time.

- 120 sec of short period data for a given time interval (including 30 sec of noise preceding the predicted or actual P wave onset). Longer records could be supplied on request, according to agreed procedures.

- For long period data, the time interval should include 5 min of noise preceding the predicted or actual P wave onset and be long enough to ensure adequate recording of surface waves in each case.

Data recorded by broad band instruments would be of the same volume as short period data. However, if only the long period band is required, the broad band data could be filtered and resampled to give the same amount of data as in the long period case.

Preliminary formats for digital Level II seismic data on magnetic tape have been considered. In future consideration of such formats, possible IASPEI recommendations should be taken into account. Formats for the exchange of such data by telecommunications channels need to be further developed, but should follow the magnetic tape standard as closely as possible. For analog data, the seismogram copies should be available in a standardized form on photographic chips, including fixed formats for station identification, instrument calibration parameters and timing corrections.

The rapidity with which requested Level II data are transmitted will depend on procedures which have to be agreed upon. In general, it is desirable to achieve digital Level II data exchange through the use of high-speed communications circuits established between the government-authorized National facilities and an International Data Center.

Each station, on request through an International Data Center, should produce copies of the requested data in digital form on magnetic media (for digital stations), or in the form of photocopies of recordings (for analog stations). Copies of such data should reach the requesting State within two weeks after copying at the IDC.

6.5 Implications for the global system

The significant developments in telecommunications and computer technology that have taken place in recent years offer possibilities, in case of future need, for the use of other types of links for improved Level II data exchange at the request of participants in addition to the WMO/GTS. The Ad Hoc Group considers it important that the impact of these developments, in particular improvements to the WMO/GTS, continue to be assessed within the framework of national investigations. The Ad Hoc Group agrees that a precise estimate of the amount of Level II data that might be requested can be given only after sufficient experience has been acquired from a comprehensive experimental exercise as proposed in CCD/558.

Exchange of Level II data will be a rather complex operation and will require agreement on certain operational arrangements. In this connection, it will be necessary to take into account the practical conditions particular to each country.

The Ad Hoc Group recommends that further investigations be made of possible formats and methods for Level II data exchange at the request of participants in connection with the preparation for the comprehensive experimental exercise proposed in CCD/558.

CHAPTER 7

International Data Centers

Summary

A number of national investigations have been conducted regarding the organization of International Data Centers (IDCs) and the data processing that would be performed. Experimental data centres have been established by some countries and some large-scale experiments have been conducted to test and develop procedures for data handling and analysis. These efforts and their implications for a global system are summarized in this chapter. A "Preliminary Operations Manual for International Data Centers" has been developed, giving a detailed outline of the operational procedures to be followed at such centres. The manual is annexed as an integral part of this report (Appendix 7). Certain aspects of the procedures developed in this annex should be tested and updated further.

Preliminary results have been obtained using automated procedures for Level I seismic data analysis in the International Data Centers to be established for the proposed global system. The experts of the Ad Hoc Group agree that automatic Level I data processing in the IDCs is one of the most complex problems for the proposed global system. Results of national investigations indicate, however, that in principle it is possible to solve this problem. The Ad Hoc Group recommends that further research into automatic processing at data centres be given high priority.

National investigations carried out by some countries have shown the effectiveness of the use of Level II data at national centres in obtaining more accurate focal parameters of events presenting an interest.

Some modifications to the procedures described in the Group's earlier reports have been agreed to. The procedure to be used for event definition should take into account a larger number of seismic phases than suggested in CCD/558 and CD/43. Further research efforts are needed to improve the accuracy of epicentre location and, most urgently, of event depth estimation. This might be achieved by using globally compiled local travel time data and also by using joint hypocentre estimation techniques. An increased use of depth phases seems, however, to be the most important step here.

Certain national investigations have shown that the more detailed analysis of information at stations of the global network (Level II data), for example with the help of polarization analysis, provides greater effectiveness in the identification of depth phases.

Procedures and formulas should be established to estimate short period and long period magnitudes from local recordings. Magnitude estimation procedures should include individual station corrections and the use of noise data for non-detecting stations. Increased effort should be given to the reporting and analysis of long period surface waves, since experiments have shown that surface wave observations can be obtained to a much greater extent than previously experienced.

Efforts should be made to increase the amount of preliminary location data from array stations and of estimates of arrival directions for long period surface waves.

Effective procedures need to be developed for receiving, copying, storing and distributing copies of Level II data to participating States which have made a request in connection with an event of interest.

7.1 Introduction

In its report CCD/558, the Ad Hoc Group recommended that International Data Centers (IDCs) be established for the proposed global system. Their purpose would be to collect, process and distribute seismic data for the use of participant States, and to act as a documentation centre.

A number of national investigations have been conducted regarding the data processing that would be performed and the organization of such centres. Experimental data centres have been established by some countries and large-scale experiments have been conducted to test and develop procedures for data handling and analysis. These efforts and their implications for the global system are summarized in the following sections. A "Preliminary Operations Manual for International Data Centers" has been developed, specifying the operational procedures at such centres. The manual is annexed as an integral part of this report in Appendix 7.

7.2 Description of procedures to be used at the envisaged International Data Centers

7.2.1 Analysis of short period data

Association of arrival times and event definition

National investigations have shown that preliminary epicentre locations by array stations, even of small aperture, are valuable for the association of arrival times and for the definition of new events. These experiments demonstrate that such array location estimates (reported as azimuth and slowness) can substantially increase the quantity and quality of defined events. The output of polarization filtering and waveform analysis at stations of the international network to improve phase identification has also been shown to be valuable in the association process at data centres.

A national investigation has defined criteria for classifying observed and reported phases as "local", "regional" or "teleseismic". Such descriptions would be valuable at International Data Centers for event definition and phase association.

National data centre experiments performed on both synthetic and real data clearly show that the output of presently used automatic association procedures can be improved by analyst interaction. Such manual interaction therefore seems necessary to obtain a high quality seismic bulletin, at least until the automatic procedures have been further improved.

A great number of so-called PKP phases are regularly observed and reported from seismic events, and national investigations have shown that such phases could be useful also for the definition of seismic events at data centres.

Location

Comparison of various location algorithms used today shows that they give fairly consistent results.

Extensive use of stations at local distances requires detailed local travel time-tables. Such data have been presented from certain regions but have not yet been compiled on a global scale. These tables are essential for accurate event location and need to be organized for use at International Data Centers.

Depth estimation

Focal depth is still the most uncertain source parameter for most seismic events. Improved depth estimates could substantially reduce the number of events for which questions of origin might arise. Experiments show that more extensive use of depth phases could be a promising way to reduce these uncertainties. National investigations also show that the problem of improving depth estimation can be resolved both through the use of the traditional method based on an iterative search for minimum errors and on the use of depth phases. It is recommended that further investigations should be carried out to permit the effective automatic identification of depth phases at stations on the basis of Level II data.

Short period magnitudes

Short period magnitude estimates obtained from recordings at local and regional distances could be of great importance. Formulas for the estimation of such magnitudes have been presented, together with amplitude-distance curves for local and regional distances for certain regions.

National investigations also suggest that the use of individual station corrections and of a procedure that takes into account both the observed signal values and the noise values of those stations which have not detected the event increase the consistency of magnitude estimates. However, the question of noise-based magnitude evaluation at stations which have not recorded a given event has not yet been studied in all its aspects.

Unassociated short period data

In the national studies presented to the Ad Hoc Group it has been observed that about half of the reported Level I observations could not be associated with any located event, and also that about half of the unassociated phases are reported as "local". The experiments have also shown that a substantial amount of the remaining unassociated arrivals could be clarified with the adoption of the criteria mentioned under paragraph 7.2.1 for classifying observed phases as "local", "regional" or "teleseismic".

The question of the number of unassociated arrivals and the number of local events is extremely complex, as the number of unidentified signals depends heavily on the area in which the stations are located, and such evaluations can be carried out only in the process of a comprehensive experimental exercise as proposed in CCD/558.

The Ad Hoc Group considers that in the future methods may be developed for the classification of unassociated arrivals as "local", "regional", or "teleseismic".

7.2.2 Analysis of long period data

Association of long period data with located events

Only a limited number of experiments using long period data have been conducted. These experiments have been dealing only with long period surface waves and not with long period body waves.

Arrival direction of surface waves as estimated from the amplitude ratio of the horizontal components, a parameter not included in Table 3.2 of CD/43, has proved very valuable in the association of surface waves at date centres.

National experiments involving systematic analysis of long period data (reported Level I data as well as digital Level II data) have shown that long period surface wave observations can be obtained to a much greater extent than previously experienced. Experiments show that such data could be obtained for most of the events that were defined and located using short period data. Long period surface wave data have also been obtained from a number of events from which no short period data have been observed. Surface wave data could thus be used to define and locate new events, although the accuracy of such locations would be inferior to that obtained when short period data are available.

Unassociated long period data

In CD/43 long period data were regarded as unassociated if they could not be matched with short period observations. As mentioned above, events can also be defined and located from long period surface waves alone. If one accepts such "LP events", the number of unassociated long period surface wave data becomes quite small.

Surface wave magnitude estimates

In the experiments conducted, surface wave magnitudes, M_s, and upper bound estimates of such magnitudes have been computed using the procedure described in CD/43 and no special problems have been encountered. At distances less than 20 degrees no magnitude formula has so far been suggested for general global application. However, for several regions, e.g. Europe, Asia and North America, such formulas have been developed and successfully applied in routine practice for distances less than 20 degrees.

7.2.3 Level II data

As part of national investigations, experimental computer systems have been established with a demonstrated capability to efficiently handle and analyse Level II data from a global network of stations. A special exercise has also been conducted to collect experimental Level II data from about 35 existing stations. This experiment clearly demonstrated the usefulness of Level II data for analysis at national centres.

National investigations presented to and discussed in the Group concerning the use of requested Level II data at national centres showed that such data would

increase the accuracy of determination of epicentre location, origin time and depth of events of particular interest, and also improve the possibility of observing surface waves for such events, etc.

7.2.4 Organization of data centres and technical interaction between centres

During the national experiments conducted and in the discussion in the Ad Hoc Group the need has been seen for detailed specifications of the functions to be performed at International Data Centers to obtain a unified operation of such centres. Such specifications would include detailed description of the procedures and software to be used.

Only one experiment to test interaction between experimental data centres has so far been conducted. No particular problems are expected in the co-ordination of Level I data, once the necessary facilities and communications have been established. It has become obvious that IDCs must ensure that they have identical data from which bulletins are prepared so that the IDC bulletins are consistent.

7.2.5 Data volumes and equipment at data centres

Data files similar to those described in CD/43 have been established temporarily as part of national experiments, and no special difficulties have been encountered.

National experiments have shown that the amount of Level I data that has to be handled and analysed at a data centre is small in relation to existing computer capabilities and therefore does not pose any particular problem.

Experimental data centre facilities established as part of national experiments have demonstrated that there is no particular restriction on the amount of Level II data produced by a global network of stations which can be handled efficiently using computer hardware and software available today. It will not be possible to assess the precise volume of Level II data that individual States parties to the treaty will request through the International Data Centers until after the conduct of a comprehensive experimental exercise of the global system.

7.3 Implications for the global system

Previous reports by the Ad Hoc Group have defined in a preliminary way the technical procedures which are to be followed at the International Data Centers. The equipment and the approximate flow of data to the International Data Centers were indicated in the Group's reports in documents CCD/558 and CD/43. Under its third mandate, considerable technical material has been received by the Group, as presented in the preceding subsection 7.2, which provides additional information on these procedures and on the practical ways in which the International Data Centers should operate. Such procedures have been implemented in experimental data centres by some countries in order to gain practical experience.

On the basis of the technical and operational recommendations received by the Group and on the practical experience acquired so far, preliminary operational procedures for the International Data Centers have provisionally been agreed upon. These procedures are given in "Preliminary Operations Manual for International Data Centers", which is annexed to the report as Appendix 7. These procedures could be revised based on the results of future testing.

7.3.1 Functions of an International Data Center (IDC)

The functions of an IDC were described in CCD/558. The IDC operates as a service to countries to assist them in their national monitoring and therefore it processes data to define and locate events, to estimate focal depths and magnitudes and to associate identification parameters. However, it does not identify events.

The automatic association/location process is initiated to define the set of seismic events that best fits the existing set of Level I data or signal arrivals. The automatic process results in a preliminary event list with tentative event solutions, the arrivals associated with each located event, and the unassociated arrivals.

Each day a seismologist examines the event definitions prepared by the automatic association/location process, in order to ensure that they are of sufficiently high quality to be released. If the results of the automatic process are modified in any way, a complete description of the manual intervention will be included in the IDC bulletin. The resulting bulletin contains the IDC definition of each event. All event definitions appearing in an IDC bulletin are reviewed by a seismologist prior to release. The bulletin prepared at each International Data Center is distributed to the other International Data Centers for review and comparison, and also to other participants. A final bulletin is then prepared and distributed to all participants. The format and content of bulletins is specified in Appendix 7.

The final list of unassociated signals is also regularly prepared at the IDC and distributed together with the bulletin of events to all participants. All data received at an IDC are consolidated and stored in the IDC data archive as they arrive (Level I or Level II data) or as they are prepared (event lists and bulletins). Event lists and bulletins are routinely distributed to all participants. The Ad Hoc Group considers that requests for Level I and Level II data in the IDC archives should be satisfied within one week.

The procedures for requesting Level 1 and Level II seismic data will be elaborated within the framework of a future treaty.

7.3.2 Procedures for data analysis

Event definition

Chapter 6 of CD/43 and its relevant appendices briefly described the procedures suggested for event definition and location. Based upon national investigations, some principal concepts of International Data Center procedures have been developed further. The complete preliminary specifications of IDC procedures are provided in Appendix 7 and are in sufficient detail so that computer codes based upon the principles involved should provide an essentially identical bulletin given the same input data. Appendix 7 both clarifies and, in some cases, suggests changes to the procedures described in CD/43. These changes, where they are made, are designed to best implement the objectives laid down in section 6.3 of CD/43, stated as:

"The association of arrival times should be carried out in a way that maximizes the probability of defining new events."

Two new criteria for event definition and location are given.

The observations that may be used to define an event consist of certain specified phases and array measurements (slowness vector). The defining phases include P (in the distance range 25 to 100 degrees), PKP (initial branch DF only) together with P and S at distances less than 25 degrees (even in the absence of local travel time-tables).

One of the following criteria must be satisfied for event definition and location:

- Four or more defining observations, not all of which are PKP, at three or more stations (an array measurement is considered to be three observations).

- Two defining array measurements at two arrays more than twenty degrees apart in azimuth.

Residuals are also specified for the various defining observations. These may be changed by later agreement - those for local arrivals if local travel time-tables become available and those for array observations as accumulated experience indicates the precision of specific array sites.

The procedure to be used for event definition should thus take into account a larger number of phases, e.g., crustal phases at local or regional distances, PKP and LP surface waves, than suggested in CD/43.

The analysis of LP, broad band and SP data should be closely integrated so that all these data could be used jointly for event definition and location. These procedures should be developed, tested and implemented at the International Data Centers.

Although manual interaction is foreseen in the processing at data centres, attempts should be made to improve automatic procedures.

Epicentre estimation

Event definition and location is an integrated and iterative procedure defined in CD/43 and CCD/558.

Starting solutions for this procedure may be provided by:

(a) Array measurements of azimuth and slowness of a particular arrival;

(b) Using arrivals identified as "local", either from analyst comment, (S-P) times, or reported crustal phases. In such a case, the arrival time and the station co-ordinates may be used as an initial hypocentre;

(c) A combinational approach, whereby all possible sets of three (or more) arrivals are tested for potential events consistent with the arrival times.

Each such event hypothesis must be tested by searching for arrivals consistent with the initial location: all such arrivals are then passed to the hypocentral location program. If the solution converges, the event is acceptable provided that it satisfies the event definition criteria given above.

Further research efforts should be undertaken to improve the accuracy of epicentre location. A better physical understanding of the transmission properties within the earth could considerably improve the location accuracy routinely achieved today. Moreover, improvements would be obtained by using globally compiled local travel time data and also by using joint hypocentre estimation techniques and well located calibration events.

Local and regional travel time information should be compiled on as wide a scale as possible, taking into account information presented to the Group in national investigations. Such a compilation, along with the development of automated methods of using these data would significantly improve the accuracy of the events located by the International Data Center procedures.

Depth estimation

In view of the importance of focal depth estimates, special attention should be paid to accurate determination of focal depth.

Depth is provided from the hypocentral location algoritnm using the defining observations. If the depth provided by successive iterations falls outside the normal range of 0-720 km, the depth should be constrained to 33 km and marked in the bulletin.

In addition, depth should, whenever possible, be estimated using depth phases. An increased use of such phases seems to be a most important step.

Magnitude estimation

The magnitude estimation formulas and procedures to be used at teleseismic distances (defined in CCD/558 and CD/43) should include individual station corrections and adequate noise data at non-detecting stations. Procedures and formulas should further be established to estimate SP and LP magnitudes from local recordings. To estimate reliably local magnitudes on a global scale, a comprehensive set of such local and regional amplitude distance curves has to be compiled and integrated into the processing procedures at the International Data Centers. In order to use surface waves recorded at distances less than 20 degrees from the epicentre, it is recommended that additional efforts be made to improve the magnitude procedures for these short ranges and to implement them at the International Data Centers.

Identification parameters

Identification parameters such as complexity, spectral ratio, third moment of frequency, etc., may have been reported for a given arrival. Such information should be listed in the output bulletin. The meaning, if any, of multi-station averages of these parameters is unclear and such averages should not be computed unless specifically requested.

Level II data

According to CCD/558, the functions of the International Data Centers in connection with Level II data will consist of:

The transmittal of requests from individual States parties to the treaty to government-authorized National Facilities for Level II data from stations of the global network;

The collection of Level II data received from these government-authorized National Facilities;

The preparation of copies of requested Level II data;

The storing of requested Level II data in the centre's data bank;

The transmittal of Level II data to States so requesting.

In the course of the national investigations presented to and discussed in the Group, the effectiveness of such data was confirmed for improving the accuracy of the parameters of the foci of events of interest at the national level.

Procedures and equipment have been developed to receive, store and transmit Level II data, but further testing of these procedures is needed.

7.3.3 IDC services

Bulletin preparation

The main service provided by the IDC is the daily prepared bulletins. A preliminary event list containing essentially epicentre information is to be submitted with a delay of at most two days to encourage participating countries to report further data. The final joint IDC bulletin is submitted with a time delay of seven days and is prepared in two parts. The first is transmitted over the WMO/GTS and contains only event parameters. The second is mailed to all participants and is a complete bulletin, containing both basic and detailed information, as specified in CD/43. Form and content of these bulletins are given in Appendix 7. The centres also regularly compile a list of unassociated signals and distribute it together with the final event bulletins to all participants.

Data request

The IDC must respond to all requests in connection with data and information which may be received within the framework of the system for the international exchange of seismological data in accordance with special procedures which will be elaborated within the framework of a future treaty.

Response to these requests should be prepared in accordance with the following principles:

- in the absence of other instruction, Level I data will be in the format defined by CD/43 for WMO/GTS use, sorted by date and station;
- digital waveform data requested by a State will be in a format consistent with that specified in Appendix 7;
- analog waveform data will be distributed on paper, microfilm or similar media.

Data archives

The principal internal output of the IDC is its data archives. There are two principal archives: one for parameter data, and one for waveform data.

Parameter data can in turn be divided into the following basic types of data:

The parameters of the events located by the centre;

Calibration data from recording instruments and information from stations;

The parameters of signals reported from stations (Level I data).

Waveform data consists of copies of original records of longitudinal, transverse and surface waves on short-period, broad band and long-period instruments as requested by individual States in accordance with the established procedures. The specific format in which all these data are stored at the IDC bank will depend on the particular hardware and data management system in use, but standardization of data formats is strongly encouraged. The handling of waveform data will differ depending on whether it was received in digital or analog form.

Reports

Information on various aspects of the activities of the IDC will probably be of interest to participants. This can be summarized in report form as follows (more detailed information is given in Appendix 7):

- message and arrival summaries are published monthly and contain information on the messages received and arrivals reported from each contributor;

- data validation report is a quarterly published list of the differences between the archives at the subject IDC and at each of the other IDCs;

- bulletin reconciliation is a monthly published annotated list of the differences between the published Final Bulletins of the subject IDC and the other IDCs (the notations describe the reasons for the differences);

- data request log is a quarterly published log of the data requests received and satisfied;

- waveform archive summary is published annually, with quarterly updates, and is a guide to the current contents of the waveform archive.

7.3.4 International Data Center equipment and software

IDCs should be designed to carry out specified functions in an equivalent way. Preliminary instructions for procedures to be used and the bulletin to be produced at IDCs are specified in detail in Appendix 7. The equipment and software of the IDCs should be adequate for the rapid and accurate execution of the IDCs' functions.

In accordance with CCD/558 the Ad Hoc Group considers that there should be more than one international centre equipped with equivalent hardware and software. Each centre would be required to provide free and easy access to all facilities designated "international". Appropriate provisions will be elaborated within the framework of a future treaty.

It is necessary to further develop and test equipment and software for the operational processing at IDCs of large flows of Level I data, an automated data management system for the IDC data bank and methods for receiving requested Level II data, making copies of such data and distributing it to States so requesting.

CHAPTER 8

Conclusions and Recommendations

As observed in this report, significant and rapid developments have taken place in recent years regarding seismology and data processing techniques, and these developments are continuing. The Ad Hoc Group notes that the results can turn out to be useful for the further development of scientific and technical aspects of the co-operative global system described in CCD/558 and CD/43, as well as for the further elaboration of a comprehensive experimental exercise of that system.

The Ad Hoc Group notes with appreciation the recent decision by the WMO Ninth Congress that the WMO/GTS may be used for regular transmission of Level I data from 1 December 1983.

The Ad Hoc Group has worked out a preliminary plan for carrying out a further technical test in 1984 for the use of the WMO/GTS channels for the transmission of Level I data, and analysis of the results obtained. The Group recommends that this technical test be conducted as soon as the necessary preparations have been made.

The Ad Hoc Group reiterates its statement made in CCD/558 that it sees a need to conduct an experimental exercise relevant to the proposed system.

The Group has noted areas in which additional scientific and technical progress is needed, as discussed in Chapters 3 through 7 of this report. These aspects are summarized in the following:

Seismograph stations and station networks:

1. Stations that may participate in the global system should as far as possible be equipped with modern seismograph systems, preferably broadband with high dynamic range, capable of continuous recording of data in digital form. However, data from analogue stations, particularly in the southern hemisphere, would continue to be useful to the global system.

2. An agreed specification of standards for stations in the network requires further study.

3. It is essential that more high quality stations be established in the southern hemisphere for the purpose of improving the direction and location of seismic events in that region.

4. Efforts under way to establish the feasibility of ocean-bottom seismograph systems should be continued, as such stations could be a valuable supplement to land-based stations, particularly in the southern hemisphere.

5. The development of special systems for T-phase (hydroacoustic wave) detection should continue as these systems could significantly improve detection capability in the southern hemisphere.

6. All countries are encouraged to assemble comprehensive data on seismic noise conditions and signal levels at their stations and deposit this information with the Secretariat of the Conference on Disarmament.

Extraction of Level I parameters

1. Regarding the Level I parameter lists proposed in CCD/558 and CD/43 the Ad Hoc Group believes that a number of new parameters could be added as being useful for an international seismic data exchange. However, the final list of parameters will be established only after a comprehensive experimental exercise of the global system.

2. Promising results on the use of filter techniques for Level I data extraction from three-component instruments (e.g. polarization filtering) and from small arrays (e.g. high-resolution wave number analysis) have been reported. The Ad Hoc Group recommends that these studies be pursued further.

3. The Ad Hoc Group maintains the goal that automatic procedures, supplemented by visual inspection, should be developed for Level I parameter extraction at the stations.

4. It is recommended that further investigations should be carried out to permit the effective identification of depth phases by automatic methods at stations on the basis of Level II data.

5. The Ad Hoc Group recommends that methods be developed to accommodate reporting of large earthquake sequences and swarms.

Exchange of Level I data through the WMO/GTS

1. A large-scale technical test should be conducted to test: the exchange of the full set of Level I parameters; the GTS circuits in Africa and South America; the transmission of bulletins from data centres; and the use of message-checking procedures.

2. Routine use of the GTS should be expanded and should be monitored to make long-term assessments of performance (message losses, error rates, transit times).

3. It is recommended that the secretariat of the Conference on Disarmament establish regular contact with the WMO secretariat to be kept informed of changes to the GTS and its procedures.

4. The Ad Hoc Group should maintain a close liaison with international seismological agencies in order to co-ordinate proposals for changes of the format of Level I parameters and the International Seismic Code.

5. The global system should include procedures at International Data Centers to monitor incoming messages and request re-transmissions by national seismic facilities.

6. National procedures should include the simultaneous transmission of outwards messages from the GTS centre to the national seismic facility which filed them.

7. National seismic facilities should be equipped to exchange messages with national GTS centres by automatic means.

8. Preparation should be made of detailed instructions and guidelines for personnel of the stations and international centres of the global system and of the receiving and transmitting points of the WMO/GTS system for the future comprehensive experimental exercise of the global system.

Exchange of Level II data

1. Standard formats need to be agreed for digital Level II data on magnetic tape. Possible future recommendations by IASPEI should be taken into account.

2. Standard formats and procedures are also needed for the transmission, on request, of digital Level II data by telecommunications channels. The formats should follow the magnetic tape standard as closely as possible.

3. The Ad Hoc Group considers that further experiemental investigations on the rapid transmission, on request, of seismic Level II data should be undertaken, and that the impact on the Level II data transmission of future developments in telecommunication and computer technology should continue to be assessed.

International Data Center procedures

1. The Ad Hoc Group recommends that further research into automatic processing of Level I data to be received at International Data Centers be given high priority. This research would include:

- efforts to improve the accuracy of epicenter location and, most urgently, of event depth estimation;

- compilation as available on a global scale of detailed local and regional travel time-tables and organization of this information for use at International Data Centers;

- development of methods for the classification of unassociated arrivals as local, regional or teleseismic;

- development of surface wave magnitude formulas for epicentral distances less than 20 degrees for general global application;

- development of procedures for analysing long period and short period data in an integrated way to improve event definition and location.

2. The Group recommends that the preliminary operational procedures for use in International Data Centers as contained in Appendix 7 be tested and revised when practical experience is gained.

3. The Group considers that procedures and equipment developed for the reception, storage, and transmission of Level II data at International Data Centers need further testing.

List of Scientific Experts and Representatives Participating in the Work of the Ad Hoc Group under its Third Mandate

States Members of the Conference on Disarmament

ALGERIA	
Mr. E.-H. Hellal	Deputy Director, CSTN, Algiers
AUSTRALIA	
Mr. P.M. McGregor	Supervising Geophysicist, Bureau of Mineral Resources, Canberra
Mr. R. Steele	Counsellor, Department of Foreign Affairs Canberra
Mr. T. Findlay	Second Secretary Permanent Mission of Australia to the United Nations Office at Geneva
Ms. J. Courtney	Third Secretary Permanent Mission of Australia to the United Nations Office at Geneva
BELGIUM	
Mr. J.-M. van Gils	Chief, Seismological Section of the Royal Belgian Observatory, Brussels
Ms. M. De Becker	Geophysicist Royal Observatory of Belgium, Brussels
BULGARIA	
Dr. L.V. Christoskov	Head, Seismological Department Geophysical Institute of the Bulgarian Academy of Sciences, Sofia
CANADA	
Mr. P.W. Basham	Research Scientist Earth Physics Branch Department of Energy, Mines and Resources Ottawa
Dr. R.G. North	Geophysicist Earth Physics Branch Department of Energy, Mines and Resources Ottawa

CZECHOSLOVAKIA	
Dr. V. Kárník	Seismologist, Geophysical Institute Czechoslovak Academy of Sciences
Dr. L. Waniek	Head of Seismological Department Geophysical Institute Czechoslovak Academy of Sciences, Prague
Dr. J. Fiedler	Scientist, Ministry of Foreign Affairs - OMO Prague
EGYPT	
Dr. R. Kebeasy	Professor of Seismology and Deputy Director Helwan Institute of Astronomy and Geophysics Helwan
Ms. W. Bassim	Third Secretary, Permanent Mission of Egypt to the United Nations Office at Geneva
Mr. A. Abbas	Third Secretary, Permanent Mission of Egypt to the United Nations Office at Geneva
GERMAN DEMOCRATIC REPUBLIC	
Dr. M.M. Schneider	Adviser, Academy of Sciences, Berlin
GERMANY, FEDERAL REPUBLIC OF	
Dr. H.-P. Harjes	Professor of Geophysics, Ruhr University Bochum
Mr. M. Henger	Seismologist, Federal Institute for Geoscience and Natural Resources, Hanover
HUNGARY	
Dr. E. Bisztricsány	Head, Hungarian Seismological Observatory Budapest
INDIA	
Dr. G.S. Murty	Head, Seismological Section, Bhabha Atomic Research Centre, Bombay
INDONESIA	
Mr. T. Soetardio	Chief, Seismological Section, Meteorological and Geophysical Institute Jakarta

ITALY	
Dr. M. Caputo	Professor of Seismology, Institute of Physics, University of Rome
Dr. R. Console	Chief of Seismological Section, National Institute of Geophysics, Central Geophysics Observatory, Rome
JAPAN	
Dr. M. Ichikawa	Research Official, Seismological Division, Japan Meteorological Agency, Tokyo
Dr. M. Yanamoto	Technical Official, Seismological Division, Japan Meteorological Agency, Tokyo
Mr. S. Mori	Technical Official, Seismological Division, Japan Meteorological Agency, Tokyo
KENYA	
Mr. J. Kiboi	Senior Assistant Secretary Ministry of Foreign Affairs, Nairobi
MEXICO	
Mr. M. Sosa	General Director, Prevention and Detection of Urban Emergencies Secretary of Human Settlements and Public Works, Mexico City
Dr. J. Yamamoto	Chief, National Seismological Service, Institute of Geophysics, Ciudad University, Mexico City
NETHERLANDS	
Dr. A.R. Ritsema	Chief, Geophysical Division Royal Netherlands Meteorological Institute de Bilt
Dr. G. Houtgast	Seismologist, Royal Netherlands Meteorological Institute, de Bilt
Dr. R. Unger	Guest Scientist, Royal Netherlands Meteorological Institute, de Bilt
PERU	
Dr. L. Ocola (contribution by mail)	Instituto Geofisico del Peru, Lima

POLAND

Mr. R. Teisseyre	Deputy Director, Institute of Geophysics, Polish Academy of Sciences, Warsaw
Dr. S.J. Gibowicz	Head of Seismological Division of the Institute of Geophysics, Polish Academy of Sciences, Warsaw

ROMANIA

Dr. C. Radu	Head of Seismological Department, Centre of Earth's Physics and Seismology Bucharest

SWEDEN

Dr. U. Ericsson (deceased) (Chairman through fourteenth session)	Minister, Embassy of Sweden, Vienna
Dr. O. Dahlman (Chairman from fifteenth session)	Research Director, National Defence Research Institute, Stockholm
Dr. H. Israelson	Senior Research Officer, National Defence Research Institute, Stockholm
Mrs. B.-M. Tygard	Research Officer, National Defence Research Institute, Stockholm
Dr. H. Ohlsson	Research Officer, National Defence Research Institute, Stockholm
Dr. P. Johansson	Research Officer, National Defence Research Institute, Stockholm
Ms. E. Johannisson	Research Officer, National Defence Research Institute, Stockholm

UNION OF SOVIET SOCIALIST REPUBLICS

Professor I. Passetchnik	Professor of Seismology, Institute of Earth Physics, Moscow
Dr. O. Kedrov	Doctor of Seismology, Institute of Earth Physics, Moscow
Dr. I. Botcharov	Adviser, Ministry of Defence, Moscow
Dr. V. Kotioujanski	Ministry of Defence, Moscow

UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND

Mr. F.H. Grover	Scientist, Seismological Research Centre, Blacknest
Mr. P.D. Marshall	Government Scientist, MOD(PE), Blacknest

UNITED STATES OF AMERICA

Dr. R.W. Alewine	Director, Geophysical Sciences Division Defense Advanced Research Projects Agency Arlington, Virginia
Col. H.L. Brown	Chief, Science and Technology Division, US Arms Control and Disarmament Agency Washington, DC
Mr. N. Carrera	Science Officer, US Arms Control and Disarmament Agency, Washington, DC
Dr. P.S. Corden	Physical Science Officer, US Arms Control and Disarmament Agency Washington, DC
Ms. A.U. Kerr	Program Manager, Geophysical Sciences Division, Defense Advanced Research Projects Agency, Arlington, Virginia
Mr. R.J. Morrow	Physical Science Officer, US Arms Control and Disarmament Agency, Washington DC
Mr. D.L. Springer	Deputy Manager, Seismic Monitoring Program Lawrence Livermore National Laboratory Livermore, California
Dr. L.S. Turnbull, Jr.	Senior Scientist, US State Department Washington, DC

State Member of the Conference on Disarmament participating as observer

CHINA

Mr. Liang De-fen	Official of the Ministry of Defence of the People's Republic of China
Mr. Xin Xian-jie	Senior Researcher, Atomic Energy Institute of the Chinese Academy of Sciences, Peking

States not Members of the Conference on Disarmament, by invitation

AUSTRIA

Dr. J. Drimmel	Head of Geophysical Department Zentralanstalt für Meteorologie und Geodynamik, Vienna

DENMARK

Mr. J. Hjelme	State Seismologist, Geodetic Institute, Charlottenlund

FINLAND

Dr. H. Korhonen	Director, Institute of Seismology University of Helsinki

NEW ZEALAND

Dr. W.D. Smith	Superintendent, Seismological Observatory Geophysics Division, Wellington
Mr. M. Lowry	Seismologist, Seismological Observatory Geophysics Division, Wellington

NORWAY

Dr. F. Ringdal (Scientific Secretary)	Project Manager, Norwegian Seismic Array (NORSAR), Kjeller
Dr. E.S. Husebye	Chief Scientist, Norwegian Seismic Array (NORSAR), Kjeller
Dr. E. Thoresen	Consultant, Norwegian Seismic Array (NORSAR), Kjeller
Mr. S. Lundbo	Counsellor (Disarmament), Permanent Mission of Norway to the United Nations Office at Geneva

Specialized Agency

WORLD METEOROLOGICAL ORGANIZATION

Dr. H.A. Bari	Chief, Operations Division, WMO, Geneva
Mr. K. Yamaguchi	Scientific Officer, WMO, Geneva

SECRETARY OF THE AD HOC GROUP (Ninth Session)

Mr. P. Csillag	Chief of Section United Nations Centre for Disarmament,*/ New York

SECRETARY OF THE AD HOC GROUP (Tenth through Thirteenth Sessions)

Mrs. L. Waldheim-Natural	Chief, Geneva Unit United Nations Centre for Disarmament

SECRETARY OF THE AD HOC GROUP (Fourteenth through Seventeenth Sessions)

Mr. M. Cassandra	Associate Political Affairs Officer United Nations Department for Disarmament Affairs, Geneva Branch

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*/ As of 1 January 1983, the United Nations Centre for Disarmament was transformed into the United Nations Department for Disarmament Affairs.

List of Convenors and Co-Convenors of the Five Study Groups established by the Ad Hoc Group

1. Seismological stations and station networks:
   Dr. Basham (Canada), Dr. Schneider (German Democratic Republic)

2.[1/] Data to be regularly exchanged (Level I data):
   Dr. Harjes (Germany, Federal Republic of), Dr. Fiedler (Czechoslovakia)

3.[2/] Format and procedures for the exchange of Level I data through WMO/GTS:
   Dr. McGregor (Australia), Dr. Mori (Japan)

4. Format and procedures for the exchange of Level II data:
   Dr. Husebye (Norway), Dr. Christoskov (Bulgaria)

5.[3/] Procedures to be used at International Data Centers:
   Dr. Israelson (Sweden), Dr. Alewine (United States of America)

1/ Dr. V. Kárník (Czechoslovakia) served as Convenor of Study Group 2 during the ninth and tenth sessions.

Dr. L. Waniek (Czechoslovakia) served as Co-Convenor of Study Group 2 during the eleventh through sixteenth sessions.

2/ Dr. M. Ichikawa (Japan) served as Co-Convenor of Study Group 3 during the ninth through fourteenth sessions.

Dr. M. Yamamoto (Japan) served as Co-Convenor of Study Group 3 during the fifteenth and sixteenth sessions.

3/ Dr. O. Dahlman (Sweden) served as Convenor of Study Group 5 during the ninth through fourteenth sessions.