CONFERENCE ON DISARMAMENT

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REPORT OF THE CONFERENCE ON DISARMAMENT

APPENDIX II

VOLUME II

List and text of documents issued by the Conference on Disarmament

GE.84-65414

CONFERENCE ON DISARMAMENT

CD/441
28 February 1984

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Decision on the re-establishment of an ad hoc subsidiary body on effective international arrangements to assure non-nuclear weapon States against the use or threat of use of nuclear weapons

(Adopted at the 245th plenary meeting on 28 February 1984)

The Conference on Disarmament decides to re-establish for the duration of its 1984 session an *ad hoc* subsidiary body on effective international arrangements to assure non-nuclear weapon States against the use or threat of use of nuclear weapons on the basis of its former mandate.

The *ad hoc* subsidiary body will report to the Conference on the progress of its work before the conclusion of the 1984 Session.

The term "*ad hoc* subsidiary body" is used pending a decision by the Conference on its designation.

GE.84-60526

CONFERENCE ON DISARMAMENT

CD/442
28 February 1984
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Decision on the re-establishment of an ad hoc subsidiary body on the comprehensive programme of disarmament

(Adopted at the 245th plenary meeting on 28 February 1984)

The Conference on Disarmament decides to re-establish an *ad hoc* subsidiary body on the Comprehensive Programme of Disarmament to renew, as soon as the circumstances are propitious for that purpose, its work on the elaboration of the Programme with a view to the submission to the General Assembly, not later than at its forty-first session, a complete draft of such a Programme.

The *ad hoc* subsidiary body will report to the Conference on the progress of its work before the conclusion of its 1984 session, in order that the Conference may be in a position to submit to the General Assembly the progress report requested in resolution 38/183 K.

The term "*ad hoc* subsidiary body" is used pending a decision by the Conference on its designation.

GE.84-60533

CHINA

Proposals on Major Elements of a Future Convention on the Complete Prohibition and Total Destruction of Chemical Weapons

The Chinese Delegation submits this paper in order to give a summarized and over-all picture of its basic position on the prohibition of chemical weapons. During the preparation of this paper, attention and consideration have been given to many constructive views and proposals presented by other countries.

The views contained in this paper do not represent the final position of the Chinese Delegation. Revisions and amendments would be made when necessary in the course of negotiations.

I. Preamble

The Chinese Delegation considers that the Preamble should contain a strong condemnation of the use of chemical weapons as a means of warfare in wars and armed conflicts, a full recognition of the historical role and the practical significance of the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare concluded in Geneva on 17 June 1925 and an appeal to all States Parties to the Protocol to continue their strict observance of its provisions.

It should also be stated in the Preamble that the prohibition of chemical weapons represents a necessary step in disarmament, that such a prohibition should be comprehensive and that all existing stockpiles of chemical weapons should be totally destroyed and production or filling facilities dismantled and destroyed.

A Convention on the complete prohibition and total destruction of chemical weapons would contribute to the improvement of the international atmosphere and promote social progress and scientific, technological and economic developments for the good of mankind.

II. Scope of Prohibition

States Parties to the Convention should undertake never in any circumstances to develop, produce, otherwise acquire, retain, stockpile, transfer, deploy on the territories of other countries, or use chemical weapons, and undertake to destroy or otherwise dispose of existing stocks of chemical weapons and production or filling facilities for such weapons.

III. Some Definitions

1. The Convention should define "chemical weapons" on the basis of "general-purpose criteria". We propose the following definition:

For the purpose of the Convention, chemical weapons are the type of weapons the casualty capabilities of which are based on the toxic physiological effects of chemical substances. They include:

(1) chemical warfare agents and their key precursors which produce a direct toxic effect on living organisms;

(2) munitions and devices specially designed to be filled with chemical warfare agents or their precursors and to disperse such agents or the reaction products of their precursors in combat state;

(3) equipment specially designed for the purpose of direct use of such munitions and devices.

2. The Convention should include the concept of "chemical warfare agents" and define it on the basis of "general-purpose criteria". We propose the following definition:

Chemical warfare agents are those toxic chemical substances the types and quantities of which accord with hostile purposes of causing injuries of different kinds or death through direct interference with or damage to the normal physiological functions of living organisms resulting from the toxic effects of such substances. Chemical warfare agents can be divided into the following three categories according to toxicity criteria:

(1) Supertoxic lethal agents: having a median lethal does which is less than or equal to 0.5 mg/kg (subcutaneous administration) or 2,000 mg-min/m^3 (by inhalation);

(2) Other lethal agents: having a median lethal does which is greater than 0.5 mg/kg (subcutaneous administration) or 2,000 mg-min/m^3 (by inhalation) and less than or equal to 10 mg/kg (subcutaneous administration) or 20,000 mg-min/m^3 (by inhalation).

(3) Other harmful agents: having a median lethal does which is greater than 10 mg/kg (subcutaneous administration) or 20,000 mg-min/m^3 (by inhalation) and a median effective dose which is less than or equal to 0.5 mg/kg (subcutaneous administration) or 2,000 mg-min/m^3 (by inhalation) but adequate enough to produce other harmful effects of military significance.

In accordance with the above definition, chemical warfare agents should include all known chemical warfare agents, dual-purpose chemical agents designed for use in chemical warfare and all potential chemical warfare agents.

3. Precursors for chemical warfare agents are chemical substances which can be used as reactants in the process of synthesis of chemical warfare agents.

Key precursors for chemical warfare agents are chemical substances which can be used as reactants in the course of synthesis of chemical warfare agents (whether in production facilities or in binary munitions) and have a decisive effect on the properties of the end products and have little peaceful use.

4. Other necessary definitions.

IV. Declaration

1. Detailed declarations should be made within three months after the entry into force of the Convention or accession to it by a State. Declarations may also be made by stages according to agreed principles.

2. Declarations should be directly related to the Convention, including in the main the following three areas:

(1) items directly related to chemical warfare capabilities and subject to prohibition:

- the possession or non-possession of chemical-weapon stocks (including key precursors for chemical warfare agents) and their sources of origin, either within a country or outside it;

- the possession or non-possession of chemical-weapon production or filling facilities (including the production facilities for key precursors for chemical warfare agents) either within a country or outside it, either under the control of administrative authorities or military authorities or transnational corporations, and in chemical complexes either for military purposes or civilian purposes;

- the names, quantities, qualities and locations of stocked chemical munitions and chemical warfare agents;

- the types, capacities and locations of production or filling facilities for chemical weapons (including production facilities for key precursors);

- any transfer to or acquisition from other countries of chemical weapons since 1 May 1945, and if any, the names, quantities and the dates of transfer or acquisition;

(2) activities relating to dismantlement and destruction:

- any destruction or diversion of chemical-weapon stocks since 1 May 1945;

- the names, quantities, qualities of the destroyed stocks and the dates and methods of destruction;

- the names, quantities and qualities of the diverted stocks, and the methods, purposes and dates of diversion;

- any conversion or dismantlement of the production or filling facilities for chemical weapons since 1 May 1945;

- the names, types, capacities and locations of the dismantled facilities and the dates of dismantlement;

- the names, types, capacities, locations and uses of the converted facilities, and the dates of conversion;

- plans for destruction or diversion of the existing stocks;

- plans for dismantlement of the existing production or filling facilities;

(3) items permitted under the Convention but subject to control:

- the names, types, capacities and locations of facilities for producing dual-purpose chemicals;

- the names, types, capacities and locations of small-scale production facilities for supertoxic lethal agents for protective purposes.

V. Dismantlement and Destruction

1. Dismantlement and destruction should be conducted under international on-site inspection in accordance with agreed principles. The host country should provide active co-ordination and assistance.

2. All chemical-weapon stocks should be totally destroyed except for dual-purpose chemical agents which, as agreed upon, may be diverted for peaceful uses. Destruction should commence at the earliest possible date after entry into force of the Convention and should be completed within 10 years at the latest.

3. In order to eliminate as early as possible the threat to mankind of chemical warfare, States in possession of chemical weapons should in the first place destroy stocks of the most toxic and dangerous types of chemical weapons, e.g. supertoxic lethal agents such as VX, Soman, Sarin, tabun, mustard gas, etc.

4. All production/filling facilities for chemical weapons should be dismantled and destroyed. Dismantlement and destruction should commence as early as possible and should be completed within 10 years. Pending dismantlement, the facilities should be mothballed and subject to the necessary verification to ensure that they are not reused for the purpose of production or filling of chemical weapons.

5. Production or filling facilities for chemical weapons are allowed to be converted into facilities for the destruction of chemical weapons. But once destruction is completed, dismantlement and destruction of such facilities should immediately commence and be completed within one year.

VI. General Provisions for Verification

1. A Convention on the prohibition of chemical weapons should include the necessary provisions for verification. The verification measures should be strict and effective to ensure compliance with the Convention and, at the same time, reasonable and appropriate to avoid unnecessary interference with civilian industries.

2. International verification should be the main form of verification and necessary on-site inspection should also be provided in the Convention. On-site inspection should cover destruction of chemical-weapon stocks, dismantlement and destruction of chemical-weapon production or filling facilities, production of supertoxic lethal agents in small quantities for protective purposes, and alleged use of chemical weapons, etc.

3. Different ways, means and procedures should be adopted for different purposes of verification on an agreed basis, such as continuous on-site inspection, routine periodical or random on-site inspection and on-site inspection by challenge.

4. States Parties should give co-operation to international on-site inspection so as to facilitate the implementation of the Convention and help build confidence.

5. Information on the implementation of the Convention acquired by any State Party through national technical means of verification should be made available to the Consultative Committee and other States Parties.

VII. Confidence-building Measures and International Co-operation

1. An important pre-condition for confidence-building lies in the strict compliance by States Parties with the provisions of the Convention.

2. Necessary international verification, including on-site inspection, constitutes an important guarantee for confidence-building. States Parties should not only subject themselves to routine inspection, but also respond in a positive manner to requests for challenge inspection authorized by the Consultative Committee.

3. International co-operation is an important means of confidence-building. States Parties should be encouraged, through bilateral or multilateral channels, or through the Consultative Committee, to:

- exchange information on the peaceful use of chemical knowledge;
- exchange information and knowledge on chemical protection;
- exchange data on newly-discovered toxic chemical compounds and advances made in the field of toxicology research and register them with the Consultative Committee;
- promote the exchange of visits of personnel working in the field of chemical protection.

4. The Convention should encourage States Parties to take unilateral, bilateral or multilateral actions that may contribute to the strengthening of confidence.

VIII. Relationship between the Convention and other Treaties

All States Parties to the Convention should at the same time undertake to observe the provisions regarding the prohibition of the use of chemical weapons laid down in the Geneva Protocol.

None of the provisions of the Convention shall in any way be interpreted as limiting or diminishing the authority of the 1925 Geneva Protocol, or as lessening the obligations assumed by any State under the Protocol, or as limiting or diminishing the legal effect of any other international treaties or instruments governing armed conflicts.

IX. The Consultative Committee

Immediately upon entry into force of the Convention, a Consultative Committee should be set up in accordance with agreed procedures. The principles of universality and equality of all States, big or small, should be taken into consideration in the composition of the Consultative Committee. For the convenience of its daily work, the Consultative Committee may establish a Standing Committee or Executive Council composed of 15 to 20 members. The Consultative Committee should have the following functions:

1. To decide in accordance with agreed procedures on routine inspection and oversee its implementation;

2. To decide, in accordance with agreed procedures on challenge inspection and oversee its implementation;

3. To review, revise or amend, when new developments in science and technology make this necessary, the technical provisions of the Convention, such as toxicity criteria, methods of measuring toxicity, list of precursors, etc.;

4. To examine and consider complaints of non-compliance with the Convention;

5. To promote the flow of information on implementation of the Convention;

6. To report on its work to States Parties and to the Depository of the Convention;

7. To assume all other functions unanimously agreed upon among the States Parties.

X. Complaints of Non-compliance

1. Complaints may be lodged by any State Party, upon discovering non-compliance on the part of other States Parties, to the Standing Committee of the Consultative Committee. Such complaints must be supported by explanations and evidence.

2. Upon receiving a complaint, the Standing Committee of the Consultative Committee should first of all encourage the parties concerned to resolve the complaint through bilateral or multilateral channels.

3. If no solution can be reached through bilateral or multilateral consultation, the Standing Committee should, within a period of one month, convene a plenary meeting of the Consultative Committee, to consider the matter.

4. The Consultative Committee, in accordance with agreed principles, may decide on the verification measures to be taken, including international on-site inspection, to ascertain the facts. The outcome of the investigation should be submitted to the States Parties and the Depository of the Convention.

5. If the Party challenged refuses to subject itself to verification, it should state its reasons and clarify the situations.

6. If the Consultative Committee finds the reasons or clarifications unsatisfacotry, the Party challenged shall be obliged to subject itself to verification. In case of dispute, recourse may be had to the appropriate United Nations bodies.

XI. Other Provisions

The Convention should also include provisions on signature, procedure for accession, entry into force, depository, procedure for amendments, review conference, duration of validity, withdrawal, languages used, etc.

CONFERENCE ON DISARMAMENT

CD/444 */
19 March 1984

ENGLISH
Original: RUSSIAN/ENGLISH

Letter dated 6 March 1984 from the Representative of the Union of Soviet Socialist Republics to the Conference on Disarmament, transmitting excerpts from the speech of the General Secretary of the Central Committee of the Communist Party of the Soviet Union, Mr. K.U. Chernenko, delivered on 2 March 1984 to voters of Moscow's Kuibyshev district

I enclose herewith the text of an excerpt concerning the international situation taken from the address of the General Secretary of the Central Committee of the Communist Party of the Soviet Union, Mr. K.U. Chernenko, to a meeting of voters of Kuibyshev electoral ward, Moscow, on 2 March 1984.

I should be grateful if you would have this text circulated as an official document.

(Signed): V. Issraelyan
Member of the Collegium of the Ministry for Foreign Affairs of the USSR, Representative of the USSR at the Conference on Disarmament

*/ Re-issued for technical reasons.

Excerpt from the address of the General Secretary of the Central Committee of the Communist Party of the Soviet Union, Mr. K.U. Chernenko, to a meeting of voters of Kuibyshev electoral ward, Moscow on 2 March 1984

Now let us turn to international affairs. One of the most important and insistent instructions of the Soviet voters was, is and will remain the instruction to safeguard peace like the apple of our eye and to ensure the security of our homeland. I can tell you that the Party and the Soviet State have been following unswervingly this instruction, doing so in difficult circumstances.

You know that the past few years have seen a dramatic intensification of the policy of the more aggressive forces of United States imperialism, a policy of blatant militarism, claims to world dominance, resistance to progress, and violations of the rights and freedom of the peoples. The world has seen quite a few examples of the practical application of this policy. These include the invasion of Lebanon, the occupation of Grenada, the undeclared war against Nicaragua, threats to Syria and, finally, the turning of Western Europe into a launching site for United States nuclear missiles targeted at the USSR and its allies.

All this compels us to attach most serious attention to strengthening the country's defences. The Soviet people want not an arms build-up but the reduction of armaments by both sides. But we must take care to ensure sufficient security for our country, its friends and allies. This is precisely what is being done. And let everyone know that none of those given to armed ventures will catch us unawares and no potential aggressor can hope to avoid devastating retaliation.

At the same time it is precisely the complexity of the situation that compels us to redouble and triple our efforts in pursuing a policy of peace and international co-operation.

One can hardly recall a problem of importance to strengthening peace on which the Soviet Union and other socialist countries have not put forward during the past few years concrete and realistic proposals. The initiatives of our countries are winning ever broader support from other States. This has been forcefully confirmed by the latest session of the United Nations General Assembly.

Imperialist politicians are trying in every way to limit the international influence of socialist countries. They are attempting to impair their cohesion and to erode the foundations of the socialist system wherever they think they can count on success. In these conditions it is particularly important to maintain and strengthen the solidarity of fraternal socialist countries. The leaders of the Warsaw Treaty countries again unanimously expressed their conviction of this during their recent meeting in Moscow.

The United States uses an economic blockade and military threats against socialist Cuba. But the hopes to scare it and to make it swerve from its chosen road are doomed to failure. This is guaranteed by the unflinching will of the heroic Cuban people rallied around their Communist Party. This is guaranteed by the solidarity displayed with the island of freedom by independent countries in Latin America and by many participants in the non-aligned movement. The Cuban people are resolutely supported by the fraternal socialist countries. As for the USSR, it was, is and will remain on Cuba's side in fair weather and in storm.

The normalization of relations with the People's Republic of China could, of course, contribute to the growth of the role of socialism in international affairs. We are consistent proponents of this normalization. Political consultations show, however, that there remain differences on a number of questions of principle. In particular, we cannot make any agreements to the prejudice of the interests of third countries. Exchange of opinions continues, however, and we consider it useful. The Soviet Union stands for the level of contacts being raised to the extent acceptable to both sides.

It is also useful that mutually beneficial contacts in the economy, culture, science and other fields are being gradually re-established. This is not to the liking of those who want to benefit by the aggravation of relations between the USSR and China. But it is to the good of both our countries and the improvement of the over-all world situation.

The danger of the imperialist policy of the incessant escalation of tension has become obvious. The graver threat it poses to human civilization, the stronger mankind's forces of self-preservation grow. Indigantion is rising in Western Europe over the actions of those who are sacrificing its security to the imperial ambitions of Washington. Millions of participants in the anti-missile movement are quite vocal in making this known.

Also, far from all the leaders of Western countries and influential political parties approve the adventurism of the United States administration. It worries a considerable segment of the United States public itself as well. They are realizing ever clearer there that the intensive militarization and the aggravation of the international situation have not brought nor are going to bring the United States military superiority and political achievements. They only lead everywhere in the world to the escalation of criticism of Washington's belligerent course. People want peace and tranquility rather than war hysteria. I can say that our conversations with the leaders of many foreign delegations who attended the funeral of Yuri Vladimirovich Andropov confirmed that with sufficient forcefulness.

All this inspires the hope that developments will eventually be turned around towards peace, the limitation of the arms race and the development of international co-operation.

Détente has struck deep roots. This is evidenced, in particular by the convocation of the Stockholm Conference on Confidence-Building Measures and Disarmamemt in Europe.

Of course, it is the bridling of the nuclear arms race that is of key importance to peace and the security of peoples. The Soviet Union's position on that issue is clear. We are against rivalry in building up nuclear arms arsenals. We were and remain proponents of the prohibition and elimination of all types of those weapons. Our proposals on this score were submitted long ago, both to the United Nations and to the Geneva Disarmament Committee, but discussion on them is being blocked by the United States and its allies.

As for Europe, we still stand for it being free from nuclear weapons, both medium-range and tactical ones.

We stand for both sides making the first major step in this direction without wasting time. In so doing, the Soviet Union has no intention of strengthening its security at the expense of others but wants equal security for all.

Regrettably, the United States has turned its participation in talks on this subject into a tool of propaganda to camouflage the arms race and cold war policy. We will not participate in this game. The Americans created obstacles to the talks both on "European" and on strategic nuclear weapons by deploying their missiles in Europe. It is the removal of these obstacles (which would also remove the need for our measures taken in response). That offers the way to working out a mutually acceptable accord.

The United States administration has lately begun to make peaceably-sounding statements, urging us to enter a "dialogue".

Attention was drawn world-wide to the fact that these statements are in sharp conflict with everything that the present United States administration has said, and, which is the main thing, done and continues doing in its relations with the Soviet Union. Assurances of its good intentions can be taken seriously only if they are substantiated with real actions. As far as the Soviet Union is concerned, it has always been for a search for mutually acceptable practical solutions to concrete questions for the benefit of both countries, for the benefit of peace. There are quite a few such questions. And the United States administration has many opportunities to prove its peaceableness by deeds.

Why should not the United States, for example, ratify the treaties with the USSR on the limitation of underground nuclear weapon tests and nuclear explosions for peaceful purposes, which were signed almost 10 years ago, and not to complete drawing up an agreement on the general and complete prohibition of nuclear weapons tests? I will remind you that the talks on these issues were broken off by the United States. The United States can also make a no small contribution to strengthening peace by concluding an agreement on the renunciation of the militarization of outer space. The USSR is known to have proposed it for a long time.

The peaceable assurances by the United States administration would inspire by far more trust had it accepted the proposal on a mutual freeze on American and Soviet nuclear weapons. So many weapons have already been accumulated that this step would not create even the slightest threat to the security of either side But, at the same time, it would considerably improve the general political atmosphere, and, it must be believed, would facilitate reaching agreement on a reduction of nuclear arsenals.

A very important task is to deliver mankind from the possible use of chemical weapons. Talks on that have been in progress already for a long time, but now it seems that prerequisites are beginning to ripen for resolving this question. The point at issue is the complete and general prohibition of the use of chemical weapons, their development and production, destruction of all of its stockpiles. We are over an effective control for the implementation of such an agreement, that control should cover the whole process of destruction of chemical weapons - from beginning to end.

It is not ruled out that reaching an agreement on the above-mentioned issues would signal the start of a real drastic change in Soviet-American relations, and in the international situation as a whole. We would wish such a drastic change. Now it is up to Washington to act.

The policy of the Powers possessing nuclear weapons is of special significance in our times. The vital interests of the whole of mankind, the responsibility of Statesmen to the present and future generations require that relations between these Powers should be regulated by certain norms. Our idea of these norms is as follows:

- To regard the prevention of nuclear war as the main objective of one's foreign policy. To prevent situations fraught with nuclear conflict. In the event such a danger emerges, urgent consultations should be held to prevent a nuclear conflagration from breaking out.

- To renounce the propaganda of nuclear war in any of its variations - either global or limited.

- To undertake not to be the first to use nuclear weapons.

- Not to use nuclear weapons under any circumstances against non-nuclear countries, in whose territory there are no such weapons. To respect the status of a nuclear-free zone already created and to encourage the creation of new nuclear-free zones in various areas of the world.

- To prevent the proliferation of nuclear weapons in any form: not to hand over these weapons or control over them to anybody; not to deploy them on the territory of the countries, where there are no such weapons; not to spread the nuclear arms race to new spheres, including outer space.

- To press step by step, on the basis of the principle of equal security for the reduction of nuclear arms, up to their complete liquidation in all their varieties.

The Soviet Union has made these principles the foundation of its policy. We are ready to reach agreement at any time with the other nuclear Powers on the joint recognition of norms of this kind and imparting them a mandatory character. I think that this would meet the fundamental interests not only of the participating countries, but also of the peoples of the whole world.

CONFERENCE ON DISARMAMENT

CD/445
7 March 1984
Original: ENGLISH

THE NETHERLANDS

SIZE AND STRUCTURE OF A CHEMICAL DISARMAMENT INSPECTORATE

CONTENTS

GE.84-60607

1. INTRODUCTION

1.1. Verification of the compliance with a Convention banning chemical weapons has been at the heart of the debate on that subject in the Committee on Disarmament and its subsidiary bodies. Little attention however has been paid thus far to the structure and size of the inspectorate which will have to perform the different vertification functions. The purpose of this document is to address that particular issue in some more detail. Of course we realize that the ultimate structure and size of a chemical disarmament inspectorate cannot be defined as long as there is uncertainty about the precise nature of the verification provisions of a CW Convention. This uncertainty has implications for questions such as inspection schemes for individual plants, the number of plants to be inspected, the number of international inspectors needed for an inspection and the amount of time an inspection will take.

1.2. Nevertheless, we deem it timely and useful to devote somewhat more attention to the kind of chemical disarmament inspectorate that would be required to verify effectively the compliance with a CW Convention. The Netherlands believes that by discussing the structure and size of such an organization a clearer picture may emerge of the organizational and financial implications of certain verification provisions.

Because of the present uncertainty on the contents of the verification provisions a number of assumptions had to be made. Discussion of these assumptions in itself can perhaps enable us to conclude whether they are reasonable and can permit us in its turn to judge to what extent they substantially influence the size of the inspectorate. On the basis of these assumptions finally, in section 4 some rough calculations will be made in relation to the size of the future inspectorate.

1.3. In order to ensure the faithful compliance with a CW-Convention some inspection of the chemical industry will be necessary. The purpose of these inspections is not a profound and detailed investigation nor a scrutiny of the entire production process of chemical plants. The sole purpose is to make sure that no undeclared production of super-toxic chemicals or their key precursors is taking place in quantities that are relevant in the context of a CW Convention. These inspections should not hamper industrial production in any way, nor should they endanger industrial secrets. The Netherlands is convinced that if the purpose of the inspections is made sufficiently clear to all parties concerned, including the managements of the plants that will have to be visited, it should not be too difficult to organize inspections in such a way as to avoid hampering industrial production and compromising industrial secrets while at the same time fully attaining the purposes of the inspection.

1.4. Which industrial plants should be inspected? It seems natural to inspect all chemical plants that are able to produce super-toxic lethal chemicals or their key precursors in relevant quantities. Parties to a CW Convention should therefore undertake to declare not only all plants that <u>are</u> producing super-toxic lethal chemicals and their key precursors, but also all plants that <u>could</u> produce these in relevant quantities.

The criteria for the declaration of such plants of course need to be developed and defined.

2. GENERAL REMARKS ON THE INSPECTORATE

2.1. It is assumed that a CW Convention would contain provisions for the creation of a "Consultative Committee" (CC) composed of representatives of all the States parties. This Committee would *inter alia* give general guidance to a Technical Secretariat, established for the implementation of the Convention.

2.2. It seems natural to assume furthermore that the Consultative Committee would elect an "Executive Council", consisting of a smaller number of States parties. This Council would, among other things, give short-term guidance to the Technical Secretariat, in particular its inspectorate, approve inspection schemes, designate inspectors, handle financing, etc.

2.3. The Technical Secretariat, consisting mainly of inspectors and supporting staff, could be set up by drawing as much as possible upon the experience of existing international organizations employing independent inspectors under strict rules of operation and with a certain degree of diplomatic immunity. This includes questions as to how inspectors are to be designated for inspections in particular countries, their inspection rights, as well as the right of countries to refuse certain inspectors.

2.4. There are three main categories of on-site inspections:

A. Systematic continuous

B. Systematic non-continuous

(i) Regular

(ii) Random

C. *Ad hoc* ("challenge")

This classification into categories of on-site inspections has a direct bearing on the kind of inspector needed, as well as on his *modus operandi*, as will be illustrated hereafter.

A. Systematic continuous inspections would take place at CW destruction facilities.

B. (i) Systematic, but non-continuous regular inspections would take place:

(a) At closed-down declared CW-plants and during their destruction;

(b) At CW-stockpiles storage depots until the destruction of the stockpiles;

(c) At facilities producing small quantities of CW-agents for protective purposes.

(ii) Systematic, non-continuous random inspections would take place at certain chemical plants, namely:

(a) At plants that have been declared for producing certain super-toxic lethal chemicals and their key precursors for permitted non-CW purposes. 1/ Verification will have to ascertain two aspects:

- that the quantity of the declared production is in accordance with declared permitted purposes (i.e. a quantitative check);

- that no non-declared production of other super-toxic lethal chemicals and their key precursors is taking place (i.e. a qualitative check);

(b) At plants that have been declared for their capability of synthesizing organic chemicals in relevant quantities. At those plants the non-production of super-toxic lethal chemicals and their key precursors will have to be verified.

C. Ad hoc inspections under a challenge system could be held anywhere from civilian plants to the battlefield.

2.5. For continuous inspections, a permanent group of inspectors will be required on the spot, i.e. resident inspectors. Recruitment procedures should take into account that working and living conditions will not be easy because of occupational hazards and likelihood that destruction plants will be located in remote areas. Thus, a high degree of motivation will be needed. There should be a rotation of these inspectors so that hardships are evenly shared.

2.6. The continuous inspection of the destruction process will be largely a matter of routine, once the destruction process is under way. The systematic non-continuous inspections, particularly in the chemical industry, will be less routine-like and may therefore require a broader expertise than will be needed for the inspection of the destruction of stockpiles. Inventiveness and a broad experience in the civilian chemical industry will be needed to be able to find during short periods of inspection at different types of plants clues of possible non-compliance. Intensive travelling will be involved for these inspectors.

2.7. Ad hoc or "challenge" inspections are of a somewhat different nature. They might be requested on the basis of various kinds of information, such as indications of the use of CW, the finding of traces of a banned agent in a river downstream of a chemical plant, indications of a hidden CW stockpile, evidence of the existence of a large versatile chemical complex that has not been declared etc. Such questions would first have to be discussed in the appropriate organ of the Consultative Committee which could then decide to initiate an ad hoc investigation. Depending on the subject, use could be made of inspectors already employed in the secretariat or of other experts, to be designated by States Parties. A standing list of experts established on a wide geographical basis could be compiled and kept up to date permitting the quick choice of appropriate experts as need may be. It may be pointed out in this connection that the number of challenge inspections is likely to be relatively low. Hence, no permanent inspectors need to be designated for

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1/ The British paper CD/353 concentrates on this category of plants.

this taks alone. The appropriate organ of the Consultative Committee must be organized in such a manner that it can handle requests for challenge inspections swiftly and smoothly, using expertise from outside (such as the WHO and UNEP) when necessary.

2.8. The inspection to ensure that no militarily relevant quantities of super-toxic lethal chemicals or their key precursors can be or are produced above the level necessary for the declared permitted non-CW purposes (B (ii) (a)) will be of a quantitative nature. The reactions to the British list in CD/353 that have been made public up to now, demonstrate that the number of these plants will be limited.

2.9. The task of inspecting non-production of other super-toxic lethal chemicals of their key precursors in the chemical plants mentioned above (2.8.) can probably be accomplished easily by the same inspection team that inspects the quantity of declared production. This inspection will be of a qualitative nature: every trace of a non-declared and forbidden agent is a sign of violation of the Convention.

2.10. The verification of non-production in plants that are declared for their capability but not for their permitted production (B (ii) (b)) is identical to the verification of non-production in plants that are declared for their permitted production (B (ii) (a)). Of course not all chemical industries have to be declared: most of them can be left on one side, either because they are clearly not capable of producing the relevant agents (e.g. paint factories) or because they are too small to produce these in militarily relevant quantities (laboratories, small pharmaceutical plants). The alternative to a systematic inspection of the relevant plants on a random basis would be challenge inspections. But a request for a challenge inspection requires the submission of reasonably convincing information that something is amiss; such information will often be difficult to obtain and/or to present.

2.11. Systematic inspections can be held regularly or at random. Inspections of the chemical industry could probably most effectively be realized on a random basis. A certain number of random inspections is much more effective than the same number of regular inspections as random inspections inject the notion of chance. If, for instance, a declared plant would be inspected on a random basis on an average of once every three years, the chance of being visited within a month is about 3 per cent (1/36), even if it had been inspected just that day before. If inspections were to be held on a regular basis a party can be sure, in this example, that a plant that has been inspected the day before will not be inspected again for another three years.

2.12. The Technical Secretariat will need the assistance of States parties to obtain sufficient knowledge of the complex subjects to be handled. One possibility is a "technical support programme" similar to that in other fields, in the context of which new verification methodology and equipment would be developed by parties and transferred to the Technical Secretariat when applicable.

3. GENERAL ASSUMPTIONS UNDERLYING THE ROUGH CALCULATION OF THE SIZE OF A CW INSPECTORATE

3.1. In analogous existing situations one notes that the number of support personnel at headquarters is about twice as large as the number of inspectors in the field. The former include, besides general services staff (personnel division, translation, secretarial work etc.) those employed in sections dealing with the (computer) handling of data, assessing inspections, possibly analysing chemical samples and/or organizing such analyses elsewhere, 2/ the training of inspectors etc. Computer handling of data with cross referencing can eventually become very useful for verification. However, less data handling will be involved than for instance in the IAEA, as the latter assesses all nuclear material flows from one safeguarded "material balance area" to another, whereas a chemical inspectorate will be mainly involved with qualitative assessments. Probably, the ratio support-personnel/inspectors working from headquarters will have to be between 1 to 1.5 and 1 to 2. In the calculations to follow, the factor of 1.8. has been used. With respect to the resident inspectors permanently present at destruction facilities less support staff seems necessary. The factor of 1.0 has been used in the latter case.

3.2. In existing international organizations one inspector can achieve 40 man days/year inspection. This seems to be a reasonable assumption for a chemical inspector also, although a higher number of man days may be feasible.

3.3. To limit travel, the possibility of establishing a few regional inspection offices could be considered in particular near large concentrations of chemical activities subject to inspection. However, in view of the small inspectorate envisaged, this in all likelihood would not be sufficiently cost-effective.

3.4. Presumably, each State party to the CW Convention will need some sort of a "focal point" enabling contacts between the inspectorate and the facilities to be inspected. It could be left to the parties themselves to decide whether to assign the functions of focal point to an existing organization or to create a special body for this purpose. Such a national organization would also systematically collect and collate data. These data would constitute the basis for international inspections. Representatives of the national body could accompany the inspectors during their visits and assist them where necessary.

4. ROUGH CALCULATION OF THE SIZE OF A CW INSPECTORATE

The various categories of inspections would give rise to the following rough calculation of the size of a CW inspectorate:

A. Systematic continuous inspections. Verification of the destruction of declared CW stockpiles

Assumptions:

- During the first 10 years after the entry into force of the CW Convention six large and nine smaller destruction plants will be working simultaneously.
- For a continuous inspection of large destruction plants to be effective two inspectors will have to be on duty at all times. For the continuous inspection of smaller plants one inspector on duty at all times will be sufficient.

2/ It is to be expected that most chemical analyses will be done on the spot.

- Taking into account work shifts, holidays, illness etc. three to five inspectors will be needed in order to be able to have one person on duty continuously.

- The present state of the art with respect to technical means to monitor destruction does not allow to dispense with the continuous presence of one or more (according to the size of the destruction plant) international inspectors.

Conclusion:

- Approximately 60 to 100 inspectors are needed for the verification of the destruction of CW stockpiles during 10 years.

B. (i) Systematic non-continuous regular inspections

(a) Verification of the closure and destruction of declared CW production and munition filling facilities

Assumptions:

- Verification of non-operation of CW facilities can to a large extent be verified by technical means (tamper-indicating seals and/or cameras, possibly capable of interrogation e.g. by telephone etc.). Occasional visits by inspectors are necessary for the placement and maintenance of equipment, inspection of seals etc.

- Verification of the destruction of CW facilities can be done by a combination of remote sensing and regular on-site inspections.

Conclusion:

- In so far as destruction of stockpiles takes place at the site of former CW production facilities, non-operation and destruction of these facilities can be verified by the resident inspectors at this CW destruction plant.

- For the (estimated) remaining 15 CW production and munition filling facilities, 15 additional inspectors working from headquarters during 10 years seem to be more than sufficient.

(b) Monitoring of CW stockpiles until their destruction

Assumptions:

- CW stockpiles can to a large extent be monitored and safeguarded by technical means. Most of the CW stockpiles are initially situated near CW production facilities, which will be submitted to systematic non-continuous regular inspection (compare B (i) (a) above), and all stockpiles will at a given, preferably early, moment, in accordance with a declared plan, be transported to the destruction facilities, which are under systematic continuous international inspection (see 3. A), so that storage monitoring can be largely carried out by inspectors charged with scrutiny of the elimination of production facilities and stockpiles.

Conclusion:

- The number of <u>separate</u> inspections required for monitoring stockpiles will be relatively small and these will at any rate only be needed until all the stockpiles are located at the sites of their destruction

(c) <u>Verification of production of super-toxic chemical agents for protective purposes</u>

Assumptions:

- There will be a number - for instance 20 - of small scale facilities worldwide.

- These plants are inspected on an average of once every one and a half years. Smaller facilities producing a few grams per annum will require less frequent inspection than facilities producing one ton a year. For each inspection two inspectors will be visiting the plant during one working day. This form of inspection would consume about 25 man days/year.

Conclusion:

- About two inspectors will have to spend about a third of their time ~~for the~~ verification of the production of super-toxic agents for protective purposes.

B. (ii) <u>Systematic non-continuous random inspections</u>

(a) <u>Inspection of plants producing for permitted non-CW purposes</u>

Assumptions:

- Worldwide, about 50 plants produce super-toxic lethal chemicals or their key precursors for permitted non-CW purposes. 3/

- These plants are inspected through selection by drawing lots. Inspection of each of these plants takes place on an average of once every one and a half years. For each inspection three inspectors will be visiting the plant during an average of five working days. Inspection of these plants would thus entail 500 man days/year.

Conclusion:

- Approximately 10-15 inspectors will be needed permanently for the inspection of declared plants producing for permitted non-CW purposes.

3/ See the suggested list of key precursors in CD/353.

(b) Verification of non-production in other plants

Assumptions:

- Worldwide, about 500 other plants are capable of synthesizing organic chemicals in relevant quantities.

- These plants, to be declared in accordance with criteria to be defined, will equally be inspected on the basis of drawing lots, using a weighing factor in order to ensure that large and versatile chemical complexes have a greater chance to be inspected than smaller and more specialized plants.

  These plants will be inspected on an average of once every three years. For each inspection three inspectors will be visiting the plant during an average of three working days. Inspection of these plants would thus cost 1,500 man days/year.

Conclusion:

- About 30-40 inspectors are needed permanently for the verification of non-production in plants that have been declared not to produce super-toxic lethal chemicals or their key precursors but to be capable of synthesizing organic chemicals in relevant quantities.

C. Ad hoc "challenge" inspections under the fact-finding procedures

Assumptions:

- There are likely to be relatively few challenge inspections (which would include investigation of allegations of chemical warfare), particularly after the Convention has been in force for some time.

- These can be performed by the existing staff at the inspectorate and/or by specialists from member States or international organizations.

Conclusion:

- The possibility of "challenge" inspections has little bearing on the size of the inspectorate.

5. CONCLUSIONS

- About 50 inspectors and 90 supporting staff are needed permanently in the context of a CW-Convention.

- In addition about 75 to 115 inspectors and about 100 or less supporting staff are needed during roughly the first 10 years.

- The size of the organization depends greatly on the answer to the question on what scale inspection is planned for plants that are declared not to produce super-toxic lethal chemicals and their key precursors but to be capable of synthesizing organic chemicals in relevant quantities.

- After the 10-year period, during which destruction of stockpiles and destruction of CW plants has taken place, the envisaged CW secretariat will in any case be considerably smaller than the part of the IAEA-secretariat, including the inspectors, involved in the application of nuclear safeguards.

CONFERENCE ON DISARMAMENT

CD/446
8 March 1984

Original: ENGLISH

Decision on the designation of _ad hoc_ subsidiary bodies of the Conference on Disarmament

(Adopted at the 248th plenary meeting held on 8 March 1984)

The Conference on Disarmament decides to designate as "_Ad Hoc_ Committees", in accordance with its Rules of Procedure, the _ad hoc_ subsidiary bodies re-established by its decision of 28 February 1984, under agenda items 4. "Chemical weapons", 6. "Effective international arrangements to assure non-nuclear-weapon states against the use or threat of use of nuclear weapons" and 8. "Comprehensive programme of disarmament".

GE.84-60626

CONFERENCE ON DISARMAMENT

CD/447
9 March 1984
Original: ENGLISH

LETTER DATED 2 MARCH 1984 FROM THE PERMANENT REPRESENTATIVE OF THE ISLAMIC REPUBLIC OF IRAN ADDRESSED TO THE PRESIDENT OF THE CONFERENCE ON DISARMAMENT CONTAINING INFORMATION ON MISSILE ATTACKS AND BOMBARDMENTS IN BOTH MILITARY AND CIVILIAN AREAS OF THE ISLAMIC REPUBLIC OF IRAN

I have the honour to remind you that during the past few days the criminal regime of Iraq under various pretexts, has continued its aggression and its missile attacks and bombardment, and especially grave is their use of chemical weapons in both military and civilian areas of the Islamic Republic of Iran.

Since 25 February 1984, thirteen bombardments have taken place, whose targets were Baneh, Ilam, Khorramabad, Pol e Dokhtar, Kahdasht, Islamabad Gharh, Gilen Gharh, Borujerd, Saqqez, Hoveizeh, Bostan, Mahabad and Bakhtaran. During these savage attacks many innocent women, old men and children have been drenched in blood and a considerable number of persons in the Islamic Republic of Iran have been rendered homeless.

The Government of the Islamic Republic of Iran, once again, draws the attention of the Disarmament Committee to the continuation of the aggression and the terrible crimes of the criminal regime of Iraq, which is in contrariety to all international rules and, once again requests all international bodies to end their silence, which constitutes an active encouragement to the inhumane crimes of Saddam and, in accordance with the duties that they shoulder in the path of promoting international peace and security, while condemning the criminal acts of the Iraqi regime, to take steps to prevent the continuation of these terrible crimes, especially the use of chemical bombs and the drenching in blood of the innocent and defenceless people of the cities of the Islamic Republic of Iran.

You are kindly requested to have this letter circulated as an official document of the Disarmament Conference.

(Signed) Nasrollah KAZEMI KAMYAB
Ambassador
Permanent Representative

GE.84-60641

CONFERENCE ON DISARMAMENT

CD/448
9 March 1984

Original: ENGLISH

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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Appendices

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/558.

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/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 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 Internatioaal 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:

- summarise 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 conditions, 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 IRMARSAT, 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

*/ 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.

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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

Appendices

GE.84-60635

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Appendix 1

Glossary of Seismological Terms and Abbreviations used in this Document

Appendix 1

Glossary of seismological terms and abbreviations used in this document

Amplitude	-	The maximum deflection from a zero reading of a recorded seismic waveform
Analog waveform	-	A seismic waveform in a non-numeric continuous representation
Array	-	An ordered arrangement of seismometers, the data from which are transmitted to a central computer and processed jointly in order to increase the possibility of distinguishing weak signals from noise
Arrival	-	The appearance of a seismic signal on a seismic record as determined visually or automatically using a set of criteria
Beamforming	-	The process of adding together time-shifted signals from the individual instruments of a seismic array
Body wave	-	A seismic wave that propagates through the earth's interior (longitudinal P-waves and transverse S-waves)
Broad-band instruments	-	Seismographs that record a wide range of signal frequencies, thus encompassing the short period and long period bands
Broad-band data	-	Recordings obtained from broad-band instruments
Degree	-	Used as a measure of distance (one degree is approximately 111 km)
Depth phases	-	Seismic waves that have been reflected from the earth's surface above the seismic source
Digital waveform	-	A seismic signal represented as a sequence of numbers
DWWSSN	-	Digital World-Wide Standardized Seismograph Network
Epicenter	-	The point on the earth's surface which is directly above the seismic source
Filtering	-	The process of operating on any signal to enhance particular frequencies and suppress others
Focal depth	-	The depth at which the source of a seismic event is located
Focus, focal point	-	The point within the earth from which the energy of a seismic event is first released
GTS	-	Global Telecommunication System of the World Meteorological Organization
Hypocenter	-	The location of the focus of a seismic event
IASPEI	-	International Association of Seismology and Physics of the Earth's Interior

IDC	-	International Data Center (see Section 7)
Level I data	-	Data (on amplitude, period, arrival time of waves, etc.) used for the description of seismic analog or digital signals. These data are to be routinely transmitted to IDCs within the envisaged international data exchange
Level II data	-	Records of raw seismic signals (in digital or analog form) concerning events of special interest which will be requested through IDCs by individual States within the envisaged international data exchange
Long period waves	-	Seismic waves of period more than 10 seconds
LP	-	See long period waves
Magnitude	-	A measure of the size of a seismic event, as determined from seismograph observations
m_b	-	Body wave magnitude, i.e., magnitude calculated from data on recorded longitudinal and transverse waves
M_s	-	Surface wave magnitude, i.e., magnitude calculated from recorded surface wave data
NEIS	-	National Earthquake Information Service (USA)
OBS	-	Ocean Bottom Seismometer
P-wave	-	A seismic body wave of the compressional type
PKP-wave	-	A P wave that has propagated through the earth's core
Period	-	The time interval corresponding to one cycle of a vibration on a seismogram
RST	-	Remote Seismic Terminal
S-wave	-	A seismic body wave of the shear type
Seismogram	-	A seismic record containing waveforms covering a certain time interval (e.g. 24 hours)
Seismograph, Seismometer	-	Instruments designed to detect earth motions caused by seismic events
Short period waves	-	Seismic waves of period around 1 second
SP	-	See short period waves
SRO	-	Seismic Research Observatory - a United States designed, digitally recording broadband seismograph system
Surface wave	-	A seismic wave that propagates along the upper layers of the earth

Surface wave magnitude	-	See M_s
T-phase	-	A hydroacoustical wave of seismic origin that propagates through the ocean
Three-component seismograph	-	A seismograph system recording earth motion in three perpendicular directions (Vertical, North-South, East-West)
USSO	-	Uniform System of Seismic Observatories (USSR)
WMO	-	World Meteorological Organization
WWSSN	-	World-Wide Standardized Seismograph Network

Appendix 2

List of national contributions submitted toward the third report of the Ad Hoc Group

Appendix 2

List of national contributions submitted toward the third report of the Ad Hoc Group

Ninth Session

AUSTRIA	GSE/A/5 - A proposal for national investigations
AUSTRALIA	GSE/AUSTRALIA/3 - Australian developments and proposals for national experiments
BULGARIA	GSE/BG/4 - Draft proposal on possible scope of operation
CZECHOSLOVAKIA	GSE/CS/2 - Czechoslovak national studies GSE/CS/3 - Tasks of the study groups
DENMARK	DK/GSE/8 - Review on present and anticipated national and co-operative investigations relevant for the Ad Hoc Group
FINLAND	Plans for national investigations
GERMANY, FEDERAL REPUBLIC OF	GSE/FRG/6 - Information about the planning of a workshop at the GRF-observatory in the Federal Republic of Germany
HUNGARY	GSE/HUN/6 - Estimation of seismic detection thresholds of seismograph stations in Hungary Plans for national investigations
ITALY	On the review and analysis of national investigations
NETHERLANDS	GSE/NETH/2 - Report on developments and plans in the Netherlands in the framework of the monitoring of seismic events
NEW ZEALAND	GSE/NZ/2 - New Zealand involvements in national investigations Statement concerning the Austrian paper GSE/A/5
NORWAY	GSE/NOR/9 - Proposal for Norwegian national research efforts
ROMANIA	National investigations
SWEDEN	SW/GSE/27 - Outline and organization to the continued work of CD seismic Ad Hoc Group SW/GSE/28 - Swedish national and co-operative studies SW/GSE/29 - Remaining problems SW/GSE/30 - A common data base for national and co-operative studies

UNION OF SOVIET SOCIALIST REPUBLICS	GSE/USSR/4 - Several additional problems calling for further studies in the compilation of the third report of the Ad Hoc Group of Scientific Experts
	USSR/GSE/5 - Statement on the Swedish proposal SW/GSE/30
UNITED KINGDOM	GSE/UK/4 - Statement on the progress of United Kingdom national investigations
UNITED STATES OF AMERICA	United States Statement on proposed Swedish organization of Working Group
	United States Statement on national efforts
	CSE/USA/5 - Information on the United States national plans for a Seismic Data Center

Tenth Session

AUSTRALIA, JAPAN, SWEDEN	GSE/AUS,JP,SW/1 - A proposal for a systematic trial exchange of seismic data on the WMO/GTS
AUSTRIA	GSE/A/6 - Report on the availability of seismic messages in Vienna - Austria
BULGARIA, CZECHOSLOVAKIA, USSR	World Data Center A for Solid Earth Geophysics - Homogeneous magnitude system of the Eurasian continent: P waves
	GSE, 5 July 1980 - Homogeneous magnitude systems - A possible basis for world standardization of magnitude determinations
CZECHOSLOVAKIA	GSE/CS/4 - Progress report - Discrimination between teleseismic P, S and LR waves by particle motion analysis
	GSE/CS/5 - Progress report - Accuracy of magnification curves of electromagnetic seismographs
	GSE/CS/6 - Progress report - Regional travel times for the Central European seismic stations
FINLAND	GSE/FI/5 - National investigations in Finland - efforts and plans
GERMAN DEMOCRATIC REPUBLIC	GSE/GDR/6 - Some principles employed in the automatic extraction of standard parameters of seismic events
GERMANY, FEDERAL REPUBLIC OF	GSE/FRG/7 - Seismological Workshop - Procedures for extracting Level I parameters at a digital broad-band station
	GSE/FRG/8 - Working paper on determination of first motion sign, clarity and onset times
	GSE/FRG/9 - Statement of the seismic expert of the Federal Republic of Germany
HUNGARY	GSE/HUN/7 - On local travel time curves, Part I
INDIA	GSE/INDIA/8 - On Level II data transmission and storage
INDONESIA	GSE/INDONESIA/1 - The nuclear explosion records from seismic station Parapat
	GSE/INDONESIA/2 - Statement of the seismic expert of Indonesia
ITALY	GSE/ITALY/4 - Italian involvements in national investigations
JAPAN	GSE/JP/9 - Automatic extraction of seismic data in Japan and development of computer program for extracting Level I data by a man-machine interactive method

NORWAY	GSE/NOR/10 - National investigations: Deployment of a small aperture array for studies of seismic events at local and regional distances
	GSE/NOR/11 - An experimental small subarray within the NORSAR array: Crustal phase velocities and azimuths from local and regional events
	GSE/NOR/12 - An experimental small subarray within the NORSAR array: Location of local and regional events
	GSE/NOR/13 - National investigations: Analysis of regional P-wave attenuation characteristics using ISC data files
SWEDEN	SW/GSE/31 - International Seismological Data center Demonstration facilities in Sweden (A total of eight separate reports were submitted with this document.)
	SW/GSE/32 - Seismological stations and station network, Swedish studies
	SW/GSE/33 - Swedish national studies on Level I data
	SW/GSE/34 - Swedish national studies on data exchange using WMO/GTS
	SW/GSE/35 - A common data base for national and co-operative studies
UNITED KINGDOM	UK/GSE/5 - Seismic stations and networks National investigations
	UK/GSE/6 - Classification of short period (narrow band) recordings
UNITED STATES OF AMERICA	US/GSE/6 - Design and development of a seismic data center
	US/GSE/7 - Investigation of the properties of CD network III using synthetic data
	US/GSE/8 - Comparison of automatic signal detectors for use in a data center
	US/GSE/9 - United States presentation on 8 July 1980
	US/GSE/10 - A concept for a remote seismic terminal
	US/GSE/11 - Automation of a regional seismic network: A case history

Eleventh Session

AUSTRALIA	GSE/AUS/4 - Format and procedures for the exchange of Level I data through the WMO/GTS
	GSE/AUS/5 - Study group 3: WMO/GTS trial
	GSE/AUS/6 - Workshop on GTS experiment
	GSE/AUS/7 - Summary of Australian developments in GSE matters
	GSE/AUS/8 - Study group 3: Summary of conclusions
AUSTRIA	GSE/A/7 - Remarks on the determination of magnitudes
	GSE/A/8 - Trial exchange of seismic data on WMO/GTS 6 October - 28 November 1980 - Result gained in Vienna
	GSE/A/9 - Proposal for the reduction of surface wave parameters
BELGIUM	GSE/B/2 - Short report on possibilities in Belgium concerning exchange of Level I data through WMO/GTS
BULGARIA	GSE/BG/5 - The Bulgarian telemetric seismological system
CANADA/GERMAN DEMOCRATIC REPUBLIC	GSE/CAN/GDR/1 - Summary of national investigations on seismological stations and networks
FINLAND	GSE/FI/6 - Seismic experiment by Finland
GERMAN DEMOCRATIC REPUBLIC	GSE/GDR/7 - The network of seismological stations in the GDR
	GSE/GDR/8 - Developments concerning the acquisition of seismological data at Moxa station
HUNGARY	GSE/HUN/8 - Progress report: Seismological telemetry network in Hungary
INDIA	GSE/IND/9 - Methods for Level II data compression in transmission and storage
ITALY	GSE/ITA/6 - Trial exchange of seismic data on WMO/GTS
JAPAN	GSE/JPN/10 - An assessment of the reliability of seismic data transmission via WMO/GTS
	GSE/JPN/11 - Comment on table 2 in GSE/AUS/5 and proposal of format for reporting messages received during the test period
NETHERLANDS	GSE/NETH/3 - Progress report: National network of seismograph stations and trial exchange of seismic data via WMO/GTS

NORWAY	GSE/NOR/11 - Study group 4: Format and procedures for the exchange of Level II data
SWEDEN	GSE/SW/40 - Common data base experiment progress report
	GSE/SW/41 - Trial exchange of seismic data on WMO/GTS Reception of data in Sweden
	GSE/SW/42 - Trial exchange of seismic data on WMO/GTS Swedish messages
USSR	GSE/USSR/6 - Material for the third report of Ad Hoc Group
UNITED KINGDOM	GSE/UK/7 - Experience of the trial exchanges of data via WMO/GTS
	GSE/UK/8 - General developments in national seismograph systems and station facilities
	GSE/UK/9 - National investigations - Development in automatic detection processes
	GSE/UK/10 - Information on national seismograph station
UNITED STATES	GSE/US/12 - A summary of United States and international seismic facilities
	GSE/US/13 - United States contribution to the data collection experiment
	GSE/US/14 - Summary of United States participation in the GSE/WMO experiment
	GSE/US/15 - A remote seismic terminal
	GSE/US/16 - International telecommunications options for seismic data transmission

<u>Study Group Papers</u>

<u>Study Group 2</u>	GSE/SG2/1 - Level I Data Extraction - Progress Report for July/October 1980
	GSE/SG2/2 - Correction to Progress Report for July/October 1980
<u>Study Group 5</u>	SW/US/GSE/1 - Procedures to be used at International Data Centers
	SW/US/GSE/2 - Procedures to be used at International Data Centers

Twelfth Session

AUSTRALIA/JAPAN	GSE/AUS,JP/2 - The second trial exchange of seismic data on the WMO/GTS, November-December 1981
AUSTRIA	GSE/A/10 - Second trial exchange of seismic data on the WMO/GTS: Comment on the Document US/GSE/17
BULGARIA	GSE/BG/6 - Characteristics of aftershock sequences in central Balkans
	GSE/BG/7 - Travel time curves for near earthquakes in central Balkans
	GSE/BG/8 - On the transmission of analog seismic records by telecopying facilities
BULGARIA/ CZECHOSLOVAKIA/ USSR	GSE/BUL, CS, USSR/2 - Homogeneous magnitude system of the Eurasian continent: S and L waves
CANADA	GSE/CAN/6 - Summary of national investigations on seismological stations and networks: Memorandum from convenor, Study group 1
GERMANY, FEDERAL REPUBLIC OF	GSE/FRG/10 - Report on results of the exchange of seismic data on the WMO/GTS
HUNGARY	GSE/HUN/9 - Report: Short period seismic noise measurement in Hungary
ITALY	GSE/ITALY/7 - Progress report: Some development in the Italian seismological telemetry network
JAPAN	GSE/JPN/12 - A recent development of digital telemetered network
NEW ZEALAND	GSE/NEW ZEALAND/3 - Study group 1 - Item 3
NORWAY	GSE/NOR/14 - An automated procedure for determination of arrival time, amplitude and period for seismic event records
	GSE/NOR/15 - Seismic moment tensors and kinematic source parameters
	GSE/NOR/16 - On the use of microprocessor technology in seismic data recording and data exchange
SWEDEN	GSE/SW/43 - Consequences for the global verification system of results obtained so far under the group's third mandate Study groups 1-4
	GSE/SW/44 - Common data base experiment - Progress report on data analysis

SWEDEN (cont.)	GSE/SW/45 - A system for analysis of Level II data
	GSE/SW/46 - T phases from earthquakes - some preliminary observations in connection with the common data base experiment
USSR	GSE/USSR/7 - Material for the third report of the Ad Hoc Group of Scientific Experts of the Committee on Disarmament to Consider International Co-operative Measures to Detect and Identify Seismic Events
	GSE/USSR/8 - Average global P and PcP travel times
	GSE/USSR/9 - To the question on estimation of earthquake parameters from observations by a standard network
	GSE/USSR/10 - Material to be inserted in chapter 3 of the third report of the Ad Hoc Group of scientific experts
UNITED KINGDOM	GSE/UK/11 - Some characteristics of seismic background noise at Eskdalemuir Array
UNITED KIMGDOM/ SWEDEN	GSE/UK,SW/1 - A trial exchange of Level II data via the WMO/GTS
UNITED STATES OF AMERICA	GSE/US/17 - Suggested procedures for the WMO/GTS seismic data exchange experiment, November-December 1981
	GSE/US/18 - Report on the global digital seismograph day-tape
	GSE/US/19 - Experience with the international data collection experiment, October 1980
	GSE/US/20 - Status of three national efforts related to International Data Centers

Study Group Papers

Study Group 1	GSE/SG1/1 - Draft - Chapter 3: Review and Analysis of National Investigations into relevant matters: seismograph stations and networks
Study Group 2	GSE/CS, FRG/1 - Draft Chapter 4 - Review and analysis of national investigations into relevant matters: Level I data extraction
	GSE/CS,FRG/2 - Draft Chapter 4 - Level I data extraction
Study Group 3	GSE/AUS/8 - Summary of conclusions
Study Group 4	GSE/NOR/11 - Draft Chapter: Format and procedures for the exchange of Level II data
	GSE/SG4/1 - Questionnaire - Level II data exchange
Study Group 5	GSE/SW,US/2 - Procedures to be used at international data center

Thirteenth Session

AUSTRALIA	GSE/AUS/9 - Guidelines for the second WMO/GTS trial exchange
	GSE/AUS/10 - Australian results from the second exchange of seismic messages on the WMO/GTS
	GSE/AUS/11 - Presentation of the basic results of the second trial exchange of data via the WMO/GTS
AUSTRALIA/JAPAN	GSE/AUS,JAPAN/3 and Add.1 - Contribution to Section 5, Extended Progress Report: the Second WMO/GTS experiment
AUSTRIA	GSE/A/11 - Second trial exchange of seismic data on the WMO/GTS
	GSE/A/13 - Answers to the Questionnaire GSE/SG5/1 (Questions of operational procedures ...)
BELGIUM	GSE/BELGIUM/3 - Report on the second trial on exchange of seismic data through the WMO/GTS
BULGARIA	GSE/BG/9 - Results of the exchange of seismic data on the WMO/GTS
	GSE/BG/10 - Automatic system for collection and processing of seismological data in Bulgaria
CZECHOSLOVAKIA	GSE/CS/7 - Participation of Czechoslovak seismic stations in the second trial exchange of seismic data on the WMO/GTS
	GSE/CS/8 - Messages received in Prague during the second trial WMO/GTS
CZECHOSLOVAKIA/ GERMANY, FEDERAL REPUBLIC OF	GSE/CS,FRG/3 - Second draft of Chapter 4, Third Report of Ad Hoc Group
DENMARK	GSE/DK/9 - Answers to the questions from Study Group 5
FINLAND	GSE/FI/7 - Results from the second WMO data exchange experiment
GERMAN DEMOCRATIC REPUBLIC	GSE/GDR/9 - Participation of the seismic stations of the German Democratic Republic in the second GSE trial exchange of scientific data on WMO/GTS
	GSE/GDR/10 - Comments on the draft progress report
GERMANY, FEDERAL REPUBLIC OF	GSE/FRG/11 - Seismic background noise at the GRF-Array
	GSE/FRG/13 - Report on results of the second trial exchange of seismic data on the WMO/GTS

HUNGARY	GSE/HUN/10 - The crustal structure of Hungary based on the results of explosion seismology
	GSE/HUN/11 - An assessment of the CDGSF reports arriving at the Hungarian Meteorological Institute via WMO/GTS
INDIA	GSE/IND/10 - Comments on GSE/DPR/1, December 1981
ITALY	GSE/ITALY/8 - Results of second trial on exchange of seismic data on the GTS
JAPAN	GSE/JAPAN/13 - An assessment of the second experiment of seismic data exchange via WMO/GTS
	GSE/JAPAN/14 - A simulation for seismic message transmission via WMO/GTS
	GSE/JAPAN/15 - A brief analysis on missing messages
NETHERLANDS	GSE/NETH/4 - The second trial exchange of seismic data on the WMO/GTS
	GSE/NETH/5 - Receipt of messages transmitted by De Bilt during the second trial exchange of seismic data on the WMO/GTS
NEW ZEALAND	GSE/NZ/4 - Second trial exchange of seismic data on the WMO/GTS
NORWAY	GSE/NOR/17 - Results of second trial on exchange of seismic data on the GTS
	GSE/NOR/18 - Level II data exchange - present capabilities
	GSE/NOR/19 - A potential back-up system for the Level I data exchange via WMO trunk lines
	GSE/NOR/20 - Optimalization of seismic array configurations on the basis of observed signal and noise correlations
NORWAY/UNITED STATES OF AMERICA	GSE/NOR-US/1 - Global exchange of Level II data - a possible future scenario
SWEDEN	GSE/SW/47 - The WMO data exchange experiment
	GSE/SW/48 - Consequences for the global verification system for results obtained so far under the Group's third mandate, study groups 1-5
	GSE/SW/49 - List of scientific reports on the common data base experiment (A total of seven separate reports were submitted with this document.)

UNION OF SOVIET SOCIALIST REPUBLICS	GSE/USSR/11 and Add.1 - Material for the third report of the *Ad Hoc* Group of Scientific Experts of the Committee on Disarmament for the Consideration of International Co-operative Measures to Detect and Identify Seismic Events
	GSE/USSR/12 - Comments on the progress report to the Committee on Disarmament on the thirteenth session of the *Ad Hoc* Group
	GSE/USSR/13 - Comments on the Preface and Overview Summary of the Progress Report to the Committee on Disarmament
UNITED KINGDOM	GSE/UK/12 - United Kingdom experience on the second trial exchange of seismological data via the WMO/GTS
	GSE/UK/13 - United Kingdom experience of the special trial exchange experiment for international data centers using the WMO/GTS
	GSE/UK/14 - Comments on GSE/DPR/1, December 1981 Draft progress report
UNITED STATES OF AMERICA	GSE/US/22 - Results of the WMO experiments, November/December 1981
	GSE/US/23 and Add.1 and Add.2 - Comments on GSE/DPR/1 (Draft Progress Report) of December 1981
	GSE/US/24 - A regional seismic test network

<u>Study Group Papers</u>

<u>Study Group 1</u>	GSE/SG1/2 - Chapter 3: Review and Analysis of National Investigations into relevant matters: Seismograph Stations and Networks
<u>Study Group 3 and Study Group 5</u>	GSE/SG3/SG5 - Proposed Experiment for the Group of Scientific Experts
<u>Study Group 5</u>	GSE/SG5/1 - Questions on operation procedures for the preparation and distribution of seismic information by I C's
	GSE/SG5/2 - Comments and recommendations on the operation of an IDC
	GSE/SG5/3 - An international data center manual

Fourteenth Session

AUSTRALIA	GSE/AUS/12 - Results and Conclusions from the Second Trial Exchange of Seismic Data on the WMO/GTS
	GSE/AUS/13 - The Second Trial Exchange of Seismic Data on the WMO/GTS: Message flow-diagrams
AUSTRIA	GSE/A/14 - Second Trial Exchange of Seismic Data on the WMO/GTS (2 November - 11 December 1981) Receiving Station Vienna, Austria: Second Report
	GSE/A/15 - A Proposal for the Reduction of Level I Data
	GSE/A/16 - Addendum to Chapter 3, Appendix 3A of GSE/SG1/3
	GSE/A/17 - A Contribution to the Problem Level II Data - International Data Centers
BULGARIA/HUNGARY/ GERMAN DEMOCRATIC REPUBLIC/USSR/ CZECHOSLOVAKIA	GSE/BUL,HUN,GDR,USSR,CSSR/1 - Material for the Third Report of the Ad Hoc Group
CZECHOSLOVAKIA/ GERMANY, FEDERAL REPUBLIC OF	GSE/SC,FRG/3 (Rev.1) - Second Draft of Chapter 4 Third Report of Ad Hoc Group
GERMANY, FEDERAL REPUBLIC OF	GSE/FRG/12 - Surface Wave Analysis including the Medium-Period Band: A Possibility for Seismic Discrimination
	GSE/FRG/14 - Conclusions from the Second Trial Exchange of Seismic Data via the WMO/GTS
HUNGARY	GSE/HUN/12 - On the Local Travel-Time Curves Part II
JAPAN	GSE/JAPAN/16 - A Contribution to an International Seismological Monitoring System using a Small Seismic Array An outline of the Matsushiro Array System of Japan
NORWAY	GSE/NOR/22 - International Seismic Data Exchange under a Potential CTBT
	GSE/NOR/23 - Seismic Array Configuration Optimization
	GSE/NOR/24 - Level II Data Exchange on an Experimental Basis
NORWAY/HUNGARY	GSE/NOR/HUN/1 - Decomposition of Regional Seismic Wavetrains
SWEDEN	GSE/SW/50 - Level II Analysis at International Data Centers
USSR	GSE/USSR/14 - Material for the Third Report of the Ad Hoc Group of Scientific Experts of the Committee on Disarmament for the Consideration of International Co-operative Measures to Detect and Identify Seismic Events
	GSE/USSR/15 - Comments to the Draft Progress Report Fourteenth Session

UNITED KINGDOM	GSE/UK/15 - Answers to Questions in GSE/SG5/1
	GSE/UK/16 - A WMO/GTS Case History
	GSE/UK/17 - Summary of Verbal Contributions from United Kingdom Delegate on GTS Matters (Requested by SG3 Convenor)
	GSE/UK/18 - Proposals for Work under a Renewed Mandate
UNITED STATES OF AMERICA	GSE/US/25 - Importance of Waveform Data for Seismological Analysis
	GSE/US/26 - United States Development of Prototype International Data Center

<u>Study Group Papers</u>

<u>Study Group 1</u>	GSE/SG1/3 - Chapter 3: Review and Analysis of National Investigations into relevant matters: Seismograph Stations and Networks
	GSE/SG1/3 (Add.1) - Revision to Draft Chapter 3, Section 3.4
<u>Study Group 3</u>	GSE/SG3-SG5/2 - Proposed Procedures for a WMO Experiment
<u>Study Group 5</u>	GSE/SG5/3 - Draft Seismological and Operational Procedures for International Data Centers
	GSE/SG5/4 - Chapter 7 - International Data Centers
	GSE/SG5/5 - Level II and its use in the International Co-operative System

Fifteenth Session

AUSTRALIA/JAPAN	GSE/AUS,JAPAN/4 - Proposed amendments to Chapter 5
	GSE/AUS,JAPAN/4/Add.1 - Amendments to appendices 5A and 5B
AUSTRIA	GSE/A/18 - Focal Depths and Travel Time Curves of Austrian Earthquakes
	GSE/A/19 - The WMO/GTS-IDC Experiment 1982 - Remarks and Recommendations
BULGARIA	GSE/BUL,CSSR,HUN,GDR,USSR/2 - Suggested paragraph for progress report
CZECHOSLOVAKIA/ GERMANY, FEDERAL REPUBLIC OF	GSE/CS,FRG/4 - Final draft of Chapter 4
DENMARK	GSE/DK/10 - Comments on draft of the Third Report and informal note
GERMAN DEMOCRATIC REPUBLIC	GSE/GDR/11 - Proposal for redrafted text of Subchapter Organization of Level I data exchange
HUNGARY	GSE/HUN/13 - A mini-array within the Hungarian Telemetry Network
ITALY	GSE/ITALY/9 - New developments in the Italian Seismological telemetry network and real time data acquisition
NETHERLANDS	GSE/NETH/6 - Revision Netherlands contributions to the Third Report - Appendices
NEW ZEALAND	GSE/NZ/5 - Proposed Amendments to Appendix A.4
NORWAY	GSE/NOR/25 - Status Data Exchange Experiment
	GSE/NOR/26 - Seismological Data Exchange of the Future
USSR	GSE/USSR/16 - Observations on the Third Draft Report
	GSE/USSR/17 - New Text describing USSR network of seismic stations
UNITED KINGDOM	GSE/UK/19 - United Kingdom experience of WMO/GTS/IDC Experiment October-November 1982
	GSE/UK/20 - Level II Data Exchange, Summary of United Kingdom work to date
	GSE/UK/21 - Comments on January 1983 Draft of Third Report

UNITED STATES OF AMERICA	Three notes with comments on draft Third Report, dated 11, 14 and 15 February

<u>Study Group Papers</u>

<u>Study Groups 3 and 5</u>	GSE/SG3-SG5/3 - Results of the 1982 WMO/Prototype IDC Experiment
<u>Study Groups 2, 3 and 5</u>	GSE/SG2-SG3-SG5/1 - Proposal for GSE Experiment: Exchange and Analysis of Level I data using the WMO/GTS

Sixteenth Session

AUSTRALIA	GSE/AUS/14 - Comments on Appendix 8
AUSTRALIA/JAPAN	GSE/AUS.JAPAN/5 - Proposed amendments to Chapter 5
	GSE/AUS.JAPAN/6 - The Exchange of Level I Data Through the WMO/GTS Recommendations made in the Third Report
	GSE/AUS.JAPAN/7 - Addition to Chapter 5 - Exchange of Level I Data
AUSTRIA	GSE/A/20 - A Contribution to Appendix 5 (Chapter 5): Level I Data Transmission
BELGIUM	GSE/BELGIUM/4 - Report on the Activities of the Royal Observatory of Belgium (R.O.B.)
	GSE/BELGIUM/4/Rev.1 - Report on Recent Developments in Belgium in the Field of Detection and Identification of Seismic Events
BULGARIA	GSE/BG/11 - On the Participation in the Second Trial for Level I Data Exchange
CZECHOSLOVAKIA	GSE/CS/9 - P-wave Residuals of European Stations and Location of Seismic Events
	GSE/CS/10 - Participation of Czechoslovak Seismic Stations in the Trial Exchanges of Seismic Data - Proposal of the Text to be Included in Appendix 5C of the Third Report
GERMAN DEMOCRATIC REPUBLIC	GSE/GDR/12 - Participation in the Second GSE Trial Exchange of Scientific Data - Proposal of Text to be Included in Appendix 5C of the Third Report GSE/GDR/12/Rev - Participation in the Second GSE Trial Exchange of Seismic Data - Proposal of Text to be Included in Appendix 5C of the Third Report
	GSE/GDR/13 - Amendment to Appendix 4B. Revisions and Amendments to the Report CD/43, Add.1
GERMANY, FEDERAL REPUBLIC OF	GSE/FRG/15 - Experiments on Level II Data Transmission of the Federal Republic of Germany
	GSE/FRG/16 - Facilities for Level II Data Transmission in the Federal Republic of Germany
HUNGARY	GSE/HUN/14 - Location of Seismic Events at the Hungarian Stations
ITALY	GSE/ITALY/10 - Reporting Long Period Amplitudes in Data Exchange

JAPAN	GSE/JPN/17 - Participation in the GSE Trial Exchange of Seismic Data - Proposal of Text to be Included in Appendix 5C of the Third Report
NETHERLANDS	GSE/NETH/7 - National Report on the Participation in the Trial Experiment of Level I Data Exchange on the GTS
NEW ZEALAND	GSE/NZ/6 - Amendments to Appendix 4B, pages A4-7
	GSE/NZ/7 - Amendments to Appendices 7, 8
NORWAY	GSE/NOR/27 - The Level II Data Exchange Experiment
	GSE/NOR/28 - Continuation of Experimental Exchange of Level II Data via Computer Links
USSR	GSE/USSR/18 - Comments on the Second Draft of the Third Report of the <u>Ad Hoc</u> Group
	GSE/USSR/19 - Additional Comments on the Text of the Appendices to the Group's Third Report
	GSE/USSR/20 - Comment on the Text of the Second Draft of the Third Report
	GSE/USSR/21 - Comments by the USSR Delegation on the Third Draft of Chapters 6 and 7
	GSE/USSR/22 - Participation in the Second Experiment in the Exchange of Level I Seismic Data through the WMO/GTS - Proposed Text for Inclusion in Appendix 5C of the Third Report
UNITED KINGDOM	GSE/UK/22 - Summary of United Kingdom Experience of Data Exchange via the WMO/GTS
	GSE/UK/23 - Review and Update of United Kingdom Material for the CD/AHGSE Archive
	GSE/UK/24 - A preliminary Consideration of the Levels of Seismic Signals Detectable in a Broad Band under Noise Conditions Prevailing at United Kingdom Seismograph Sites
UNITED STATES OF AMERICA	US/GSE/26 - Preparation of Level I Parameters
	US/GSE/27 - Comments on Second Draft of Chapter 6
	GSE/US/28 - Participation in the Second GSE Trial Exchange of Scientific Data

Study Group Papers

Study Group 1	GSE/SG1/4 - Aspects of the Global System that require further Development and Testing
Study Group 2	WG/2 - Level I Data Extraction - Future Work
Study Groups 2, 3 and 5	GSE/SG2-SG3-SG5/2 - Comments on CRP/122
Study Group 5	GSE/SG/4 - Functional Description of a Computer Program for Automatic Association
	GSE/SG5/5 - Third Draft of Chapter 7
	GSE/SG5/6 - Corrections and Amendments to Appendix 7
	GSE/SG5/7 - Recommendations from Chapter 7

Seventeenth Session

AUSTRALIA	GSE/AUS/15 - GSE EXPERIMENT 1984, Summary No. 1
	GSE/AUS/16 - Proposed Australian participation in the GSE experiment
	GSE/AUS/17 (and accompaniment) - Comments on Draft 3, Chapter 5, Appendix 8 - Third Report
	GSE/AUS/18 - Proposed Australian Seismological Developments
AUSTRIA	GSE/A/21 - Comment on the Third Draft of the Third Report to the Conference on Disarmament
	GSE/A/22 - Answers to Questionnaire GSE/AUS/15 (Proposed Global Experiment 1984)
BULGARIA	GSE/BG/12 - Principal Notes on th Third Draft of Third Report
CANADA	GSE/CAN/7 - Canadian Participation in the 1984 WMO/GTS Experiment
	GSE/CAN/8 - Telephone Circuit Exchange of Waveform Data
DENMARK	GSE/DK/11 - Comments on Third Draft of Third Report
	GSE/DK/12 - Comment on GSE/USSR/23 comment No. 1
EGYPT	GSE/EGYPT/1 - Working paper on a contribution to international monitoring system using Egyptian National Seismograph Network
	GSE/EGYPT/2 - A summary of the working paper on a contribution to international monitoring system using Egyptian National Seismograph Network
GERMAN DEMOCRATIC REPUBLIC	GSE/GDR/14 - Comments on the Third Draft of the Third Report to the Conference on Disarmament
	GSE/GDR/15 - Comments on the Appendices of the Third Draft Report
GERMANY, FEDERAL REPUBLIC OF	GSE/FRG/17 - Aspects of modern developments in seismic event recording techniques
HUNGARY	GSE/HUN/15 - Preliminary location of seismic events originated from explosions
ITALY	GSE/ITALY/11 - Teleseism detection and location by the Italian National Network
JAPAN	GSE/JAPAN/18 - Comments on GSE/STUDY GROUP 3/1
	GSE/JAPAN/19 - Comments on Third Draft of Third Report

NETHERLANDS	GSE/NETH/8 - Finalization of the text of the Third Report
NEW ZEALAND	GSE/NZ/8 - Comments on Appendix 8, Annex A8-V
SWEDEN	GSE/SW/51 - E84 - An electronic mail system available for participants in the proposed GSE technical test
USSR	GSE/USSR/23 - Comments on the Third Draft of the Third Report
	GSE/USSR/24 - Comments on the Third Draft of the Appendices of the Third Report
UNITED KINGDOM	GSE/UK/25 - Suggested Definitions for Experimental Tests
	GSE/UK/26 - Notes on United Kingdom Participation in the Proposed Third Trial Exchange of Data using the WMO/GTS
	GSE/UK/27 - Comments on Working Paper GSE STUDY GROUPS 3/1
UNITED STATES OF AMERICA	GSE/US/29 - Comments on the Third Draft of the Third Report
	GSE/US/30 - Results of a Seismic Data Exchange Experiment
	GSE/US/31 - Proposed United States Participation in the planned 1984 GSE Technical Test Concerning the Exchange and analysis of Level I Data using the WMO/GTS on a Regular Basis

<u>Study Group Papers</u>

<u>Study Group 3</u>	GSE/STUDY GROUP 3/1 - Purpose and Outline of GSE Technical Test: Exchange and analysis of Level I Data using the WMO/GTS
<u>Study Group 5</u>	GSE/SG5/8 - A Program for Automatic Association and Location of Seismic Events
<u>Study Groups 2, 3 and 5</u>	GSE/SG2,3,5/2 - Outline of Procedures to be used in the 1984 GSE Technical Test (GSETT)

Appendix 3

Summaries of national contributions on recent developments in seismograph stations and networks

3A: Summaries of national seismograph developments

3B: Summaries of national developments of facilities for extraction of Level I data

3C: Comprehensive seismic noise estimates at global seismograph stations

Appendix 3A. Summaries of National Seismograph Developments

Australia

In Australia the array station at Alice Springs is operated jointly by Australia and the United States. The array is being expanded from 13 to 19 short-period vertical seismometers in boreholes, at 2.5 km spacing. A six-component SRO-type seismograph (dynamic range 120 dB) has been operational since February 1982. Array signals are transmitted digitally to the central recording and processing facility. At Mawson, Antarctica, a long-period vertical seismograph and visual recorders have been added. At the Canberra national seismological centre, data handling and connections to the GTS centre (Melbourne) have been automated. An experimental broadband digital seismograph will be installed in 1983. Extra regional stations have been installed in Western Australia, Queensland and New South Wales (1983).

Austria

Austria operates a seismograph network of 12 stations. Ten are equipped with short-period vertical seismometers, one has a three-component broad-band system, and one has a broad-band vertical seismometer. All stations have continuous recording on chart recorders. The Austrian Earthquake Service is upgrading its facilities. Within the next few years a digital network will be installed - one three-component broad-band system and 10 to 15 short-period single element or, sporadically, three-component instruments with a high dynamic range - and the data will be telemetered to the Central Institution for Meteorology and Geodynamics in Vienna. This modernization of the seismograph facilities will be a solid base for an effective participation in an international exchange of seismic data, though its original purpose is to monitor the local seismicity.

Bulgaria

Bulgaria has installed a telemetered seismological network comprising 12 stations to monitor local seismicity. Plans are being made to expand the network to 16 stations, each equipped with a short-period vertical seismometer and a two-stage preamplifier with low- and high-gain output. Both gain signals are sent by FM telemetry to the central station in the Geophysical Institute in Sofia. A long-period three-component seismograph is in operation at one station. A minicomputer system is being developed for automatic processing of the seismological data.

Canada

Canada operates a national network of more than 50 seismograph stations of various types, including digital telemetered networks in eastern and western Canada. Two of the stations that may be of particular interest within an ISDE system are the Yellowknife seismological array and the borehole seismograph near Ottawa. These two stations are being maintained in operational status with modest additional developments from time to time.

Czechoslovakia

Czechoslovakia operates a three-component broadband seismograph system with 0.3-300 second passband, 80 db dynamic range, magnetic tape recording and a data processing system. This provides the data base necessary for the study of the dynamic parameters of body and surface waves. Czechoslovakia has also undertaken a study of the accuracy of calibration curves for electromagnetic seismographs. Calculations have been made for various seismograph models to establish the effect of particular parameters on the response curves.

Denmark

One WWSSN seismograph station, Godhavn (GDH) in Greenland has been upgraded to digital recording. This station is now included in DWWSSN. Investigations in the northern parts of Greenland have shown that the geostationary satellites cannot be used for data transmission because they are too low on the horizon.

The Swedish network of 17 stations for local seismicity studies was extended into Denmark with three additional stations, thus enabling a uniform study of the border regions. The digital data recorded in Stockholm have been used together with data from supplementary graphically recording stations for studies in Denmark. A digital recorder with an automatic event detector has been tested but did not fulfil the expectations.

Egypt

Helwan station has been in active operation since 1899. Instruments have been renewed several times until 1962 when Helwan became one of the world wide standard seismological stations. In late 1975, three more stations were installed in Aswan, Abu-Simbel and Mersa-motrouh. In 1982 a plan was adopted to establish the national network which includes 20 stations distributed around the country.

As from July 1982 a radio-telemetery of nine stations covering an area of 70 x 40 km was operated in Aswan region. Data from these stations is transmitted in analog form to a center in Aswan where it is recorded, played-back and processed. In 1984, this network will be expanded to include two three-component and three single-component stations.

The Helwan seismological center receives earthquake information from all stations in Egypt including the Aswan network. In 1984 this center will be equipped with A/D converters and play-back and processing systems for precise location and magnitude determination of local earthquakes. Also in 1984, data on detected teleseismic events will be transmitted via the WMO/GTS.

Finland

The Finnish array station has been upgraded by increasing the dynamic range of the system, by standardizing the seismometer and transmission equipment and by adding new equipment and storage facilities to the digital tape recording system. In addition, there are six other seismograph stations in continuous operation in Finland. Two of them are equipped with digital recording systems.

German Democratic Republic

The GDR has maintained the three stations that report data to the international seismological community. In order to improve the chances of detecting and locating weak local seismic events by the national network, a recording and evaluation facility has been established in the past few years. For the station Moxa, use of a digital data acquisition and processing system is currently being made for research purposes. FM seismic signals are transmitted over telephone lines from Moxa to Jena, where an on-line computer provides over-all control, analog-to-digital conversion and data storage.

Germany, Federal Republic of

The FRG has installed an array of 13 broadband stations with recording at the Central Seismological Observatory Graefenberg. Three of the array stations are equipped with a three-component set of seismometers. The main purpose of the array is to record fine structure of seismic signals in the frequency-wavenumber domain with large dynamic range and high resolution within a spectral range between 1 s and 20 s. Gain-ran ed data are digitized at 20 samples per second and transmitted at 1200 or 2400 baud on telephone lines to the data center. A secondary 75 baud transmission channel is used for command codes for system control and seismometer calibration. Recording is on digital magnetic tape with additional graphic display of selectable seismometer outputs. A real-time operating system has been specially developed for and adapted to the array data acquisition, transmission and recording.

Hungary

Hungary is developing a digital telemetered network to monitor local seismicity, with a recording and analysis center at the central station in Budapest. Each of the five stations will be equipped initially with short-period vertical seismometers; at the central station the seismometer will be in a 200-m borehole to avoid high noise levels. Two stations will have long-period seismographs with digital data acquisition. Data will be radio-transmitted, initially one-way but with future plans for duplex channels. Signal processing facilities will include a front-end processor, digital-analog conversion for visual monitors and automatic phase identification, location and magnitude determination controlled by a computer. During 1983-1984, a very small-aperture array will be installed in south-eastern Hungary within the telemetry array. The array will have a diameter of 1 km and consist of five vertical short-period borehole seismometers.

India

The seismic data which may be of particular interest within a global system are those of the Gauribidanur seismic array, operated by the Bhabha Atomic Research Centre. This is a short-period array of the United Kingdom type with 20 short-period and 3 long-period seismometers spread over an aperture of 25 km in the shape of an "L". The short-period seismic data are currently recorded on both analog and digital tape, while long-period data are recorded on analog tape. A daily list of SP events detected by the Seismic Array System Processor is prepared on punched tape.

Indonesia

Indonesia operates a national network of 19 seismograph stations, 1 of which is equipped with three-component short- and long-period seismometers. Data from this network are transmitted by Telex or radio to the national headquarters in Jakarta where they are employed in locating local earthquakes and compiled for forwarding to international agencies.

Italy

Italy operates a national network of about 60 stations, 30 of which (equipped with vertical short-period seismometers) have data FM telemetered to the Center in Rome. At this center, staffed 24 hours per day, recording is carried out in parallel on continuous drum recorders, triggered chart recorders, and a triggered digital acquisition system. In the Central Observatory of Monte Porzio Catone other instrumentation, such as standard three-component short- and long-period seismometers and a new broad-band vertical seismometer with digital recording, are also in operation.

Japan

The Japan Meteorological Agency has nearly completed two projects and is implementing one that will contribute to the national earthquake prediction program, and also to the monitoring of underground nuclear explosions. The first project is to establish a real time, or semi-real time seismic data processing system. More than 100 seismograph stations have been installed on land and 4 ocean-bottom seismographs have been installed off the south coast of central Japan. However, with the current off-line processing system it takes more than one month to calculate parameters of earthquakes occurring in and near Japan. Developments will enable seismic data from most stations to be telemetered to local centers and pre-processed by mini-computer. The pre-processed digital seismograms are transmitted to Tokyo through a national meteorological system and processed by a central computer. This system will considerably reduce the time for determining earthquake parameters and enhance the detection capability. The second project is to establish a small seismic array near the Seismological Observatory at Matsushiro located in central Japan to reduce the high background noise. The array consists of seven bore-hole seismometers arranged on a circle with a diameter of about 10 km. Array processing facilities are expected to enhance the detection capability. The third project is to establish another ocean-bottom seismograph system consisting of four ocean-bottom seismographs off the south coast of central Japan.

Netherlands

The Netherlands operates a network of five stations with recording via telephone lines at the central station in De Bilt. This makes analysis of seismic events possible in real time. The vertical broadband signal of the central station and the short-period vertical signals of three out-stations are recorded on digital type. The development of automatic procedures for signal analysis is under way. The raw data for important specific events are stored on cassette tapes for rapid retrieval and display.

New Zealand

New Zealand operates a network of 35 stations which extend from Samoa to the Antarctic. Most stations are designed for study of local earthquakes, but the network includes three WWSSN stations, one DWWSSN station and one SRO station. A telemetered network of 10 short-period vertical seismographs operates near Wellington, with analog recording on film. Experiments are being made with event detection under the control of a microprocessor and more digital recording is planned.

Norway

Norway has undertaken a series of experiments to study the potential benefits of using small-aperture arrays for the comprehensive analysis of seismic events at local and regional districts. One of the NORSAR sub-arrays has been modified to a small-aperture array with six sensors. The data have been employed to study noise and signal coherencies at high frequencies, to identify crustal phases from regional events, and to detect and locate regional events. Norway has also started a project with the goal of utilizing commercially available microprocessor components to design "intelligent" field equipment for seismic data collection. The design tasks include: analog/digital conversion; prefiltering coupled with an event detector; short (daily transmission) and long term storage (tape) of detected signals; and two-way communication (via radio, telelinks or satellite) with a centrally located host computer for exchange of recordings, calibration, operational status checks and new task implementation.

Peru

Peru is operating a five-element radio-telemetered seismograph network between 11.5°S and 15°S latitude along the coastal area, with central recording located at Lima. One element of the network is 60 km offshore on an island. Each station is equipped with a short-period vertical seismometer. It is planned to expand the network to 10 elements by placing 5 additional stations across the Andes, and to install and implement a digital, real time, automatic, data processing and recording system.

Romania

Romania operates a network of 40 stations, 10 of which are equipped with telemetry systems for central recording. Installation has begun on a large telemetry network of 18 stations with analog and digital recording of data on magnetic tape. Data processing with this network will be performed in real time.

Sweden

Sweden has supplemented the Hagfors Observatory with a local network of 17 short-period stations to be used primarily for the study of local seismicity. Digital data from these stations are also being collected for the study of discrimination between local earthquakes and explosions at short distances and for study of teleseismic events. A high speed computer communication link has been established between the stations in Hagfors and the analysis facilities in Stockholm. This on-line connection is being used to gain experience with high speed data transmission and interactive computer preparation of the Hagfors bulletin.

Union of Soviet Socialist Republics

The USSR operates 250 seismograph stations in the Uniform System of Seismic Observatories (USSO). The USSO comprises base and regional networks and regional and Union processing centres. Data are telemetered from the base stations to the Union centre in Obninsk.

Stations of the USSO are equipped with a wide variety of instruments: short-, medium- and long-period. Four stations of the USSO are equipped with STSR instruments which record seismic oscillations in digital form on magnetic tape. STSR instruments are also installed at a number of regional stations. The USSR operates two stations in the Antarctic (Mirnij and Novo-Lasarevskaya).

There is a fast reporting service in the USSO and for local networks in some regions where real-time connection with regional centers has been established. The wide territorial distribution of the seismic stations permits the recording of earthquakes over an extensive range of epicentral distances and the determination of their epicentral parameters; in the case of weak shocks, only from data obtained by regional stations, and in the case of strong ones, from observations by all of the stations that have recorded a given earthquake.

The territory of the USSR has been regionalized (in total, 14 regions) so that the data can conveniently by computer-sorted and processed. In the routine processing of the USSO, hypocenter co-ordinates based on station arrival times and magnitudes based on P and L waves are determined for every earthquake. For many earthquakes, fault-plane solutions are determined from the signs of the first arrivals; for the largest earthquakes globally, dynamic source parameters such as seismic moment, stress drop, velocity of rupture propagation, source dimensions, etc., are also determined.

In the USSR, within the framework of a program being carried out for the elaboration of methods for forecasting earthquakes, a network of forecasting polygons has been established, in which complex geophysical investigations are being carried out. Test forecasting is being carried out at some polygons. The seismological network of the Soviet Union is participating in the international system of fast reporting of large earthquakes.

United Kingdom

The United Kingdom continues to operate a 20-element, 10 km aperture, short-period array station at Eskdelemuir. Experiemental broad-band data are recorded locally on analog tape and chart recorders, while selected data from the station are transmitted continuously to the Seismological Centre at Blacknest via a digital data link. The outputs of four fixed elements of the United Kingdom broad-band array are recorded continuously on digital tape, other sites of the array are used for the evaluation of seismometers under development for broad-bank operation. A network of nine stations in the United Kingdom has an aperture of around 500 km and is equipped with broad-band instruments. The stations are linked by telephone lines to the Blacknest Centre where the individual station outputs are recorded on digital tape. An associated computer system carries out automatic detection and location processes using a filtered short-period version of the network data to complement the detection log from the Eskdalemuir on-line array processor with more refined location information.

United States of America

The United States operates the United States Seismic Network which consists of 56 short-period stations in the continental United States and nine stations in Alaska and the Aleutian Islands. Data are telemetered continuously from all locations and recorded at the National Earthquake Information Service (NEIS) in Golden, Colorado. Digital data from the stations in Alaska are collected in real time at Palmer, Alaska, via a geostationary communications satellite and forwarded by the same satellite to the NEIS. Data from the continental United States arrive by leased telephone lines. The network receives long-period data from nine locations within the United States. In addition, Digital World Wide Standard Seismograph Stations (DWWSSN), which record both short-period and long-period data, are now operating at Longmire, Washington; Jamestown, California; French Village, Missouri; and State College, Pennsylvania. Other WWSSN stations are being systematically upgraded to digital stations. The United States continues to operate digital, three-component Seismic Research Observatories (SRO) at Albuquerque, New Mexico, and Guam, Marianas Islands and a High Gain Long Period (HGLP) station at Ogdensberg, New Jersey. Data from the full SRO and Abbreviated SRO network continue to be received and merged for distribution to the world-wide seismic community. Rapid, reliable transmission and recording of high-quality seismic data is one of the goals of the United States. One example of this is the Regional Seismic Test Network (RSTN) which has been installed recently in North America. This network consists of five stations: three in the United States (Tennessee, New York and South Dakota) and, by co-operative agreement, two in Canada (Northwest Territories and Ontario). This network will be operated on a research basis to develop and test high-quality, high dynamic range, broad-band digital seismographic systems in the context of general seismological problems as well as nuclear test-ban monitoring problems. Currently, data are being received at the Seismic Control and Receiving Stations (SCARS) in Albuquerque, New Mexico; at the seismic research observatory in Livermore, California; and at the prototype International Data Center (IDC) located at the Center for Seismic Studies in Washington, D.C. At the Center for Seismic Studies the RSTN data is routinely processed. Other stations and networks are operated for the development and testing of high-quality seismographic systems, for local earthquake monitoring and for earthquake prediction research. Many of these stations and networks are already operating in a digital mode and more will be upgraded to digital operation in the future.

Appendix 3B. Summaries of National Development of Facilities for Extraction of Level I Data

Australia

Australia has undertaken a one-month trial extracting Level I data from SRO analog records to demonstrate the wordload imposed by recommendations described in CD/43.

Canada

Digital telemetered networks are being expanded and developed in eastern and western Canada to monitor local seismicity. Developments at the recording and analysis centers include improved data base management and interactive graphic facilities. Experience gained with these facilities will be applicable to the analysis and management of Canadian seismic data under an international exchange system.

Czechoslovakia

The data processing system developed in Czechoslovakia performs rapid multi-channel filtering, simulation of standard seismograms and a variety of analysis and plotting functions. Polarization analysis is being used to discriminate among various seismic waves, for separating phases which cannot be distinguished on direct records, and for selection of wave groups for spectral analysis.

German Democratic Republic

The GDR has studied the principles employed in the automatic extraction of standard parameters of seismic events. They have concluded that, depending on the degree of automation and the required accuracy of the results, it is reasonable to have the results checked by a seismologist. The technique employed should have the inherent option of choosing from among several interpretations, simultaneous determination of several parameters and detection of possible misinterpretations.

Germany, Federal Republic of

The FRG has made a comprehensive study of the procedures for extracting desired data at individual stations under a range of conditions, and they hosted an informal workshop of Ad Hoc Group participants in July 1980 to demonstrate these procedures. At the Graefenberg Observatory procedures were developed for daily evaluation of digital data and the results are being published in a monthly bulletin. The interactive processing system prefilters the original broadband data in various frequency bands and produces an appropriate data format. Filters can simulate most of the common short-and long-period seismograph systems. The parameters are not automatically extracted; instead, use is made of interactive procedures whereby all computerized measurements are visually followed and controlled by a seismologist.

Japan

Japan has developed a computerized method of automatically picking the onset times of P and S waves and has conducted other research on automatic interpretation of digital seismograms. Experience has shown that it is difficult to automatically extract some of the Level I parameters from digital data in a reasonable time. A man-machine interactive method has been developed for computerized interpretation of analog seismograms. The interactive extraction of the Level I data is carried out with the analog seismogram attached to an X-Y digitizer, a video display to guide the procedure, a "menu" to guide the data extraction and read characters, and a computer system to manage the data and perform various numerical conversions.

Netherlands

As a new facility in the Netherlands, a direct connection with a B6800-Burroughs computer has been established using a terminal, videoscreen and printer. Presently, identification of waveforms is still based on analysis of analog records of the network. The new facilities will permit automatic data extraction, phase reading and instantaneous determination of azimuth, slowness, distance and epicentral location.

Sweden

In connection with a possible extension of the local seismograph network, Sweden is developing procedures for automatic on-line signal processing. The aim is to obtain computer algorithms for the automatic on-line detection and preliminary location of seismic events, and for the extraction of signal parameters for event identification. This work is focussed primarily on signal processing for automatic monitoring of local seismicity but the results should be applicable to teleseismic events.

Union of Soviet Socialist Republics

The USSR has developed facilities for automatic processing of three-component digital data to determine standard parameters for the formalized description of any wave and its coda. Signal detection is carried out on the vertical channel and three-component data for detected signals stored on disc. Results of analysis are monitored with graphic and alphanumeric displays. Filtering and polarization analysis is performed on onset signals to confirm P waves and calculate approximate azimuths and angles of incidence. Components are rotated and analysis applied to detect shear and secondary waves. All results are printed out and stored with the original signals on magnetic tape.

United Kingdom

In the United Kingdom, operations at the Eskdalemuir array include the extraction of some Level I parameters by an automatic process which involves on-line detection and beamforming. Off-line processing is carried out at Blacknest and provides onset-time, amplitude period, azimuth, velocity and noise data for each recorded event. The developments of the processor for the UKNET will include digital filtering, improvements in the accuracy of automatically-determined relative onset times, refinement of epicenter location procedures, and the provision of outputs of certain automatically extracted parameters.

United States of America

As part of its program on the design and development of a seismic data center (see also chapter 7), the United States has developed the concept of, and demonstrated to the Ad Hoc Group, a Remote Seismic Terminal (RST). The RST was developed to accommodate digital seismic data available since the previous Ad Hoc Group reports. The number of such stations and therefore the volume of data make the traditional methods of human visual inspection to extract Level I parameters (anticipated in earlier Ad Hoc Group reports) time consuming and tedious. The RST was developed to provide a technologically simple alternative and tedious. The RST was developed to provide a technologically simple alternative for handling digital data using widely available equipment. It is a microprocessor-based system which supports interactive measurement of Level I parameters and can communicate with an International Data Center to exchange data and receive bulletins. With current technology it is also possible to extend the capabilities of the Remote Seismic Terminal by connecting it to a seismometer to collect data and detect signals for subsequent parameter measurement.

Appendix 3C. Comprehensive Seismic Noise Estimates at Global Seismograph Stations

In order in future to make accurate estimates of the detection capability of a global network of seismographs, it will be necessary to have available comprehensive descriptions of seismic noise conditions at each of the stations. Accordingly all States are encouraged to assemble this type of information and deposit it with the secretariat of the CD. The purpose of this appendix is to summarize the information that has been made available to the Ad Hoc Group for currently operating seismograph stations. Copies of the referenced sources of information are available on request to the secretariat of the CD.

Country: Denmark

Station	Lat.	Long.
COP	55.68	12.43
DAG	76.77	-18.77
GDH	69.25	-53.53
KTG	70.42	-21.98

Reference: E. Hjortenberg and J. Hjelme (1980). "Seismic noise at Danish stations in relation to detection". Publ. Inst. Geophys. Pol. Acad. Sc., A-9 (135).

Summary: Monthly histograms and averages of the amplitude of vertical component, 1 Hz noise at each station for one year.

Country: Germany, Federal Republic of

Station	Lat.	Long.
GRF (array)	46.69	11.21

Reference: GSE/FRG/11, Working Paper to the Ad Hoc Group.

Summary: Average power spectra of broadband noise for 13 array sites for day and for night conditions.

Country: Hungary

Station:	Lat.	Long.
BUD	47.48	19.02
Piszkesteto	-	-
Ujkigyos	-	-

Reference: GSE/HUN/9, Working Paper to the Ad Hoc Group.

Summary: Averaged spectra of vertical component short-period noise at each station.

Country: United Kingdom

Station	Lat.	Long.
EKA (array)	55.33	-3.16

Reference: GSE/UK/11, Working Paper to the Ad Hoc Group.

Summary: Ten-day mean values of single array site, short period noise over a two and a half year period; 10-day mean values of array-sum, short period noise over a year and a half period; average spectral density of single-site and array-sum noise for noisy and quiet periods.

Country: Soviet Union

Station	Lat.	Long.
OBN	55.17N	36.60E

Reference: GSE/USSR/6 Annex 1, characteristics of micro-seismic noise of natural origin in continental areas of the USSR.

Summary: As part of the national investigations conducted in the USSR, the spectral characteristics of microseismic noise of natural origin in the continental areas of the European and Asiatic parts of the Soviet Union in the frequency range 5 to 0.01 Hz, as well as the characteristics of its fluctuations over time, have been obtained from representative material.

Appendix 4

Summaries of National Contributions on Level I Data Extraction and Technical Recommendations

4A: Summaries of national studies on Level I data extraction

4B: Revisions and amendments to the report CD/43, Add.1

4C: Recommendations by IASPEI Commission on Practice concerning amplitude and period measurements

4D: Summaries of national investigations on automatic parameter extraction

4E: Summaries of national experiments with graphic systems

Appendix 4A. Summaries of National Studies on Level I Data Extraction

Australia

During the Common Data Base Experiment (CDBE) stations Alice Springs (ASP), Charters Towers (CTA) and Narrogin (NWAO) provided data. The following conclusions are based on experiences using World Standard and SRO seismograms.

(a) There are difficulties in reading noise parameters at periods near the signal periods (i.e. in the range 0.2 - 1.0 seconds). It is suggested that ambient noise parameters are more practical and that the format for noise be the same as for signals viz: IDENT: TIME: PERIOD: AMPLITUDE.

(b) Maxima at periods, 10, 20, 30, 40 seconds are not well defined and a simple LP maximum with its corresponding period is favoured.

(c) Maxima on the horizontal components rarely occurred within a half-signal period.

In conclusion the Australian experiment recommended to reduce Level I parameters to absolute essentials in favour of enhanced availability of Level II data.

Austria

The Austrian delegate reported a proposal for the reduction of Level I parameters:

1. Broad-band recordings flat to velocity are to be preferred;

2. Instead of maximum amplitudes with periods of 10, 20, 30, 40 seconds the arrival time of the Rayleigh wave maximum and its period are found to be excellent indicators for the focal region of earthquakes with normal foci. Moreover surface wave magnitude M_S is optimally determined from $(A/T)_{max}$ of the Rayleigh phase.

Finland

Level I data extraction made from three-component SP and LP analog seismograms at stations NUR, KJF, and KEV was restricted to contain phase arrival time, P-wave amplitude and period, surface wave amplitude and period, and noise level preceding the first P-wave onset.

The study was scheduled in accordance with the CDBE during the time interval 1 - 15 October, 1980.

The Finnish report specifically recommends reading of surface wave arrivals from maximal peaks.

Germany, Federal Republic of

Using recordings from the Central Seismological Observatory Graefenberg the Federal Republic of Germany extracted and reported the whole set of Level I parameters during the CDBE period 1 - 15 October, 1980. Using a partly automated procedure recordings of one day could be analysed within four hours.

Particular conclusions from this experience are

(i) that the correction of onset times due to instrumental time delays needs further consideration;

(ii) that the first motion of P arrivals should have the same sign for SP and LP instruments. If they are reported differently this indicates a misreading due to low signal/noise ratio and should therefore carefully be considered;

(iii) that onset times of Rayleigh and Love wave trains as well as maximum amplitudes with periods of 10, 20, 30 and 40 seconds are hard to read.

Japan

Japan (and also New Zealand) taking part in the CDBE propose an abbreviated reporting for local events because the large amount of Level I data will be a burden to WMO/GTS. For example, the number of recordings obtained by the Japanese network for local events amounts to 200 for about 15 local shocks a day on the average.

The following proposal is offered for consideration:

1. In the case of a main shock and after shock sequence, all events with magnitude above a threshold 2 units less than that of the main shock should be reported in full.

2. In the case of a swarm, with no clearly defined major event, the threshold should be 1 unit less than the magnitude of the largest event which has occurred at the time of reporting.

3. All smaller events that are above the detection threshold defined by the local agency may be reported in abbreviated form, using the double parentheses comment feature of the International Seismic Code.

Netherlands

The manual extraction of the complete Level I data from analog records during the CDBE, according to accepted formats, has appeared to be very time-consuming. For the reporting on a routine basis the list of requested parameters should be considered carefully and, if possible, reduced and revised without missing the vital information needed for identification purposes of especially small events.

New Zealand

The delegation of New Zealand proposed the inclusion of T-phases in Level I data exchange. Concern has been expressed many times within the Ad Hoc Group about the lack of seismograph stations and the lack of detection ability in the Southern Hemisphere. It is stated, that T-phases, however, propagate well in the ocean, with little attenuation and are often clearly visible on short-period seismographs at coastal stations as an extremely harmonic wavetrain. The International Seismic Code allows the reporting of T-phase arrival times. Amplitude and period data could follow, as specified in CD/43. New Zealand also proposed, jointly with Japan, a scheme of abbreviated reporting for large local sequences (see Japan section above).

Sweden

Practical experience with Level I data extraction was obtained from the preparation and development of the CDBE. This work indicated that some parameters may not be of great practical value. Similarly parameters not listed at present may be of great potential use. It was found that data giving the direction of recorded surface waves could be of significant value in the association procedures. Before any revision of the current parameter list is carried out, however, it will be necessary to acquire practical experience with this as well as other parameters.

Surface waves were recorded for many events for which no short period data were available. Many of these events were in the Southern Hemisphere.

Union of Soviet Socialist Republics

The USSR has experience of visual extraction of parameters of Level I data at seismic stations. The following conclusions may be drawn from the research carried out:

(i) No fundamental difficulties arise in measuring the full set of Level I parameters from seismograms, but the services of an additional operator are required;

(ii) At the present state of research, no revision of Level I parameters is justified;

(iii) Attention is called to:

(1) the problem of arrival time delay due to the effects of instrument characteristics;

(2) the low precision in determining surface wave arrival times and the separation of Rayleigh waves and Love waves;

(3) experience with successful measurement of surface wave amplitudes at 10, 20, 30 and 40 seconds;

(4) determination of Level I parameters at digital stations consistent with the procedures at analog stations.

United States

The US delegation submitted the largest data set to the CDBE. Data were collected from 25 seismic stations, most of which are digital Seismic Research Observatories installed by the US during 1976 - 80 and operated by the host countries.

The United States provided Level I data reports according to the Swedish delegation instructions. Accordingly, the number of Level I data was reduced to approximately 10. Because of the time that would have been required to accommodate the various formats of the digital data, analog data was used to prepare Level I data for the two week period. Over 900 seismograms were individually scanned for signal detection and Level I parameter extraction. Digital data for two days of the data collection period were processed to compare the performance of Level I parameter measurement using analog data and digital signal processing methods.

Appendix 4B. Revisions and Amendments to the Report CD/43, Add.1

As a result of discussions on national reports which were summarized in the previous chapter the following revisions of proposed procedures and addition of new parameters were adopted by the Ad Hoc Group (refer to: Second Report of the Ad Hoc Group, CD/43/Add.1, 25 July 1979; Appendices):

(a) Add.1, p. 4, last sentence of the top paragraph should be replaced by: "Theoretically the first onset should have the same sign on SP and LP instruments. However, due to different noise conditions, frequency response and magnification of SP and LP recordings the first motions do not need to agree, particularly for multiple events starting with weak arrivals. In the case of a discrepancy in the directions, the reasons should be checked by the operator before the information is reported."

(b) Add.1, p. 5, item 6 (seismic noise amplitude), the words "at a frequency close to that of the signal" should be replaced by "at frequencies between 0.5 and 1 Hz".

(c) Add.1, p. 8, item 25, precision of time reading should be 1 s instead of 0.1 s.

(d) Add.1, p. 10, item 40 (see also CD/43 p. 11), the following explanation should be added: "The amplitudes associated with defined periods are difficult to read from paper records, however, they can be obtained by analysis of magnetic tape records."

(e) Add.1, p. 11, item 45, add: "The Love wave and Rayleigh wave arrivals can be found more easily by separating the radial and transverse components which can be achieved with digital records."

(f) Add.1, p. 12, qualitative remarks: It is recommended to introduce instead of the description of local and regional events a more detailed classification permitting to use simple identifiers of the wave forms as follows:

LA - Local event within a very short distance, not possible to separate P and S phases

LB - Local event within a short distance, P and S separated but S-P interval less than 20 sec, i.e., focal distance less than about 160 km

R - Regional event somewhere between 2° and 20°, i.e., the wave pattern is influenced by waves travelling between the crust and the 20° discontinuity

TA - Teleseismic event, weak, a simple seismogram with largest amplitudes within first few seconds

TB - Teleseismic event, seismogram is made up of more than one discrete arrival

TC - Teleseismic event with a complex waveform made up of many arrivals (phases) of different amplitude, onsets difficult to interpret.

Appendix 3.2 of CD/43 is now superseded by the IASPEI recommendations reproduced in Appendix 4C of this report.

New parameters

It is suggested to include the T-phase in data exchange. The T-phase propagates in the ocean with little attenuation and is clearly recorded on SP seismographs even from events of low magnitude. The reporting of T would significantly augment the detection ability of coastal stations in the Southern Hemisphere in relation with tests in oceanic areas. In messages the arrival time of the T-phase can be reported using the International Seismic Code, and then followed by period and amplitude measured as specified in CD/43 for other phases.

It was recommended to rewrite the paragraph on very large earthquake sequences in the middle of p. 15, CD/43, as follows:

"During an especially large local earthquake sequence, it would be allowable to give a general description of the seismic field, such as 'a local sequence took place between (time A) and (time B)' without supplying individual readings at Level I. This abbreviated reporting may be used for aftershocks which are smaller by two magnitude units or more than the main shock of the sequence, i.e., $M < M_{max} - 2$, and in the case of a swarm if $M < M_{max} - 1$."

Appendix 4C. Recommendations by IASPEI Commission on Practice concerning Amplitude and Period Measurement

Adopted at Canberra
1979

IASPEI COMMISSION ON PRACTICE

SUB-COMMISSION ON MAGNITUDE

Instructions for Measuring and Reporting Amplitudes and Periods for Magnitude Determination from Observations at Regional and Teleseismic Distances

The determination of earthquake magnitude is based on observations of amplitude A and period T of seismic waves. It is essential for subsequent earthquake studies to report the time that an observation of A and T is made.

The amplitude of a seismic signal on a record is defined as its deflection from the base-line. It is important that A, T, and the time of the observation should be measured for P, S, and surface waves.

For many phases, and particularly in surface waves, the record is symmetrical about the base-line and amplitude may be determined either by direct measurement from the base-line or by halving the peak-to-trough deflection. For phases that are strongly asymmetrical the amplitude should be measured as the maximum deflection from the base-line.

The amplitude and period from the vertical component is the most important. If horizontal components are available, readings from these should be also reported. When such readings are reported, they should be measured at the same time on the record so that the amplitudes can be combined vectorially.

The period T corresponding to amplitude A is measured in seconds between two neighbouring peaks, or two neighbouring troughs, or from trace crossings of the base-line.

P WAVES

The P wave amplitude measured should be that of the maximum trace deflection, usually within the first 25 seconds of the first onset or before the arrival of the next clear phase, but this interval may be extended up to 60 seconds for large earthquakes recorded on broad-band instruments. When more than one component is available, the amplitude from each should be reported separately.

The observation time should always be measured as the time to the first peak or trough of the trace cycle being measured. This need only be estimated to the nearest 1 to 2 seconds. The amplitude measured on the record should be converted to ground motion in nanometres or some other stated SI unit, using the amplitude-period response curve of the instrument. When several instruments of different frequency response are available, the amplitude and period from each should be reported separately.

S WAVES

The measurement of amplitudes and periods on the seismogram is performed as described above. It is recommended that the beginning of the S wave be checked against travel-time tables. The amplitude and period should be selected in the interval up to 40-60 seconds after the beginning of S waves.

SURFACE WAVES

For surface waves the measurement of amplitudes, periods and times of observation on records is performed as described above for the maximum deflection from the base line. If the maximum deflection does not occur in the period range 17-23 seconds, then the largest deflection within this range should also be reported for tele-seismic distances ($\Delta > 25^{\circ}$).

For large earthquakes when mantle waves are often recorded, amplitudes and periods of the vertical and horizontal components with the period in the neighbourhood of 200 seconds should also be measured.

* * *

The observations of A and T for all waves mentioned above should be included in station reports. It is essential in reporting such observations that the type of instrument used is clearly stated. For this, the classification given in the Manual of Seismological Observatory Practice may be used. Broad-band instruments are preferred for all measurements of amplitude and period.

NOTE: Seismograms can be very complicated and, ultimately, the selection of a particular measurement must be left to the observer's experience.

Additional considerations for local earthquakes

TRACE AMPLITUDE MEASUREMENT

On some types of short-period instruments it is not possible to measure the period of seismic waves recorded from close events, and thus to convert trace deflection to ground motion. In such cases magnitude scales may be used which depend on measurement of trace amplitude.

DURATION MEASUREMENT

For local earthquakes, stations should report the signal duration defined as: the time in seconds between the first onset and the time the trace never again exceeds twice the noise level which existed immediately prior to the first onset. Very often local earthquake recordings will cause high-gain, short-period instruments to saturate, thereby making an amplitude reading impossible even for small seismic disturbances. Therefore, to provide data from which to derive relations between magnitudes based on duration and those based on signal amplitude, both types of observations should be made of as many of the same earthquakes as possible.

Appendix 4D. Summaries of National Investigations on Automatic Parameter Extraction

Working papers of several delegations discussed a general philosophy of automatic parameter extraction. In the following those national investigations are summarized which are based on actual teleseismic data because automatic location procedures for local events are well known for many seismic areas (e.g. California, Italy, Japan).

Norway

At the Norwegian Seismic Array (NORSAR) an automated procedure for determination of arrival time, amplitude, and period of teleseismic events has been implemented successfully. The parameter extraction is done on unfiltered traces for signal-to-noise ratios above a given threshold, otherwise a filtered trace is used. In the latter case, the filter distortion effect is compensated for. The best estimate of the parameters is extracted by using an iterative process. Conventional STA/LTA-ratio is used in the detection algorithm, the start of the first detection is the initial estimate of arrival time. Signal amplitude and period are automatically extracted after defining appropriate windows. The procedure has been refined to a level where the measured parameters are changed by the analyst only rarely.

United Kingdom

The United Kingdom has installed a Seismometer Network Analysis Computer (SNAC) to automate the detection and location processes using a network of single element broad-band stations. The basic program is an on-line system which gives arrival times and calculated epicenters. For each event a file of Level II data is stored containing 60 seconds of waveform data from about 10 seconds before the onset together with details of the processing and system status at the time.

Union of Soviet Socialist Republics

The USSR has experience of automatic extraction of Level I parameters characterizing P-waves via a short-period recording channel: A_i, T_i and t_i (i = I, ..., 4), where A_i = maximum amplitudes (NM), T_i = periods (seconds) corresponding to amplitudes A_i, and t_i = relative moments of arrival of amplitudes Al at intervals of 0-6, 6-12, 12-18 and 18-300 seconds from the moment of arrival of the P-wave.

The analysis carried out established that the selection and extraction of these parameters proceeds without distortion up to a certain threshold signal-to-noise ratio.

In the automatic analysis of signals for which the signal-to-noise ratio is below the threshold, noise first has a distorting effect on the signal parameters A_4, P_4 and t_4, and then on A_3, T_3 and t_3, and so forth.

The introduction of frequency filtration in order to suppress low-frequency noise makes possible automatic distortion-free extraction of all the parameters in question at smaller signal-to-noise ratios.

United States of America

During the Common Data Base Experiment (CDBE) conducted by Sweden the United States compared the performance of Level I parameter measurement using manual and automatical techniques. For two days of this period (2 and 4 October) a detection algorithm was run, followed by a post-detection processor which automatically measured the signal onset time, its maximum amplitude and corresponding dominant period. At the beginning the automatic algorithm attempts to classify a detected event as local, regional or teleseismic. The assignment is made on the basis of frequency content by comparing the power in the 3-8 Hz band to that in the 0.3-1 Hz frequency band. After this distance determination the signal is high-pass filtered (cut-off at 2 Hz) for local arrivals and band-pass filtered (0.8-3 Hz) for the others. A short to long term average comparison (STA/LTA-ratio) is then used to determine the signal onset time, and the rate of increase of STA immediately after the detection is used to decide whether the signal is impulsive or emergent. For impulsive arrivals the first motion (compression or dilatation) is determined. The maximum peak-to-trough amplitude and the corresponding dominant period during the following six seconds are obtained and the amplitude corrected to ground motion.

Studies with the automatic parameter measurement algorithm have shown that it can at present provide an onset time within one second of what an analyst would choose for 90 per cent of the signals it designates as impulsive and for about 70 per cent of those it considers emergent. Since the automated procedure applies the same objective criteria in evaluating the arrivals on all seismograms, its picks are more consistent than those of human analysts as first comparisons for the previously-mentioned two days-period have shown. Its chief drawback at present is reported to be its inability to identify secondary phases such as S from local events and depth phases.

Appendix 4E. Summaries of National Experiments with Graphic Systems

Germany, Federal Republic of

In a national demonstration the Federal Republic of Germany showed an interactive processing system to extract Level I parameters from the Graefenberg digital broad-band data. The Interactive Processing System (ISPLOD) preprocesses the original broad-band data mainly automatically to minimize the time needed for the evaluation of the large number of Level I parameters. At any stage the analyst can interactively control and correct the automatic process using a graphic screen.

The main elements of the ISPLOD-program are:

- The organization of the procedure which controls program execution. Usually it contains a supervisor program to link different program segments or executable subroutines.

- The preprocessing and graphics part of the procedure which inputs the seismic data and performs error checking. The preprocessed data are normally stored on disc and visualized on the graphics terminal.

- The analysis and output part of the procedure which includes all subroutines for parameter extraction. This is the most important segment of the software where identical algorithms have to be used to get compatible results.

Japan

A computer program has been developed to extract Level I parameters from analog recordings by a man-machine interactive method in the Seismological Division, Japan Meteorological Agency. The system consists of a mini-computer with x-y digitizer and usual peripherals. The measurement of Level I parameters proved to be successful. Compared to conventional manual practice the system remarkably reduced the operation time.

Sweden

At the Hagfors Observatory a graphic display system has been used for sometime for off-line analysis. This system which is connected to a VAX 11/750 allows extensive manipulation of signals like expansion of time and amplitude scales. Many traces can also be handled simultaneously on the screen. In addition, filtering and spectral computation can be applied to enhance signal-to-noise ratios. The system produces easy access to signals and makes it possible for an analyst to make accurate measurements of parameters like arrival times and amplitudes. The possibility of easy and quick crosscorrelation between traces also facilitates the interpretation of secondary phases and other characteristics of the seismic signals. The arrival times could optionally be determined automatically from prediction-error filtered signals.

United States of America

As part of a national investigation, an interactive Remote Seismic Terminal (RST) has been developed. The RST is a low-cost, micro-processor-based system which, in addition to providing data communications with an international data center, can be used to interactively analyse and prepare data from local stations. The basic RST configuration would include a processor, disk storage, video terminal, graphics display, printer, and telephone circuit modem. Additional data storage and peripherals could be added for special purpose applications.

Appendix 5

Basic features of the Global Telecommunication System (GTS) and summaries of national contributions on Level I data transmission through the GTS

5A: Basic features of the Global Telecommunication System

5B: Authorization and recommendations by the WMO for using the GTS

5C: Summaries of national contributions to the WMO/GTS technical tests

Appendix 5A: Basic Features of the Global Telecommunication System

General descriptions of some aspects of the Global Telecommunication System (GTS) have been given previously in the reports CCD/558, CCD/558/Add.1 and CD/43. This summary itemizes those features which are relevant to the exchange of seismic data, particularly as they might apply to an international exchange proposed by the Ad Hoc Group of Scientific Experts. Detailed instructions for this purpose are given in Appendix 8, Chapter 2.

The main features of the GTS in this context are:

- It is a world-wide communication network established and operated jointly by the 157 member States of the World Meteorological Organization (WMO).

- Its primary objective is the distribution and exchange of meteorological messages every three hours (at and after 00, 03, 06, 09, 12, 15, 18, 21 hours UTC); it operates 24 hours a day.

- Usually there is spare capacity during the two hours preceding the meteorological exchanges, and arrangements have been made for the transmission of seismic messages during those intervals (see below).

- The basic elements comprise a Main Telecommunication Network (MTN), regional networks and national networks. The nodes of the system are located at World Meteorological Centres (Melbourne, Moscow and Washington), Regional Telecommunications Hubs and National Meteorological Centres.

- States provide and fund their own national centres, and share the costs of exchanging messages with adjacent States.

- The equipment at centres, and the quality of communication circuits is not uniform. Equipment varies from automatic computerized message-switching systems to manually switched telex systems. Circuits vary from 50-baud lines to 9,600 bits per second links.

- Procedures for using the GTS, formats of messages and codes for texts are specified and approved by the WMO; they must be adhered to strictly.

The Eighth (four-yearly) Congress of the WMO (1979) agreed in principle to the use of the GTS for the transmission of seismic data by the Ad Hoc Group. Under this agreement, and after receiving specific approval from the Secretary-General/WMO, the Ad Hoc Group conducted two trial exchanges in 1980 (October-November) and 1981 (November-December).

As a consequence of these trials the need was found to conduct additional experiments utilizing the GTS on a more regular basis. Consequently, the Committee on Disarmament, through a letter from its Chairman to the Secretary-General of the World Meteorological Organization (WMO) requested the WMO to take steps to make necessary arrangements to enable the Ad Hoc Group to continue to utilize the GTS on a regular basis for the transmission of seismic data in order to detect and identify seismic events. (Reference: CD working paper No. 73 of 26 August 1982).

The Commission for Basic Systems of the WMO at its eighth session in Geneva, 31 January to 11 February 1983, adopted a recommendation which was to be submitted for approval to the WMO Congress and Executive Committee in May/June 1983. In the General Summary of its Final Report the Commission stated, inter alia:

- The Commission was of the opinion that the GTS should be used for the global exchange of seismic Level I data only and Members should be urged to ensure reliable and efficient transmission of seismic bulletins on the GTS. However, it was also of the opinion that the GTS should not be used for exchange of the much more detailed seismic Level II data because of its very large volume.

- The Commission agreed that the implementation date of global exchange of seismic data will be 1 December 1983.

- The Commission felt that detailed telecommunication arrangements should be made between the GTS centre and national seismological centres in each country in order to ensure efficient exchange of seismic data between the two centres concerned.

- The Commission requested the Secretary-General to maintain close co-ordination with the Ad Hoc Group of the Committee on Disarmament and to arrange for periodical monitoring exercises as appropriate with a view to improving, as necessary, the efficiency of the exchange of seismic data on the GTS.

The recommendation of the WMO Commission for Basic Systems was subsequently approved by the WMO Ninth Congress. Thus the Ad Hoc Group, beginning 1 December 1983, has the formal approval necessary for regular utilization of the GTS for Level I data transmission.

Appendix 5B. Authorization and recommendations by the WMO for using the GTS

LETTER DATED 15 JUNE 1983 ADDRESSED TO THE CHAIRMAN OF THE COMMITTEE ON DISARMAMENT FROM THE SECRETARY-GENERAL OF THE WORLD METEOROLOGICAL ORGANIZATION (WMO) 1/ 2/

I have the honour to refer to your letter of 31 August 1982 concerning the use of the Global Telecommunication System (GTS) of the World Weather Watch (WWW) on a regular basis for the transmission of specific data for the detection and identification of seismic events.

As I informed you by WMO letter No. 52.635/W/SY/T.3.4 dated 6 September 1982, the necessary arrangements for this matter have been made by the eighth session of the WMO Commission for Basic Systems which met in Geneva in January/February 1983.

The WMO Executive Council at its thirty-fifth session, held in Geneva in May/June 1983, approved Recommendation 18 (CBS-VIII) - Inclusion of seismic bulletins in the global exchange programme - and decided that this should be implemented as soon as possible, but not later than 1 December 1983. You may wish to bring the above information to the attention of the *Ad Hoc* Group of Scientific Experts to Consider International Co-operative Measures to Detect and Identify Seismic Events.

I avail myself of this opportunity, Mr. Chairman, to extend to you the expression of my highest consideration.

(*Signed*) A.C. Wiin-Nielsen
Secretary-General

1/ The text of this letter is contained in Working Paper No. 99 of 20 June 1983.

2/ This letter is in reply to the letter dated 31 August 1982 from the Chairman of the Committee on Disarmament, the draft of which is contained in Working Paper No. 73 and which the Committee approved at its 183rd plenary meeting on 31 August 1982.

DOCUMENT SENT BY THE WORLD METEOROLOGICAL ORGANIZATION (WMO)
FOR SUBMISSION TO THE SIXTEENTH SESSION OF THE AD HOC
GROUP OF EXPERTS 1/

USE OF THE WMO GTS FOR EXCHANGE OF SEISMIC DATA

As reported in the fifteenth session, the WMO Commission for Basic Systems at its eighth session adopted Recommendation 18 (CBS-VIII) concerning "Inclusion of seismic bulletins in the global exchange programme". The WMO Executive Council at its thirty-fifth session (Geneva, May/June 1983) approved this recommendation and decided that the amendments in Recommendation 18 (CBS-VIII) should be implemented as soon as possible, but not later than 1 December 1983.

The above-mentioned decision will be notified to all WMO Members in due course.

It is recommended, therefore, that national seismological authorities should contact their national meteorological authorities in order to make the necessary telecommunication arrangements. In particular, detailed telecommunication arrangements should be made between the GTS centre and national seismological centre in each country in order to ensure efficient exchange of seismic data between them, namely arrangements concerning working hours of the telex or other communications between two centres should be made in order to ensure the smooth transmission of data and to avoid an unacceptable workload at the GTS centres.

It should be borne in mind that the GTS should not be used to exchange the much more detailed seismic level-II data.

1/ This document has been submitted to the Ad Hoc Group as Conference Room Paper No. 119.

Appendix 5C. Summaries of national contributions to the WMO/GTS technical tests

The *Ad Hoc* Group conducted two global trial exchanges of routine seismological data: a pilot exchange in 1980, which emphasized the need for a well-documented set of procedures; and a more widespread exchange in 1981, to further test the procedures. Additionally, a dual-purpose, multilateral experiment in 1982 gave more practical experience with the GTS. These have led to the compilation of detailed procedures for the use of the GTS for seismic data exchanges (Appendix 8, Chapter 2).

Full details of the national contributions to the GTS trial exchanges have been reported in about 50 papers (Appendix 2): the following summarize the participation and experiences of each State.

Australia

Australia organized the two trials (with Japan), provided liaison with the WMO/GTS Secretariat, compiled guidelines for the second trial (GSE/AUS/9), and took part in both trials.

Messages were sent from two "national" seismological centres, one in eastern and one in western Australia, to the World Meteorological Centre, Melbourne for insertion into the GTS. During the 1982 multilateral experiment, the National Seismological Centre at Canberra simulated a network of southern hemisphere stations, which entailed the daily transmission of large quantities of Level I data (GSE/SG3-SG5/3).

In both GTS trial exchanges the percentage of messages received from Australia was unacceptably low - average 55 per cent in the second trial - despite the use of correct GTS procedures and message-headers by the seismological centres. Where the causes could be traced to local failings, they were attributable to a lack of fully automatic, duplex connections between seismological and GTS centres. However, many losses occurred outside Australia, and the exact causes were not established.

As a result of these experiences, automated connections and procedures are being introduced between the Canberra (seismological) and Melbourne (GTS) centres. Also it is intended to use regional networks of the GTS for routine seismic data transmissions.

Austria

The seismological service has direct access to the WMO/GTS, and for several years seismic data have been exchanged regularly with other countries, some outside Europe. Early in 1980 the availability and success rate of seismic messages in Vienna was analysed (GSE/A/6) and the results were encouraging.

Austria took part in both trial exchanges, and concluded that the unsatisfactory result of the 1980 trial was not due to the GTS: the preparation time was too short, and some participants were inexperienced with the GTS.

The results of the 1981 trial were better but still unsatisfactory, mainly because some countries established contact with GTS centres too late, or not at all; this meant that GTS computers could not be reprogrammed, or were adjusted after the start. The success rate varied between 0 and 100 per cent, depending also on whether messages were transmitted during main or intermediate synoptic times.

The Austrian experience with the use of the GTS is that after obtaining official permission to use it and after this permission is published in the WMO Manual (WMO - No.9.TP.4, Ch 1), satisfactory exchanges can be expected provided participants consult their GTS hubs and follow WMO rules strictly.

Belgium

Belgium has been using the WMO/GTS for routine seismological data exchanges for more than 30 years.

It took part in the second trial, at which time the Seismological Centre of the Royal Observatory, being connected to the Common Computer Facilities at Uccle, was able to transmit its seismic data directly through the link of the Meteorological Institute to the GTS.

This connection worked satisfactorily and 22 messages were transmitted. However only a few inwards messages from other countries were received.

The Institute is ready for full co-operation with the Observatory and seismic messages can be inserted via the permanent computer link at any time.

Bulgaria

Bulgaria participated in the second trial exchange with data from station Vitosha (VTS). The messages were elaborated for experimental transmission of seismological data on the WMO/GTS channels. The exchange in Bulgaria was realized on two circuits. Circuit "A" ensured the data transmission within the country and circuit "B" (with starting/end point - the National WMO/GTS Centre in Sofia) - the glocal circulation of the messages.

In total, 11 seismological messages were prepared at the National Seismological Centre in Sofia, 10 of which were sent by the National WMO/GTS Centre for global circulation.

In total, 244 messages from the other participants in the trial were received in Sofia at the National WMO/GTS Centre and at the National Seismological Centre respectively. This corresponds to the average success rate of over 60 per cent. Messages from some countries were not received at all, whereas from some other countries the complete number of messages was received and documented.

It was observed that the average success rate of transmission of messages between National WMO/GTS Centres, located along the Main GTS trunk circuits was higher than 80 per cent.

Czechoslovakia

Czechoslovakia did not take part in the First Trial Exchange with special messages, but the Level I Data of the Czechoslovak Stations PRU and KHC made on routine basis were involved in the final treatment. According to the analysis of this Trial, among the 59 stations selected for processing, the quality of observations of the two Czechoslovakian stations was comparable with the data prepared by the official participants of this experiment.

Owing to the importance of this type of experiment for further progress Czechoslovakia participated in the Second Trial by transmitting messages in the format required for Level I Data. Considering the fact that this trial exchange was focussed rather to testing the transmission capacity and reliability of the WMO/GTS, than to verifying the detection ability of the individual stations, Czechoslovakia participated only with the central station PRU, although the station KHC has better conditions for recording weak seismic signals. During the experiment 23 messages were transmitted. No failures of transmission and reception occurred in the national links. A very good quality of the transmitting channels of the WMO/GTS for Level I Data was proved.

The results of both trials demonstrated their usefulness for the further development of the individual seismic stations participating in the global network. Further experiments are recommended to improve and to supplement final instructions.

Denmark

In Denmark the seismograph stations are operated by the Geodetic Institute whereas the communication with the WMO/GTS is maintained by the Meteorological Institute.

Received SEISMO messages are routinely relayed by public telex to the Geodetic Institute, where they are accumulated in a computer file usually covering one month of data.

During the trial exchanges the test messages arrived together with the routine messages. The increased load created some problems because punched paper tape is used as the link between the meteorological computer and the telex as well as between the telex and the geodetic computer. Punched paper tape is not sufficiently reliable. Hardcopies of received but not telexed messages were mailed by the Meteorological Institute.

After the second trial in 1981 a special cdgse file was established but due to many errors or missing parts the accumulated files had to be edited manually before extraction and merging.

Copies of the received messages have been distributed to the sender countries. Photocopies of the "mailed" messages have also been distributed. The convenors and the scientific secretary have received complete copies of the material.

Tables summarizing the number of received and non-received messages during the second trial have been distributed.

During the second trial special cdgse bulletins were sent five days a week at a fixed hour. According to an arrangement with the Meteorological Institute these messages were sent to a telex number connected directly to the meteorological computer. With an introductory director the messages were automatically transmitted to the GTS. A list of transmitted bulletins has been distributed.

After the trial the Geodetic Institute continues to transmit bulletins to the GTS. These routine bulletins are sent semi-weekly with the preliminary readings from the Danish stations.

Finland

Finland took part in the first and second trial exchanges. Altogether 68 seismic messages were sent by telex from the Finnish seismic data centre to the national WMO centre in Helsinki for further transmission through the WMO/GTS. During the second trial the computer of the national WMO centre was programmed to receive and to store all the arriving seismic messages automatically on magnetic tape. The study based on these tapes indicated that in the average about 80 per cent of all messages reported to be sent by the participating countries were received in Finland. The loss percentage was higher during the weekends, when only a few messages were transmitted. Exceptionally high loss of messages was found during the period 29 November - 3 December when about half of the sent messages were not received in Finland.

German Democratic Republic

The German Democratic Republic participated in the second GSE trial exchange of seismic data 1981 through the stations at Moxa and Berggiesshuebel. Level I data were transmitted as within the framework of routine international co-operation for the determination of focal parameters. The messages were formatted according to the guidelines given for the experimental transmission of seismological data on the GTS. They were telexed for global exchange to the WMO/GTS terminal of the GDR Meteorological Service at Potsdam twice a week in accordance with established reading schedules at the stations. Incoming messages were transmitted in printed form from this terminal to the Central Institute for Physics of the Earth at Potsdam. No failures of transmission and reception occurred in the national links. The total of messages sent was 22, that of messages received 224, i.e. 56 per cent. The total of messages received from the individual participating States ranged from zero to 100 per cent.

Germany, Federal Republic of

The main reasons for the Federal Republic of Germany participating in the first and second trial exchanges of seismic data on the WMO/GTS were:

- to contribute to the general objectives of the tests
- to gain experience in handling seismic traffic between the Seismological Observatory at Erlangen and the national GTS centre Offenbach
- to test procedures for monitoring incoming seismic messages and handling requests for retransmission of missing data
- to develop automatic procedures in order to reduce errors caused by manual interaction
- to test the quality of the telecommunication system with respect to transmission errors and messages transit time between national and international facilities.

Results from the first and second trial exchange were compiled and analysed in the working papers GSE/FRG/10, GSE/FRG/13 and GSE/FRG/14. The over-all reception rate for seismic messages in the experiments was 72 per cent and 86 per cent, respectively. In the second test in a few cases a success rate of 100 per cent was achieved for received messages. The excellent results can be attributed to the support provided by the national GTS centre Offenbach, which is a regional telecommunication hub (RTS) of the WMO/GTS main trunk.

The main conclusions which have been drawn from the tests can be summarized as follows:

1. The ability of the WMO/GTS to transmit seismic data has been proven in principle.
2. Results of another short-term experiment are not expected to be substantially better than those gained in the second test.
3. Further improvements in the reliability of the WMO/GTS can only be achieved if the network is used on a regular basis.

4. A future long-term experiment (several months) should simulate as closely as closely as possible all elements of Level I data exchange on the WMO/GTS as foreseen in the envisaged global system.

Hungary

In the main trial exchange in 1981 Hungary sent messages once a week in the format adopted for the exchange. Outgoing messages were well received in most countries (on average 81 per cent), but only a few incoming messages were received by the national GTS centre at Budapest, (19 per cent).

It is expected that the latter deficiency will be remedied in a future exchange if sufficient notice is given to all GTS nodes.

Italy

Italy participated in both trial exchanges.

Messages containing Level I data from stations MNS (SP Readings) and RMP (LP readings), which constituted part of the information routinely sent to International Centres, were telexed for global exchange to the WMO/GTS terminal of the Italian Meteorological Service in Rome. Incoming messages were obtained in printed form from the same terminal.

According to the information provided by experts of other delegations, in both trials several messages were not received by any country at all. This indicated deficiences in their headings which prevented them from leaving Italy.

As for inwards messages, in the first trial 54 per cent were received from 10 countries, and in the second trial 48 per cent from 20 countries.

The results demonstrated that improvements must be made in the arrangements for transmitting and receiving messages at the Rome WMO/GTS.

Japan

During the first trial data exchange, the Seismological Observatory (MAT) at Matsushiro transmitted 23 messages for the purpose of the trial, in addition to the usual daily data transmission to USGS.

All messages received at JMA, a regional telecommunication hub (RTH) of GTS, were printed out on a printer in the Seismological Division of JMA over the test period. 755 messages including usual seismic messages were received and switched at the regional hub.

During the first trial, a total of 208 messages were sent and 157 messages were received with success rates varying from 14 to 100 (total 75) per cent.

During the second trial, 40 messages were dispatched from MAT to the RTH of the WMO/GTS at JMA, where they were automatically switched to Melbourne and Washington.

Comparison of the success rates obtained from the first and second trial indicated a remarkable improvement. During the second trial, a total of 420 messages were sent and 368 messages were received with success rates varying from 42 to 100 (total 88) per cent. The over-all high success rate may be attributable to arrangements which were conducted by a national GTS centre and seismic centre in each country prior to the trial.

Estimating the message transit time was a main object in the second trial. The transit time for each message was calculated by using the time in the message headings and was varying from 5 to 97 minutes.

Messages received by Tokyo were compared to the corresponding message copies sent from individual participating countries. Errors were found out by the visual comparison, and the error rate was 5×10^{-4}.

Most of the messages from centres in Europe, except United Kingdom, Belgium and Netherlands, were duplicated. The message duplication problem in European countries may be solved if the routing of messages is established on the basis of the routing given in the manual of the GTS.

Netherlands

The participation of the Netherlands has been helpful in finding potential difficulties for a future data exchange programme.

The over-all receipt of the messages transmitted by the Netherlands had a score of 85.8 per cent; Austria, Finland, Federal Republic of Germany, German Democratic Republic, Norway, Sweden, United Kingdom, United States and USSR received the complete set.

The over-all score for received messages was 85.7 per cent. The complete set of messages from Austria, Czechoslovakia, Japan and Sweden were received by the Netherlands.

Some special conclusions of the experiment are:

1. One heading for the messages of a nation should consistently be used.

2. If more than one message is sent under one heading, this should be specifically stated.

3. Complete instructions to the GTS station next in the system for the reception and transmission of messages is essential.

4. The sending of messages should not take place at the full hours 00, 03, 05, 09, etc.

5. A system for requesting re-emission of missed messages should be developed.

6. The double reception of certain messages remains unexplained.

New Zealand

New Zealand participated in both the GTS trial exchanges, in October-November 1980 and November-December 1981. On both occasions messages were sent weekly, from the Wellington GTS node to Melbourne and thence on through the system. There is no data connection between the seismological centre in Wellington and the GTS centre, but they are in adjoining buildings so messages were carried by hand.

During the first trial, no statistics of messages received in Wellington were kept. During the second trial a total of 276 messages were received, representing a success rate of 66 per cent. The highest success rates were from Austria, Sweden and the United Kingdom, all over 90 per cent and the lowest from Belgium and German Democratic Republic (Moxa), both 0 per cent.

Norway

Norway participated in both trial exchanges. Messages containing abbreviated Level I data from the NORSAR observatory were compiled and transmitted on a weekly basis. The results from the two trials were similar, although a slight improvement in the percentages of messages successfully exchanged was observed for the second trial. The average success rate was around 70 per cent both for incoming and outgoing messages. Further experiments are clearly needed to identify the reasons for loss of messages and to obtain more practical experience with the GTS.

Peru

Peru participated in the second GTS trial exchange, through the NNA seismic station of the Institute of Geophysics of Peru. It was the first experience of this kind of data exchange. SP and LP from the seismic station were read daily and a TTY-paper tape prepared according to the experimental exercise format at the Geophysical Institute headquarters. The paper tapes were delivered twice a week, Tuesday and Friday, at the GTS local centre. The messages were to be transmitted through the Lima (Peru) - Buenos Aires (Argentina) - Washington D.C. (United States) channel at about 15:00 (U.T.). Twenty-two messages were delivered at the local WMO/GTS centre. No attempt was made to retrieve data from other participant stations at this centre. Because of some technical problems, only 13 useful messages were transmitted, of which two reached final destination. Since the header and address seem to have been in order, it would appear that the remaining messages were lost within the GTS.

Sweden

Sweden took part in both GTS trial exchanges and provided an international data centre during the 1982 multilateral experiment. During the 1981 trial 20 countries participated, transmitting data daily, or on certain days per week according to an agreed upon time-table. Among these 20 were all 13 countries which took part in the first trial in 1980. The format of the messages was given in GSE/AUS/9 Appendix B, but this was not followed strictly by all countries. The results obtained in Sweden varied from 17 per cent (Peru) to 100 per cent (Austria, Czechoslovakia and the Netherlands).

There was a marked difference in weekly loss rates: 10 per cent during the first three weeks; 16 per cent in week four; 31 per cent in week five; and 18 per cent in week six. This gives an over-all figure of 16 per cent missing messages, which is too high to be acceptable. An increase was noticed in the percentage of received messages from most countries which participated in both trials. For example, some comparative percentages were: Austria - 100 (1981), 88 (1980); New Zealand - 83/14; United Kingdom - 92/57. But there was a big decrease for Italy - 42/100; and a small decrease for Australia - 65/69.

Attempts to trace missing messages were mostly unsuccessful, except for some Finnish and United Kingdom messages.

The second trial was also used to prepare event bulletins. This could be achieved only with a delay of two weeks owing to the lateness of some incoming data.

Union of Soviet Socialist Republics

During the period from 2 November to 11 December 1981, the USSR took part in an experimental exchange of Level I data through WMO/GTS channels.

The following establishments were involved in the experiment:

The Central Meteorological Radio Centre, Moscow;

The "Obninsk" Central Seismic Observatory; and

The Seismic Information Centre at Obninsk.

Seismic bulletins containing Level I data from signals recorded at the Obninsk Observatory were transmitted daily through the Central Meteorological Centre to WMO/GTS channels in the time interval 0-12 UTC.

The content and format of the bulletins were in accordance with the instructions elaborated by the Ad Hoc Group of Scientific Experts. At the same time, the processing of seismograms did not go beyond the limits of the regular routine reports used in the processing of earthquake data at USSR stations.

During the period of the experiment, some 6,000 communications from 127 stations belonging to the 20 States taking part in the experiment were received at the Obninsk Seismic Information Centre. The number of communications per day varied between 1 and 293. Communication times varied from several minutes to several hours, amounting on average to approximately 30 minutes.

During the period of the experiment, no errors were detected in the content of communications; however, communications from a number of stations arrived irregularly or began to arrive after the time fixed for the beginning of the experiment. Consequently, the efficiency of data reception varied between 50 per cent and 100 per cent and amounted on average to 82 per cent. However, if allowance is made for the organizational problems encountered during the conduct of the experiment (the absence of clear instructions on the organization and rules for conducting the experiment, the lack of any trial testing of the WMO/GTS channels before the experiment, the absence of a rule requiring daily bulletins, etc.), then the real average efficiency of data reception at the Seismic Information Centre would be nearer to 90 per cent.

Bearing in mind the organizational problems in the conduct of the experiment enumerated above, it may be concluded that this communication system potentially fully satisfies the requirements for the rapid and undistorted transmission of Level I data from stations of the global network to international data centres.

United Kingdom

The United Kingdom participated in each of the trial exchanges of data and carried out some separate evaluations nationally.

In the 1980 trial exchange a wide variation in the results was observed by us. For received messages, the "success rates" varied from 0 per cent to 100 per cent, but we did note that results better than 80 per cent were obtained from five countries on or near the main trunk circuit. The United Kingdom's own transmission suffered a partial failure due to a coincidental change in the computer installations of our GTS node at Bracknell. A detailed account of our experience of this trial was given in GSE/UK/7.

In the second trial in 1981 we received messages from each of the other 20 participants, but again with very mixed levels of success. Nevertheless detailed analysis indicated a definite over-all improvement with an average 86 per cent receipt in the United Kingdom of messages known to have been transmitted. Also around 75 per cent of messages transmitted by the United Kingdom were received on average by other participants. Concurrent with the main 1981 experiment, the United Kingdom engaged with three other States in an additional exchange in which a part of the data collected in 1980 by Sweden to form a common data base was sent by WMO/GTS to centres in Sweden and the United States which carried out the proposed functions of International Data Centres. The results obtained in the main 1981 trial exchange and the sub-experiment were presented to the Ad Hoc Group in GSE/UK/12 and GSE/UK/13 respectively.

From results of long-running national assessments of the GTS, the United Kingdom noted that over a five-year period the "success rate" for seismic messages collected via WMO/GTS from a single source (Japan) improved from 68 per cent to 93 per cent. This improvement had not taken place steadily, but was related to known episodes of close liaison between the seismological centre and the GTS centre. In particular, the close attention given by the whole WMO/GTS to successful transmission of seismic messages during the two GSE trials appeared to have given incidental benefit to this separate evaluation. It was also noted that this improved performance tended to fall off after the stimulus of a global exchange was removed. These results were presented to the Ad Hoc Group as a specific case-history in GSE/UK/16.

A bilateral trial test of the possible use of the WMO/GTS for transmission of Level II data was also carried out jointly by the United Kingdom and Sweden during the first half of 1981. The results of this experiment, which demonstrated that limited quantities of Level II data could be rapidly transmitted completely successfully, were reported to the Ad Hoc Group in GSE/UK/SW/1.

United States of America

The United States took part in both GTS trial exchanges and operated a prototype international data centre during the 1982 multilateral experiment.

During the main trial (1981), Level I data were prepared and transmitted over the WMO through the Centre for Seismic Studies in Rosslyn, Virginia which includes a prototype international data centre.

For data exchange over the WMO/GTS, a DEC minicomputer was connected to two ports of the message-switching computer operated by the National Weather Service. Both ports were attached to a single full-duplex data line between the Center for Seismic Studies and the United States National WMO/GTS Center in Suitland, Maryland. This computer link, when properly established, minimized the potential errors in transmission between national seismic centres and national WMO centres.

During the trial about 400 messages were sent; 43 messages of which were sent by the United States; 283 messages were received with loss rates varying from 0 to 100 per cent. Approximately 183 of the messages received were duplicates. Transmission times varied from less than one hour to two days. Analysis of transmission times indicated that most delays occurred between seismic centres and national WMO/GTS centres.

Since the trial exchanges, the Center for Seismic Studies now automatically and routinely reads the WMO/GTS messages, stores them on the Center database and uses them to prepare seismic bulletins.

Appendix 6

Summaries of national contributions on seismic Level II data exchange and technical information on some existing transmission systems

6A: Summaries of national investigations on Level II data exchange

6B: Some international telecommunications options for seismic data transmission and exchange

Appendix 6A. Summaries of National Investigations on Level II Data Exchange

In this appendix, the outcome of a multinational experiment in Level II data exchange is first described. Thereupon contributions from individual countries are summarized.

THE MULTINATIONAL LEVEL II DATA EXCHANGE EXPERIMENT

1. Background

During the Ad Hoc Group meeting in August 1982 the Norwegian Delegation invited the other delegations to participate in an experiment aimed at exchanging Level II data between different countries. The outcome of this experiment is described in the following.

2. Outline of the experiment

- The NORSAR Data Center near Oslo, Norway, was to co-ordinate the experiment.
- Step 1 was to establish links/ensure data exchange between NORSAR and seismological centers/computer installations in individual countries.
- Step 2 was to transmit a given data set from one country to another with start/end at NORSAR.
- The data exchange protocol was to be based on SAFT (Simple ASCII File Transfer), which is available for most computer systems.

3. Trial exchange in practice

Experts from the following countries indicated their intention to participate actively: Australia, Belgium, Canada, Denmark, Federal Republic of Germany, Japan, Netherlands, New Zealand, Sweden, United Kingdom and United States. A number of other experts were also interested, but unable to participate for the time being.

Data and messages were successfully exchanged with Canada, the Federal Republic of Germany, Belgium and the United Kingdom, using the SAFT protocol for transfer. Previously, this had been achieved with a data center near Washington D.C. Exchange of messages/data not using the SAFT protocol was achieved with computer centers/installations in Denver, Stockholm and Uppsala. Successful exchange using SAFT has not yet been achieved with Australia, Belgium, Japan, the Netherlands or New Zealand.

The number of successful data exchange trials based on the SAFT protocol was modest, and in consequence it was deemed somewhat premature to try to implement step 2 of the experiment for the time being.

4. Evaluation of experiment

A critical assessment of the efforts described above, i.e., experiments aimed at demonstrating the viability of exchanging Level II data on a global basis via temporary computer linkages, give that the experiment must be rated partially a success. On the positive side: (i) valuable experience has been gained in pinpointing major obstacles to easy and reliable data transfer between computers in different countries, and (ii) the interest in exchanging Level II data between national data centers on an experimental basis is quite large. However, a number of practical and technical problems were encountered, the most important being:

(i) Experiment design. International data transfer should not be attempted before such skills are mastered on a local/national level.

(ii) Programming skills. Data transfer via computers requires special system programming skills which are quite different from that of coding scientific problems/mathematical algorithms. Most of the technical problems encountered are clearly related to a lack of professional system programmers at hand.

5. Conclusion

The experiment has demonstrated that fast and reliable exchange of Level II data on a global basis is feasible, although the lack of extensive practical experience in such undertakings remains a problem at many national seismological data centers. It is therefore necessary to continue the experiments with multinational exchange of Level II data and several additional countries have indicated their willingness to participate in the future.

NATIONAL CONTRIBUTIONS

Canada

Canada has investigated the various options for the exchange of digital waveform data which are provided by the national telephone company. These include switched analog (dial-up), circuit switched and packet switched connections. National investigation GSE/CAN/8 summarizes the advantages and disadvantages of each of these three types of connection, as well as the costs (from Canada) of each for representative file lengths. It is particularly noteworthy that packet switched networks are becoming increasingly available: from Canada it is possible to obtain access to such networks in 36 countries, including some in Africa and South America, at relatively low cost.

In connection with the multinational Level II data exchange co-ordinated by Norway, it has been possible to dial-in (switched analog) to the NORSAR/PDP-11 computer and retrieve a short file from that machine. Work on implementing SAFT on both a PDP-11/40 and a VAX 11/750 is in progress and it is anticipated that two-way transfer of waveform data files between Canada and Norway will be successful very shortly. Similar connections with other countries are being investigated and all GSE participants are encouraged to attempt to establish such exchanges with Canada.

Germany, Federal Republic of

The Federal Republic of Germany participated in the experimental Level II data exchange which was initiated by Norway. To conduct the test it was necessary

- to connect a computer with the commercial telephone net using a 1200 baud modem

- to implement the SAFT (Simple ASCII File Transfer) program on a computer for handling the data transfer.

Before the Level II data exchange experiment was started, internal transmission tests between different computer types (VAX 11/780, VAX 11/730, PDP 11/60, PDP 11/34) were carried out. The SAFT programs for these systems were provided by Norway.

Only communication between the VAX computers worked satisfactorily. Data transfer between computers of different type caused problems. Similar difficulties arose when transmission tests between our VAX system and the Norwegian PDP 11/34 computer were conducted.

More successful was the bilateral Level II data exchange experiment with a Swedish VAX 11/750 computer. The reliability of the telephone line proved to be excellent. Two data files which were transmitted and retransmitted contained 30 seconds of data from all 19 seismometers of the GRF array, which corresponds to 24064 characters each. The time needed for transmission of one file was 608 s.

According to this result the transmission time for Level II data (specified in chapter 6, section 6.4 of the third report) has been estimated to be 5 minutes. This time refers to short-period data (sampling rate 20 Hz) of a 3-component station which covers a time interval of 120 seconds. For long period data (sampling rate 1 s) 8 minutes are needed if for 3 component recording an interval of 50 minutes is assumed.

Further experiments with other countries are encouraged to be conducted on the basis of the results of this test.

<u>The Netherlands</u>

Preparations are being made in both hardware and software for participation in an experimental exchange of Level II data. It is expected that our first connection with NORSAR will be established in May or June 1983.

<u>Norway</u>

Norway has developed a low-cost, microprocessor-based system for exchange of Level II data as well as messages via ordinary telephone lines. This system was demonstrated to the <u>Ad Hoc</u> Group during its fourteenth session in August 1982. A small North Star microcomputer was temporarily installed in the restaurant on the top floor of Palais des Nations, Geneva, together with video display screens. By using the restaurant's telephone lines, seismic waveform data, bulletins and messages were transmitted to and from computer facilities in the United States, Norway and Australia.

The following transmissions were demonstrated:

1. To/from a data center in Washington D.C., United States of America.

   <u>Purpose</u>: Simulate communication between two International Data Centers. By dialling up a PDP 11-44 computer at this site, both message exchange, retrieval of seismic bulletins and waveform data were accomplished.

2. To/from NORSAR data center at Kjeller, Norway.

   <u>Purpose</u>: Simulate communication between an International Data Center and a National center.

   Similar functions as under 1. were demonstrated, in addition retrieval of waveform and parameter data in near real time was accomplished.

3. To/from a small prototype seismic station in Trondheim, Norway.

Purpose: Simulate communication between an International Data Center and a remote seismic station.

This experiment was conducted to retrieve automatically detection logs and selected waveform data, without any operator intervention necessary at this unmanned station.

4. To/from a seismological data center in Australia.

Although not a planned part of the demonstration, communication was established and seismic bulletin data and messages were exchanged.

During this demonstration, which was attended by some 100 scientific experts and delegates, no serious technical problems were encountered.

The conclusion from the demonstrations described above is that modern, international telecommunications services today permit easy exchange of Level I data, Level II data and relevant messages between most countries, using standard telephone services. The cost of a minimum configuration would be relatively modest, approximately in the order of $US 5,000. Line charges would come in addition. Norway recommends that further experiments using this and similar systems be encouraged, with the purpose to include this method of rapid data exchange in the global seismological system which might be established under a comprehensive nuclear test-ban treaty.

Norway has now undertaken a project to further develop the microprocessor system used during the demonstration, with the aim to implement a number of additional functions relevant to the envisaged processing at seismograph stations and data exchange between stations and International Data Centers.

United Kingdom

The United Kingdom has continued to evaluate techniques for the exchange of Level II data, on a national basis, by the routine use of methods in three categories listed in chapter 5 of the Ad Hoc Group's second report, CD/43, i.e., (i) facsimile transmission of graphical recordings, (ii) transmission of data by various means in numerical form, (iii) standard and express airmail.

In addition, internationally, transmissions of Level II data have been made during co-operative experiments with other Ad Hoc Group participant states. Thus in November 1980 the United Kingdom contributed Level II data tapes via mail to the common data base suggested by Sweden in GSE/SW/35, while later, during 1981, experimental transmissions of Level II data were made to Sweden via the WMO/GTS and reported subsequently to the Ad Hoc Group in GSE/UK/SW/1. In 1982/83 the necessary technical arrangements were made for participation in the experiment proposed to the Ad Hoc Group by Norway for the rapid exchange of Level II data between computers linked via international telephone channels. A preliminary report of progress in this ongoing experiment was made to the Ad Hoc Group in GSE/UK/20.

From this experience it is concluded that a variety of methods exist whereby Level II data may be exchanged promptly and successfully. An important matter outstanding is to achieve agreement on standard formats for the exchange of digital waveform data.

Appendix 6B. Some International Telecommunications Options for Seismic Data Transmission and Exchange

BACKGROUND

The appendix addresses the technical means by which Level II (waveform) seismic data in digital form and also other types of relevant information in alphanumeric form like Level I data and messages can be transmitted/exchanged between International Data Centers and seismic stations/national observatories located world-wide.

Much of the seismic data transmission planning for the envisaged global system (CCD/558) has been based upon the use of the World Meteorological Organization/Global Telecommunications System (WMO/GTS). However, as noted in CD/43, "... at present the WMO/GTS does not have the capacity to handle extensive Level II data exchange ...". Accordingly, the capabilities of alternative transmission media are examined in the sections to follow, and in this respect very extensive use is made of the United States document US/GSE/16.

1. THE NEED FOR TRANSMISSION USING COMMERCIAL FACILITIES

The world's telecommunications facilities include many systems that might be technologically feasible but which are unsuitable for other reasons. Systems dedicated to particular applications, such as the Global Positioning System (GPS) and the Landsat, cannot be used because their capacity and design are dedicated to specific program objectives which do not include seismic data transmission. While the operators of experimental satellites and other experimental facilities might be willing to handle seismic data, and possibly even encourage it, such systems often use non-standard technical parameters, and generally operate for a limited period of time only, beyond which a follow-on program often does not exist.

The foregoing factors motivated investigations of leased commercial facilities (circuits) to meet international seismic data transmission requirements to send alphanumeric and waveform data.

1.1 The role of the common carriers

A common carrier provides end-to-end service on a leased or switched basis between two or more locations, within or between countries. This service may be designated "transparent" to denote the fact that the carrier does not intentionally alter the transmission in any way. In most countries, the common carrier role rests with a governmental postal, telephone and telegraph (PTT) organization. Examples of specialized common carriers for bulk transmission of data are Telenet and Tymnet, which link their United States-facilities to facilities overseas through contractual arrangements with one of the international record carriers (IRCs), like ITT World Communications or the French Telegraph Cable Company.

Completion of an international circuit at the foreign end is arranged by the IRC with the PTT organization of the foreign country.

1.2 The role of the carrier's carrier

Many transoceanic circuits, whether via satellite or underseas cable, are operated by a "carrier's carrier", like INTELSAT and others, which do not deal directly with a user. Instead, they supply channels in bulk to the international carrier which, in turn, interfaces with the user, often through the user's local franchised carrier. There are technical and economic reasons, as well as regulatory reasons, for this. A carrier's carrier has in geostationary orbit a satellite(s) designed to operate with the uplink power of its own earth stations and to transmit preplanned power levels to them. These earth stations, in turn, are designed to handle a large number of channels and often are located remotely from large cities to minimize interference problems. At the user's end, the facilities to his premises are furnished by the national PTT providing telephone service to him.

The INTELSAT earth stations in most countries are owned and operated by the nation's PTT organization. Agreements between INTELSAT and these countries usually provide that INTELSAT will interface only with the PTT. The primary reason is that the PTT wants its share of all communications revenue to its country. The advantage to INTELSAT from a technical viewpoint is that it can assign a well-defined amount of its transponder to each user country based upon known usage patterns. Section 3.1 discusses transponder power and other satellite operating parameters.

2. SERVICE OPTIONS FOR SEISMIC DATA TRANSMISSION

Ideally, seismic data would be transmitted from a dish at the site of origin directly to a satellite, from which it would go directly to a dish on the roof of the data center. A few of the circuits, using domestic or regional satellites, may function this way. An example here is the recent INMARSAT system designed explicitly for ship/shore communications. However, many of the circuits will involve additional relay operations for regulatory or economic, if not technical, reasons. This section discusses (1) direct arrangement with the carrier's carrier, (2) direct arrangement with a common carrier, and (3) service via the end offices of a common carrier.

2.1 Direct arrangement with the carrier's carrier

Because of INTELSAT's arrangements with its member nations, it is not free to deal with users directly.

2.2 Direct arrangement with a common carrier

Users may arrange for international data transmission directly with any of the international record carriers, or, for domestic service, directly with one of the domestic carriers. For example, direct service via a domestic satellite may be arranged from a seismic station within a country to its national seismic data center, although interference problems are likely to prevent direct roof-top reception at centrally located centers.

Direct arrangements with a common carrier would allow direct INTELSAT service from a seismic station only if the national PTT agreed to place an earth station there and obtained INTELSAT concurrence. While this is theoretically possible from a regulatory viewpoint, it is not very likely from an economic or technical viewpoint because INTELSAT generally does not transmit to/from the small-sized terminals (e.g., 5 meter dishes) that most likely would be used. On the other hand, the INMARSAT system has dishes less than 2 meters and have been used for transmission of scientific data from stations in Antarctica.

Domestic satellite systems are operated in such countries as Canada (Anik), Japan (Sakura), USSR (Statsionar), United States of America (SBS) and Indonesia (Palapa) with more being planned. Regional satellite systems included Symphonie (France and the Federal Republic of Germany), and OTS (European Space Agency).

2.3 Service via the offices of a common carrier

In obtaining service via the offices of a common carrier, no roof-top terminals would be used. Instead, the circuit is requested from the common carrier, which in turn arranges it. The result probably will be a combination of terrestrial and either satellite or undersea cable for international linkage. For digital transmission, the bit error rate will be on the order of 10^{-3} to 10^{-5} if no error correction is implemented. Since rate 1/2 coding is planned for seismic data transmission, the actual error rate of the circuit may not present serious problems. Leased circuits to many of the developing nations may exhibit relatively high bit error rates in the absence of error correction. This may also be the case under direct arrangements with a common carrier, so care must be taken to negotiate the best possible circuit arrangement at the foreign end. Unfortunately, the PTT is in the driver's seat there and even the international record carrier may be unable to get the desired circuit quality at the foreign end.

3. TRANSMISSION FACILITIES

This section discusses some of the basic parameters that govern the operation of the various types of transmission facility, such as satellite, undersea cable and microwave radio relay. Also included is the possibility of sending magnetic tape by air express where adequate facilities are not otherwise available.

3.1 Satellite transmission

A satellite system is characterized by several basic parameters that govern its performance and are detailed in the following:

3.1.1 Frequency band

The most popular frequency band for commercial satellites is 5925 to 6425 MHz for the uplink and 3700 to 4200 MHz for the downlink. These are the bands recommended for seismic data transmission. Future years (the mid-1980s) will see some extension of these bands based upon the recommendations of the World Administrative Radio Conference held in Geneva in 1979. Because of the heavy utilization of these bands, however, more use is being made of the newer 14,000 to 14,500 MHz uplink band and the 11,700 to 12,200 MHz downlink band. Such satellites as the INTELSAT Vs and many of the new domestic satellites will operate in both the old and new bands, while the SBS satellites and the Japanese domestic satellites operate only in the new bands.

3.1.2 Back-off

Because of the large number of signals carried within a given satellite transponder, the possibility of interference among them is very real. In fact, if the transponder were operated at its full rated power, serious interference, known as intermodulation, would exist. Only by keeping the total signal power into the transponder down to about 25 per cent of the transponder's capability can intermodulation be kept reasonably low. This is done simply by limiting the power level from each uplink earth station to such a value that the total power from all uplink earth stations does not exceed the value that would cause the transponder output to exceed 25 per cent of its full capability. Because of intermodulation, satellite operators hesitated for a long time to permit direct user uplinks. That situation, in response to competitive pressures, at last is changing, at least in the United States of America.

The foregoing paragraphs have described the most commonly used transponder sharing arrangement: frequency-division multiple access (FDMA). The alternative, time-division multiple access (TDMA), avoids the intermodulation problem entirely by having only one channel use the transponder at a time. However, another problem is introduced: the individual users must take turns transmitting according to a very well synchronized high-speed sharing arrangement. A larger version of this is time division multiplex, in which, for example, each of 24 channels is sampled 8000 times per second, and the whole process time-interleaved with 27 other such processes on a single transponder. Such transmission must be accomplished by doing all the channel combining on the ground and sending the composite signal to the satellite.

3.1.3 Bandwidth

Each commercial satellite transponder usually has a bandwidth of about 36 MHz. This bandwidth is enough to allow transmission at a data rate as high as 90 Mb/s using a technique called 8-phase shift keying (8-PSK), in which 3 bits are sent each time the transmitter is keyed. The keying rate thus is 30M baud. However, for seismic data transmission, current practice (and equipment availability) calls for the use of FDMA, in which each channel uses a pre-assigned 38 kHz portion of the transponder's spectrum. Such a system provides the equivalent of a single telephone (voice) channel from each seismic station. The digital data rate that can be sent over such a channel is 9600 b/s, done by sending 4 bits each time the transmitter is keyed, and keying the transmitter at a 2400 baud rate.

3.1.4 Polarization

The early domestic satellites operated with only a single polarization, thus allowing 12 transponders, each of 36 MHz bandwidth, to be allocated in the 5924-6425 MHz uplink and the 3700-4200 MHz downlink band. The development of better polarization control techniques has allowed newer satellites to have 24 transponders, each of 36 MHz bandwidth, within 500 MHz of spectrum. This can be done by the use of polarization diversity, in which 12 of the transponders are on one polarization and the other 12 are on the other polarization. For example, "vertically" polarized signals ideally will not be sensed by a "horizontally" polarized receiving antenna.

The greatest enemy of polarization diversity is precipitation. Rainfall causes the polarization vector to rotate so that a signal that is transmitted as a vertically polarized one, for example, is received as an elliptically polarized one, thus exhibiting some horizontal component. Depolarizers have been devised to help correct such a situation, but they are usually only on large multichannel earth stations becuase of their cost and complexity.

3.1.5 Footprint

A satellite's "footprint" is its coverage area on the earth, which does not extend beyond ca 80 deg latitudes. It depends upon the satellite's orbital location as well as its antenna pattern or beamwidth. The early commercial satellites usually had "global" beams, which were beams having a 18.5° width, thus transmitting to the entire portion of the earth visible from the satellite. Some satellites, such as INTELSAT V, now have both global and spot beams in use simultaneously, with different antenna patterns being connected to different transponders. As an example here, the geostationary INTELSAT positions (over equator) over the Atlantic, Indian and Pacific oceans are tabulated below.

ATLANTIC OCEAN		INDIAN OCEAN		PACIFIC OCEAN	
Longitude	Satellite	Longitude	Satellite	Longitude	Satellite
2°W	IV F7	57°E	IV F5	174°E	IV F8
4°W	IV F2	60.2°E	IVA F3	179°E	IV F4
18.5°W	IV F1	62.9°E	IVA F6		
21.5°W	IV F3				
24.5°W	IVA F1				
25.5°W	IVA F2				
35°W	IVA F4				

3.3 Microwave radio relay

Microwave radio relay systems are used extensively throughout the world. In many countries they use the same frequency bands as do satellites, especially the 3700-4200 MHz, 5925-6425 MHz, and 11,700-12,200 MHz bands. These frequencies allow propagation only along nearly line-of-sight paths, so microwave repeaters must be placed at distances of 40 to 50 km over most terrain types. Most microwave relay systems are built to handle at least 600 voice channels, and sometimes as many as 2700 or more voice channels within a 30 to 40 MHz bandwidth allocation.

3.4 Tape by air express

Where electronic means of data transmission are not available, the use of air express can allow magnetic tapes to be moved to many places in the world in about two days. In view of the objective for expeditious transport of seismic data, the movement of magnetic tapes by air express appears to be a viable alternative to electronic transmission in certain regions.

4. TRANSMISSION TYPES

Data is transmitted in either of two forms, analog or digital. Their primary differences are discussed next.

4.1 Analog transmission

The natural output of a seismic sensor is in analog form, i.e., a measure of the actual earth movement sensed. However, analog signals suffer degradation on transmission facilities because of the need for repeaters which introduce noise and distortion. The greater the distance over which the signals must be transported, the greater will be the noise and distortion.

4.2 Digital transmission

Because of the limitations of analog transmission, digital transmission is becoming increasingly popular. The data is sent as a stream of alphanumerics, each of which is expressed as a combination of 1's and 0's. Thus actual waveforms are not sent as such. At each repeater the signals expressing the 1's and 0's can be regenerated or restored so that the effects of noise and distortion can be eliminated. Transmission bit errors can be kept as low as 1 in 10^7 for a transcontinental or satellite circuit, and error detection and correction techniques exist to permit lower error rates. Telex and high-speed teleprinters and cathode-ray tube (CRT) display systems all illustrate the use of digital data transmission.

. [illegible]ONOMIC FACTORS

A user can order a leased service from a common carrier without necessarily knowing what type of facility he will be assigned. In fact, transoceanic dial-up circuits for two-way voice often are made up of a satellite path in one direction and undersea cable in the opposite direction. If a user should have an interactive computer system or a facsimile circuit requiring line-by-line verification, he will want to know whether or not a satellite link is part of his circuit. Otherwise, the satellite delay may render his end-to-end system inoperable or, at best, cause it to operate unduly slowly. Such a problem should not occur with seismic data transmission because the seismic station sends data continuously without waiting for an acknowledgement from the data center.

5.1 Satellite service

5.1.1 Space segment

If a user obtains satellite service directly from a common carrier rather than via the carrier's office, he will be furnishing his own earth stations and thus he may be able to negotiate a tariff more **favourable** than the standard published tariffs which are based on the use of the common carrier's earth stations. Accordingly, this section assumes that a negotiated rate will be applicable to the services obtained. An example is a $1600/month payment in the United States for 1 per cent of the bandwidth of a transponder. INTELSAT tariffs can be expected to be higher, regardless of which international record carrier is used to obtain the service. The rates may well depend upon the size of earth stations to be used.

5.1.2 Earth segment

The price a user must pay for his own earth station will vary widely depending on such factors as whether it is for:

- Voice/data or video
- Transmit/receive or receive only

and also upon its features and technical design, like:

- Dish size and antenna pattern
- Type of polarization used, etc.

For receive-only earth terminals, a well-equipped station for a single data channel might cost as much as $US 40,000. However, this is a high price to pay if it can be avoided by a simple leased telephone line to a not-too-far-distant major earth station of a common carrier. A well-equipped station for 5 or 6 data channels might easily cost $US 100,000.

5.2 Microwave radio relay

Microwave radio relay systems also require land for repeater sites as well as building space, and total costs may well exceed $US 100,000. Only in unusual circumstances should the construction of microwave relay be needed for seismic data transmission. Where a few channels of terrestrial transmission are needed, they should be leased from a common carrier if at all possible.

6. REGULATORY LIMITATIONS

Before a PTT will grant data service, the purpose of the leased line probably will have to be explained. This may result in some delay, especially if language differences impede understanding. The PTT wants to make certain that it derives its fair share of all telecommunications revenue for circuits into and out of the given country. Accordingly, the PTT may insist on installing and operating these circuits, which may be of very poor quality in some cases. Where the PTT already is providing some seismic data transmission, negotiations should go more rapidly. However, several months to a year may be required to obtain service in some countries.

Appendix 7

Preliminary operations manual for International Data Centers

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ANNEX

SECTION 1

INTRODUCTION

In two earlier documents CCD/558 and CD/43 the Ad Hoc Group of Scientific Experts has put forth the concept of an International Data Center (IDC) to "facilitate the monitoring of a comprehensive test ban". One of the major objectives of the IDCs is the preparation of equivalent (if not actually identical) bulletins by all IDCs. A prerequisite for the achievement of that objective is a rather complete operational manual, specifying the functions, operations, and procedures of an IDC. This report is a first attempt at the production of such a document. It follows closely the recommendations of CD/43 where they are sufficiently specific, and proposes additional procedures where necessary.

SECTION 2

Data Input to International Data Centers

1. Definitions

1.1 Level I

"Level I" data consists of parameters as specified in CCD/558, revised and amended in CD/43 and in Appendix 4B of this report. The principal means of distribution is the WMO/GTS. A complete description of Level I data will be found in Annex A7-I to this Appendix.

1.2 Level II

"Level II" data mainly consists of waveform data, whether digital or analog. The principal means of distribution of digital waveform data is magnetic tape, but other media (e.g., satellite transmission) are in use. A large number of formats has been defined for the recording and transfer of Level II digital data, and an IDC should be prepared to accept "any reasonable format". The use of a standard format, however, would be beneficial both to users and to operators of an IDC. Such a standard is proposed in Annex A8-V.

2. Data Flow for Bulletin Production and Data Distribution

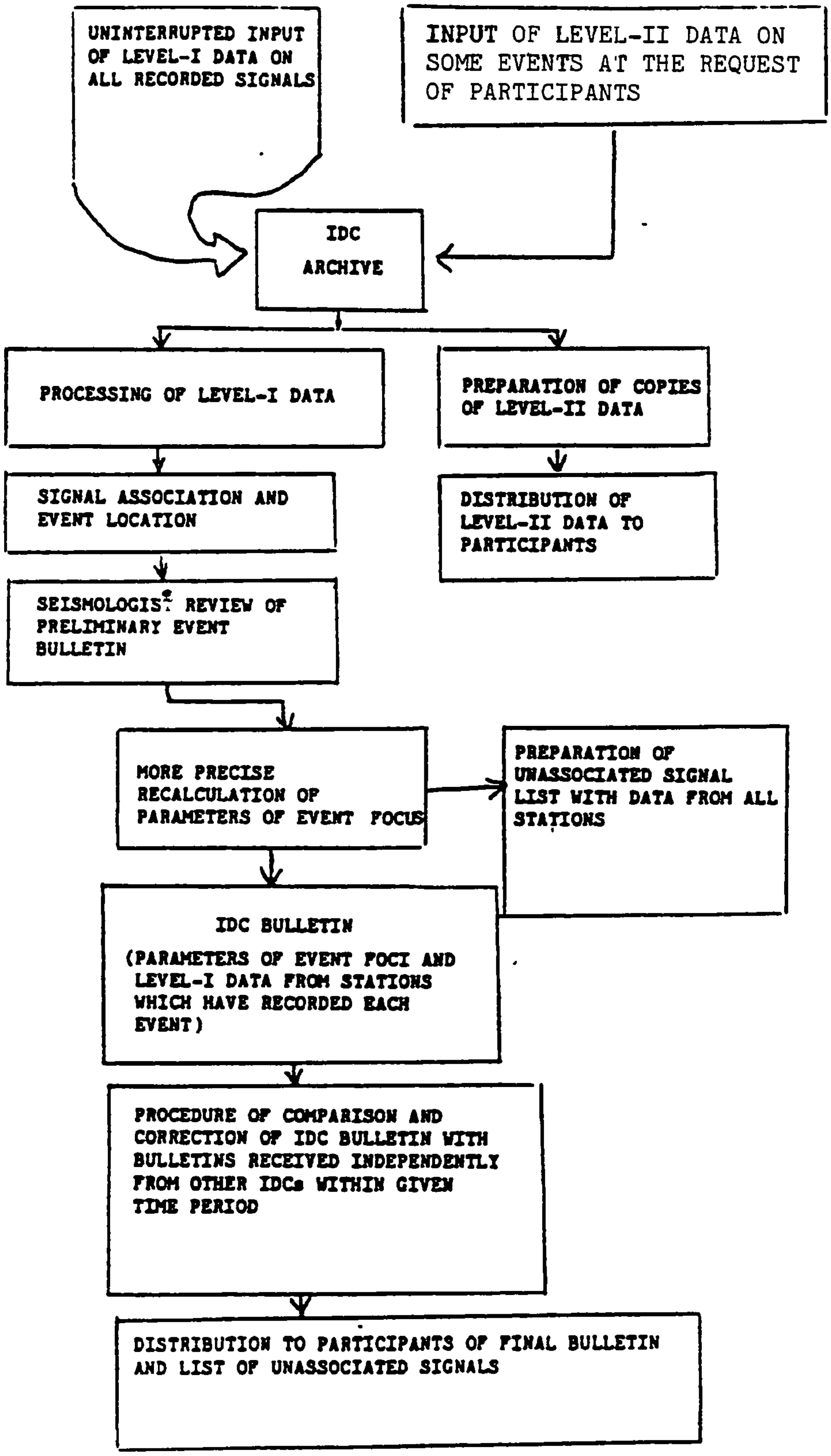
Data flow for an IDC is shown in the figure on page 2; the description below refers to the function steps shown in this diagram.

- Input: The input consists of uninterrupted Level I data, and Level II data on events at the request of participating States.

- Archive: All data is entered into the Archives. Current data is also passed on to the automatic Signal Association and Even Location process. Level II data is retrived for transmittal to individual National Authorized facilities upon request.

- Initial Data and Complete Data: Not all of the data for a day will have been received by the time the Preliminary Event List is prepared. The "initial data" is the data used in the preparation of the Preliminary Event List; the "complete data" is all of the data available for the preparation of the final IDC Bulletin.

FIGURE 7.1


UNINTERRUPTED INPUT OF LEVEL-I DATA ON ALL RECORDED SIGNALS
INPUT OF LEVEL-II DATA ON SOME EVENTS AT THE REQUEST OF PARTICIPANTS
IDC ARCHIVE
PROCESSING OF LEVEL-I DATA
PREPARATION OF COPIES OF LEVEL-II DATA
SIGNAL ASSOCIATION AND EVENT LOCATION
DISTRIBUTION OF LEVEL-II DATA TO PARTICIPANTS
SEISMOLOGIST REVIEW OF PRELIMINARY EVENT BULLETIN
MORE PRECISE RECALCULATION OF PARAMETERS OF EVENT FOCUS
PREPARATION OF UNASSOCIATED SIGNAL LIST WITH DATA FROM ALL STATIONS
IDC BULLETIN
(PARAMETERS OF EVENT FOCI AND LEVEL-I DATA FROM STATIONS WHICH HAVE RECORDED EACH EVENT)
PROCEDURE OF COMPARISON AND CORRECTION OF IDC BULLETIN WITH BULLETINS RECEIVED INDEPENDENTLY FROM OTHER IDCs WITHIN GIVEN TIME PERIOD
DISTRIBUTION TO PARTICIPANTS OF FINAL BULLETIN AND LIST OF UNASSOCIATED SIGNALS

- Signal Association and Event Location: The automatic Association/Location process attempts to define that set of (seismic) events that best fits the existing set of arrivals. This is an iterative process involving the generation of successive hypotheses, associating arrivals with hypothesized events, locating the events, and evaluating the solutions. At the completion of this process, the automatic process proposes a preliminary bulletin, listing all tentative event solutions, the arrivals associated with each, and indicating arrivals it was unable to associate with a particular event. (All information in the tentative list of events or preliminary bulletin is also stored in the data base.)

- Event Definition: Events are defined as soon as enough data has been received to allow definition. Hypocenter calculations are upgraded each day as more data become available. The IDC will prepare a bulletin using all data received at the IDC within five days after the occurrence of the event. Event definition by the automatic process is tentative, until reviewed and accepted by an IDC analyst or seismologist.

- Preliminary Event List: A Preliminary Event List is prepared for each day's input. The format and content of event lists is specified in Annex A7-III.

- Seismologist Review: Each day, a seismologist will examine the event definitions prepared by the automatic association/location process, in order to ensure that they are of sufficiently high quality to be released. In the event that the results of the automatic process are modified in any way, a complete description of the manual intervention will be included in the bulletin.

- IDC Bulletin: The final IDC Bulletin contains the official IDC definition of each event. This definition is final in the sense that it will not be changed unless a particiapting country requests a recalculation based upon late-arriving data. ("Late-arriving" means data received more than five days after the occurrence of the event.) All event definitions appearing in an IDC Bulletin are reviewed by a seismologist prior to release.

- Comparison of Bulletins: After each International Data Center prepares a bulletin, it is distributed to the other International Data Centers for review and comparison. Through consultation a final bulletin is prepared which incorporates the results of all the IDCs. This bulletin is then distributed to all participants. The format and content of bulletins is specified in Annex A7-IV.

- Data Distribution: All data received at an IDC is consolidated and stored in the IDC data archive as it arrives (Level I or Level II data) or is prepared (event lists and bulletins). Event Lists and bulletins are routinely distributed to all participants. Requests for Level 1 and Level 2 data are satisfied within one week.

SECTION 3

Procedures for Automatic Association and Location of Seismic Events

Chapter 6, and the relevant appendices, of CD/43, describe briefly the procedures suggested for association and location. This chapter of the IDC Manual, based upon the collective experiences of seismologists from the Group of Scientific Experts with particular emphasis on the results of processing data provided by the Common Data Base Experiemnt of October 1980, attempts to specify an association and location method in sufficient detail that computer codes based upon its principles should provide an essentially identical bulletin given the same input data. It both clarifies, and, in some cases, suggests changes to, the procedure 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."

The following are proposed as new criteria for event definition and location; where they differ from CD/43 this is indicated by an asterisk (*) and justification given.

3. Defining Phases

The following phases may be used for event definition:

P (25 $\leq$ distance $\leq$ 100 degrees)

PKP (initial DF branch only) *

P and S (distance $\leq$ 25 degrees) (even in the absence of local travel time-tables) *

Crustal phases Pg, Pn, P*, Sn, Sg, S* *

Inclusion of PKP (DF), local P and S, and crustal phases, substantially increases the number of events defined, thereby greatly reducing the number of unassociated arrivals and consequently the risk of false events being created. PKP is often well recorded at low noise Northern hemisphere stations from Southern hemisphere events for which there are insufficient P observations for definition and location. The use of local P and S, and crustal phases, even in the absence of local travel time-tables, is often essential for the location of small events, and the S phases in particular are frequently crucial for depth determination. The lack of accurate calibration in the form of local travel time-tables can be allowed for by permitting slightly larger residual acceptance windows for these phases than for teleseismic P. These acceptance windows may be in future reduced when local travel time curves are available.

4. Event Definition

As given in CD/43, (page 38)

"The minimum number of stations necessary to define and locate an event is:

(a) Four single stations, not more than two of which are local stations;

(b) One array station at teleseismic distances, and two single stations (no restriction on distance);

(c) Two array stations at telesismic distances."

In criterion (a) above, the requirement that at least two of the observations be teleseismic is presumably intended to reduce the appearance of large numbers of small local events in the final bulletin. It is recommended, however, that such events should be located, if only in order to remove the corresponding arrivals from the automatic association procedure, thereby minimizing the possibility of false events being created.

Criterion (c) above may cause problems if the two recording arrays are close to each other, in which case a very poor, or even erroneous, location may be produced.

The following new criteria for event definition and location are proposed:

(i) Four or more defining observations, not all of which are PKP, at three or more stations.

(ii) Two defining array observations at arrays more than 20 degrees apart.

For the purposes of (i), an array measurement is considered to be three observations.

The observations used by these criteria must consist of defining phases or defining array observations, as given above in Part 1 above, with final residuals of less than 1.5 <u>a priori</u> standard deviations. These <u>a priori</u> standard deviations are:

P (25 $<$ distance $<$ 100 degrees)	1 second
P (distance $<$ 25 degrees), including Pn, Pg and P*	3 seconds
S (distance $<$ 25 degrees), including Sn, Sg and S*	5 seconds
PKP (DF branch only)	1.5 seconds
array observations: slowness vector	
teleseismic	1.5 seconds/degree
distance $<$ 25 degrees	3 seconds/degree

These <u>a priori</u> standard deviations may be reduced by later agreement - those for local arrivals if local travel time-tables become available, and those for array observations as accumulated experience indicates the accuracy of specific array sites.

Local S and crustal phases (Pn, Pg, P*, Sn, Sg, and S*) may be used as defining only if reported as such. P and PKP observations must have been reported as primary arrivals identified as P, PKP (for association as PKP only) or without phase identification.

5. Initial Epicenter Determination

Starting solutions for the location and association 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 hypocenter.

(c) a combinatorial 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 in Part 4 above. Certain rules must be applied in extending the group of defining arrivals beyond those initially provided by (a), (b) or (c) above. These are:

(i) If both P and S (or their crustal phase equivalents) are reported, both must be accepted or rejected - i.e. if the S time fits the hypothesis, but that for P does not, the S arrival may not be used, and vice-versa;

(ii) the arrivals used must lie within the 99.7 per cent confidence interval (4 standard deviations) of that predicted for the given station and phase by the co-variance of the source parameter uncertainties;

(iii) the arrivals must not have been already flagged as predicted (see Part 8 below) by an already accepted event.

It has been traditional to assign surface focus (depth = 0) to the initial hypocenter. If the event producing the arrivals is actually deep, there is the possibility that insufficient arrivals for event definition may be collected with the surface focus restriction, particularly using method (c) above. A variety of possible depths (0, 223, 413, and 603 km) should be used. To minimize the computation that this requires, depths other than 0 should be tested only if there have historically been events at depths greater than 80 km within 6 degrees of the geographical location of the initial hypocenter based on surface focus.

6. Hypocentral Location Technique

The arrival times consistent with the initial hypothesis are passed to a hypocentral location program which minimizes, in a least-square sense, the difference between theory and observation. In obtaining the best solution it is often necessary to reject some of the arrival data: it is important that only one arrival be removed at a time. The rule for such truncation is that the arrival with the largest residual in units of a priori standard deviation of the observation is removed when this exceeds 1.5. Location is then carried out using the truncated set of observations and this process is repeated until the final solution is obtained. During this process, previously truncated observations may be returned to the set of arrivals used. The uncertainty of the source parameters should be estimated using the a priori standard deviations of the observations. Small corrections, such as those for ellipticity and elevation, are applied only to the last iteration of the location procedure.

7. Depth Determination

In view of the importance of focal depth estimates for event identification, special attention should be paid to accurate determination of focal depth. This is carried out as follows for an event which fulfils the event definition criteria.

(i) Depth is provided from the hypocentral location algorithm using the defining observations P, PKP (DF) and local P and S phases. During this process, if the depth provided by successive iterations falls outside the normal range of 0-720 km, the depth should be constrained to 33 km, if possible, as an indication that the depth is completely undetermined. The standard error of the depth should always be given as it pertains to free depth location even if the depth has been constrained in this manner.

(ii) A search is made for possible depth phases, followed by relocation, now including pP and sP as defining observations. The hypocenter location that maximizes the number of defining observations is determined.

(iii) If an unconstrained depth solution is found in this manner and if the number of defining observations (now including pP and sP) has been increased by two or more over the solution given by (i) then this new solution is accepted; otherwise that given by (i) is retained.

(iv) In (ii) above, a depth **phase** may only become defining if

- it has not been flagged as predicted by a previously accepted event;
- it has been reported as pP, sP, P, PP, PcP or as an unidentified secondary or primary phase;
- a careful check has been made that the phase cannot be PcP, which at certain distance ranges is a prominent arrival soon after P, and often misreported as a depth phase;
- the ratio of the residual to the assumed a priori standard deviation must be less than 1.5. The a priori standard deviation for pP and sP is 2 seconds.

8. Flagging of Arrivals as Removed from Further Consideration

Arrivals corresponding to events with five or more defining observations at four or more stations (note that this slightly greater than the event definition criterion) should be flagged such that they may not be used as defining observations for later events, provided that they satisfy the following requirements:

(1) the predicted 87 per cent confidence interval of the expected arrival time for the given station and phase should be less than 30 seconds;

(2) the travel time residual should lie in

.. the interval (-3 to +10 seconds)

.. or in the smaller of

$(-\sigma_c \text{ to } +2\sigma_c)$

and (-5 to +10 seconds)

where

$$\sigma_c^2 = \sigma^2_{\text{event, phase}} + \sigma^2_{\text{phase}}$$

The asymmetry of these windows is intended to accomodate the tendency for the signal onset time to be picked late, both by automatic procedures and the human analyst.

Non-defining secondary phases (i.e. phases of types other than those given in Section 1 above and, if used, the depth phases pP and sP) may also be flagged as predicted, providing that they satisfy the requirements given above. The following secondary phases should be flagged for all events, if associated as such:

PKP (BC)
PKP (AB)
PP

For large events, with more than 10 arrivals at distances greater than 25 degrees, the following associated secondary phases should also be flagged, subject to the same restrictions, however they may have been reported:

PcP
PKKP (all branches)
PKPPKP (P'P') (all branches)
SKP (all branches)

The *a priori* standard deviations for these later phases are

PcP, PP	-	2 seconds
PKP (AB, BC)	-	1.5 seconds
All others	-	3 seconds.

These secondary phases do not affect the location of the event.

9. Association of Arrivals

Arrivals may be associated to an event so that they appear in the event listing even if they are neither predicted nor flagged according to the conditions given in Part 8 above. The requirement for association is that the arrival time residual lie in the range

(-5 to +10 seconds).

Note that arrivals may be multiply associated if they are not flagged as being predicted. However, associated but unpredicted arrivals may later become defining, whereas predicted arrivals may not.

Note that defining arrivals for a given event need not necessarily be predicted by that event, and in such a case are "free" to become defining to a later event. If they are also predicted by the later event, they may no longer be defining arrivals for the earlier event and this may then require that the earlier event be deleted if the event definition criteria are no longer satisfied. If a given arrival appears to be defining to both (a contradiction of terms) but is predicted by neither, a decision must be made by a seismologist. Both events should be given in the output bulletin, with an indication of the problem and the seismologist's recommendation.

10. Amplitude Consistency Checks

CD/43 (page 38 and appendix 6.1) recommends the application of statistical procedures involving not only the stations which have reported signals but also those which have not. This information is compared with a priori estimates of detection capabilities of the individual stations for events in various regions, in order to establish whether or not a certain association of arrival times fulfils a preset probabilistic requirement for defining an event.

In practice this method occasionally causes problems and even causes valid events to be rejected, primarily because station reporting characteristics are not as consistent as the technique requires and also because such essential information as station down times is not available. Refinements and changes to this technique are currently being studied.

Potentially this method is very powerful in deciding whether or not small events, which only just satisfy the event definition criteria, are valid, and this technique should routinely be applied only to events recorded at six stations or less. It can also be used to point out inconsistencies in the solution, without actually affecting the solution, for larger events. Amplitude-distance relations for the suggested additional defining phases (see part 3 above - PKPDF and local P and S) are required for full application of this technique to all arrivals.

11. Calculation of Body Wave Magnitude

Individual station body-wave magnitudes should be computed using the amplitude and period observations, corrected for distance by the Gutenberg-Richter amplitude-distance relation. Station magnitudes should only be calculated from measurements for which the corresponding arrival is defining for the event, and only at distances greater than 20 degrees, as recommended in appendix 6.3 of CD/43, until regional magnitude scales have been established.

Appendix 6.4 of CD/43 points out that an event magnitude based on an average of the individual measurements is in principle incorrect and often strongly biased too high. Maximum likelihood methods should be applied in computing event magnitude, but care should be exercised in their application as the a priori estimates of station noise levels and/or detectability often appear to be over-optimistic. Further studies must be made of the detection capabilities of the reporting stations.

12. Association of Long-Period Data

A procedure by which reported long-period surface wave data are associated with events located from short-period data should be used at International Data Centers. The travel times should be computed with the method described in CD/43, appendix 6.5. Love wave group velocity for continental and oceanic structure could be obtained, with sufficient accuracy, from J. Oliver BSSA 52.81 (1962). Reported long-period surface wave data should be tentatively associated with an event if the computed arrival time at the reported period agrees with the reported arrival time within a predetermined time interval. A good choice of the time interval is three minutes plus one tenth of the theoretical travel time. Surface wave reports without adequate information should not be considered, e.g. a surface wave associated to a P wave by the reporting station, but reported without an arrival time, should not be used in the magnitude calculation.

The procedure outlined above could lead to a surface wave being associated to two or more events. The multiple association should be resolved by the following criteria:

(1) If both Love and Rayleigh waves are reported, both must fulfil the travel time criterion;

(2) If the azimuth is reported, it is not allowed to deviate more than 50 degrees from the theoretical value;

(3) If the time residual to one of the events is less than 3 minutes associations with a time residual of more than 5 minutes should be excluded;

(4) Amplitude consistency check as described in section Part 10.

If the multiple association cannot be resolved, the surface wave report should not be allowed to enter into the calculation of an event magnitude.

A large number of unassociated surface waves during a short time period is a strong indication of the existence of a previously undefined event. Such an event should be located by the surface waves or by a combination of surface waves and short-period waves. The analysis of LP and SP data should be closely integrated so that both kinds of data could be used jointly for event definition and location. These procedures should be developed, tested and implemented at the IDCs.

13. Calculation of Surface Wave Magnitude

Individual station surface wave magnitudes should be calculated using the Prague formula as suggested in CCD/558. Until a formula for general global application for regional distances is agreed upon the Prague formula is used also for regional distances. At least two approved station magnitudes should be used in the maximum likelihood computation of the event magnitude.

14. Identification Parameters

Identification parameters may have been reported for a given arrival. Such information should be listed in the output bulletin; the meaning, if any, of multistation averages of these parameters is unclear and such averages should not be computed unless specifically requested.

15. Contents of the Output Bulletin

For each event, the estimated source parameters and their standard deviations should be given. Body-wave magnitude, surface-wave magnitude (or an upper bound to these) should be given.

For each associated arrival, indication should be made of whether or not it is defining and/or predicted. The phase identification, both as reported and as associated, should be given. For array observations, observed and predicted azimuth, slowness and distance should be reported. For all observations, the arrival time, its residual, the theoretical distance, azimuth and back azimuth, the amplitude and period, and, if computed, the station magnitude, should be given.

SECTION 4

IDC Output

16. IDC Bulletins

The principal external output of the IDC consists of the daily bulletins. There are two kinds of bulletins: Preliminary Event Lists and Final Bulletins. One of each is prepared for each day. The Preliminary Event List contains all "events in progress", i.e., those events for which enough data has been received to allow hypocenter determination, but which have not yet appeared on a Final Bulletin. The Final Bulletin contains the "official" description of each event, i.e., utilizing all data that has been received within five days after the date of the event.

The Event Lists will contain only basic information, as defined in CD/43, while the Final Bulletin will contain the latest estimates of the basic information plus a listing of all arrivals associated with the event, whether defining or non-defining. The Final Bulletin will also contain a list of unassociated arrivals.

17. Data Archives

The principal internal output of the IDC is its data archives. There are two principal archives: for parameter data and for waveform data. Parameter data consist of arrival parameters submitted to the IDC by the reporting stations, through the National Authorized facilities. Waveform data consists of waveform segments. Other parameters resulting from processing of Level I data, such as location of events, origin times, etc., will also be kept in the IDC archives.

17.1 Parameter Data

Parameter data should be stored in the Parameter Archive. This archive contains parameters for all arrivals and events known to the IDC, and its contents should be easily retrieved. The specific format in which the data is stored will depend upon the particular hardware and data management system in use at the IDC.

17.2 Waveform Data

The handling of waveform data may differ depending upon whether it was received in digital or analog form. Waveform data received in digital form should be stored in computer-readable form in the Waveform Archive. The existence of non-digital entries of waveform data is logged, but the data itself is not converted to or maintained in computer-readable form.

The IDC archive contains all waveform data received by the IDC. It also contains a complete set of descriptive parameters for each waveform entry source time, instrument type, channel, etc.

18. Reports

Various aspects of the activities of the IDC will probably be of interest to participants. They can be summarized in report form and include:

- message summary: monthly; in sum and for each source, the number of messages received, the number of messages with errors, the number of missing messages, the number of retransmissions, etc., plus, for each source, the number of the last message received;

- event/arrival summary: monthly; for each source, the number of arrivals; total number of arrivals; total number of events; number of unassociated arrivals;

- data request log; quarterly; a log of the data requests received and satisfied during the quarter, showing source of the request, date, nature of the request (data requested), data sent, date sent;

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

- bulletin reconciliation: monthly; an 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);

- Waveform Archive summary: annual, with quarterly updates; a guide to the current contents of the Waveform Archive.

19. Data Requests

The IDC must respond to all requests for data and information made by participating States. It is expected that the majority of the requests will be for more or less well-defined subsets of IDC archival data. Response to these requests should be prepared in accordance with the following principles:

- in the absence of other instructions, Level 1 data will be in the format defined by CD/43 for WMO/GTS use, sorted by date and station;

- digital waveform data will be in IDC preferred input format (see Annex A7-II);

- nine-track, 1,600 bpi magnetic tape is the preferred medium of distribution for all data except analog waveform data;

- analog waveform data will be distributed on paper, microfilm or similar media.

All requests will be noted in the request log described above.

SECTION 5

Operational Procedures for IDCs

20. Message Handling

The IDC will maintain a message log, containing (at least) the following information for each message:

(a) medium of transmission (WMO, RST, postal service, etc.);

(b) source;

(c) date of data;

(d) date of transmission;

(e) date of receipt;

(f) message number;

(g) correction history.

In the case that "duplicate" messages (i.e. two messages from the same source with the same message number) are received, only the most recent is kept. ("Most recent" means bearing the latest time of transmission; in the case of messages bearing identical times of transmission, that with the latest time of receipt is most recent.)

As a result of the multiple connectivity of the WMO/GTS, truly duplicate messages are sometimes received. In general, this will present no problem, for earlier copies will be discarded. It may happen, however, that the message number itself is garbled in one copy of the message (so that it no longer qualifies as a "duplicate"); the IDC is expected to detect such situations and discard the erroneous message.

Corrections should be submitted using standard WMO/GTS procedure.

The "correction history" entry in the log will note the number of times the message has been corrected, and whether the last correction originated at the IDC or at the source of the message.

The source is responsible for assigning consecutive message numbers to messages it originates. The IDC will interpret gaps in the message numbers from any source to be evidence of lost messages, and will initiate action to recover the missing messages.

All messages - including those containing comments or data service requests - will be handled in the same fashion.

The IDC will ensure that the source and message number will be kept in the archival record for each arrival received.

An IDC may translate incoming data, if necessary, into its internal standard format before recording the data in the Parameter and Waveform Archives. On the other hand, the IDC will maintain a true (character for character) copy of all incoming messages, in the original form or on tape, for historical reference.

The IDC will maintain statistics on message traffic (incidence of errors, incidence of multiple transmission, incidence of gaps, delay before transmission, delay before receipt, etc.).

21. Input Formats

21.1 Level I

The input format for Level I data is given in Annex A7-I.

21.2 Level II

Because of the proliferation of recording formats for such data, the IDC must be prepared to accept Level II data in any of several forms (CD/43 notes in particular that an IDC "should be equipped to handle waveform data supplied in any reasonable format" [emphasis added].) Nevertheless, some standard formats must be specified for Level II data. The preferred format is specified in Annex A7-II.

Note that the sending station must include with the Level II data enough descriptive material to enable the IDC to reconstruct the waveforms.

22. Archive Maintenance

The IDC will maintain several kinds of archival information input message archive; message log; Parameter and Waveform Archives; bulletin file; station and instrument descriptions. These archives are to be kept up-to-date: information will be entered into the archives by the end of the working day next after the day it has become available to the IDC. They may, but need not, exist as separate files or file systems. The structure and format of the archives at each IDC will depend upon the hardware and software in use at that IDC at the time.

(a) input message archive: This archive contains a true copy of all messages received by the IDC, either on tape or in their original form. In either case, the IDC will maintain suitable computer-resident indexing information to enable access by source, date, and message number.

(b) message log: This archive contains the information specified in Part 20 above. The IDC will publish a monthly summary of message traffic giving, for each source, the number of the last message received, the number of messages actually received, the number of gaps, the number of corrected messages, and the number of missing messages.

(c) Parameter Archives: These archives contain the parameter data received by the IDC, in IDC internal format. The data is organized and indexed so as to be accessible in at least the following ways:

- by event (or lack of event - i.e. unassociated arrivals)
- by time
- by reporting station, country, or region
- by phase
- by any event parameter (e.g. latitude, longitude, depth, etc.).

(d) Waveform Archives: The archives contain the waveform data received by the IDC, whether continuous or segmented, in IDC internal format. The data is organized and indexed so as to be easily searchable and accessible by a number of characteristics.

The IDC will not attempt any action to create "data" to fill gaps in waveform data as archived.

(e) bulletin file: This archive contains all bulletins, indexed by date of issue and date of event, issued by the IDC. If other IDCs issue bulletins which differ significantly from those issued by the subject IDC, they shall also be entered into this archive (and indexed by source, as well as by date of issue and date of event). (For the purposes of this requirement, an unassociated arrival is treated as an event.)

f) station and instrument descriptions: These archives contain complete current and historical descriptions of all the stations and instruments that have supplied data to the IDC. The data is organized and indexed so as to be easily searchable by a number of characteristics.

The instrument descriptions shall include instrument response characteristics and calibrations as supplied by the station.

The IDC will make every effort to maintain all archives in machine-readable form; where this is unfeasible (as, for example with photographs, microfilms, facsimiles of seismograms, or other graphical data) the IDC will maintain on-line indexes to the information.

23. Bulletin Preparation

The IDC will prepare two bulletins for each day, a Final Bulletin for the events of day -7 and a Preliminary Event List for the events of day -2. ("Day -n" refers to the day n (calendar) days prior to the date of the bulletin). The schedule and the elements of the bulletin preparation procedure, in outline form, are given below (and in the figure on page 16):

Day 0: data day

Day 2: IDCs exchange and reconcile input from Day 0;
prepare preliminary event list (PEL);
publish PEL;
(after publication) compare and reconcile PEL with those of other IDCs

Day 3: upgrade event definitions, in consultation with other IDCs

Day 4: upgrade event definitions, in consultation with other IDCs

Day 5: upgrade event definitions, in consultation with other IDCs

Day 6: prepare and exchange tentative final bulletin with other IDCs

Day 7: reconcile and publish (both parts of the) final bulletin.

The final bulletin is prepared in two parts. The first is transmitted over the WMO/GTS and contains only event parameters. Individual National Authorized facilities may make additional arrangements for a direct electronic connection to the IDC to receive the IDC bulletins. The second is mailed to all participants (on the same day the first part is transmitted), and is a complete bulletin, containing both basic and detailed information, as specified in CD/43. The second part of the bulletin also contains all unassociated data, and a copy of the preliminary event list for the same day (for comparison purposes).

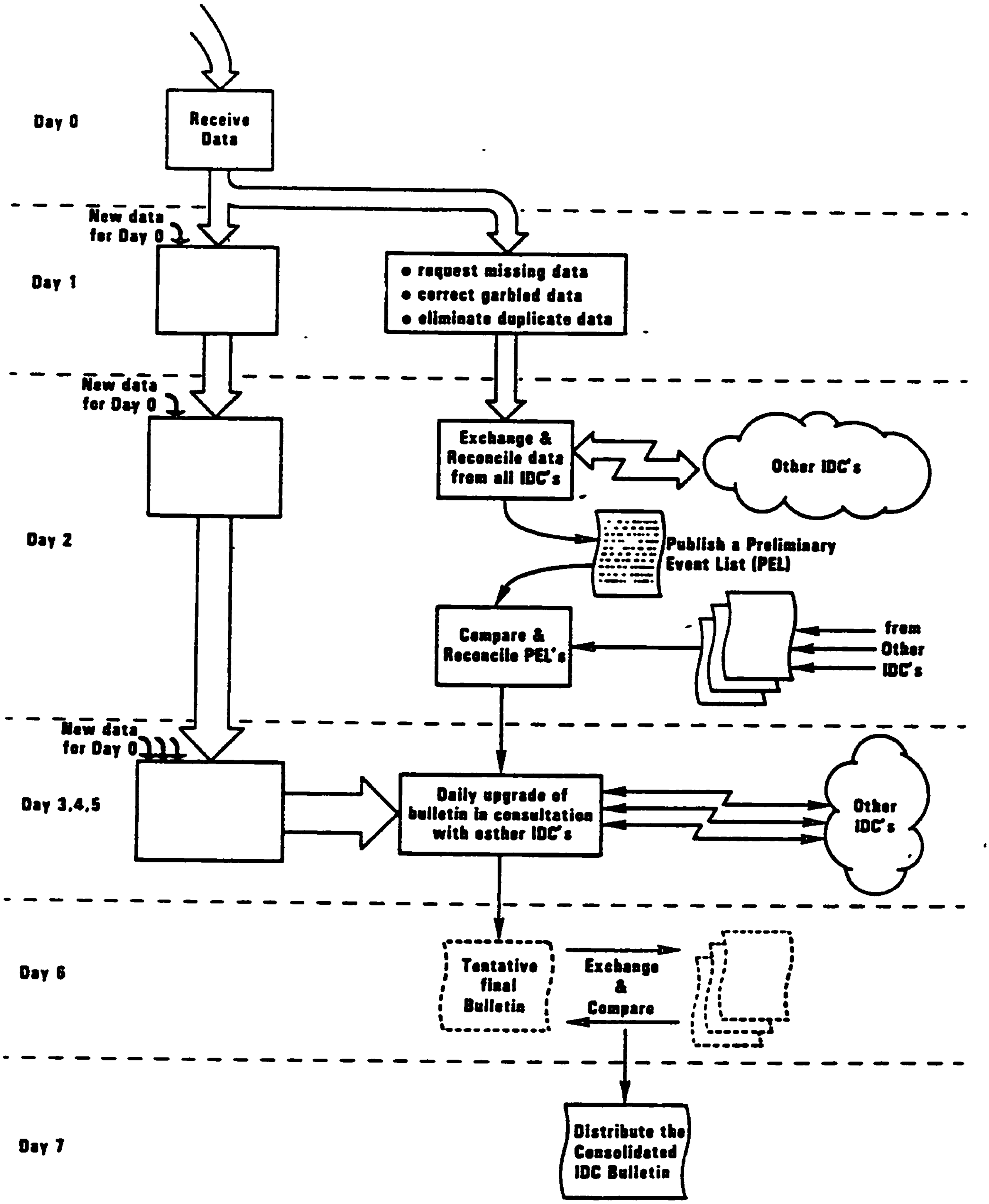


Figure 5.1 Schedule for Bulletin Preparation

The form and content of both the preliminary event list and the final bulletin are discussed in detail in Annex A7-III through Annex A7-VI.

If a participating State requests a new computation for any event after the release of the appropriate Final Bulletin, a Revised Bulletin will be prepared for distribution on the next working day after the receipt of the necessary corrected data.

24. Data Services

The IDC will supply data from its archives to authorized uers. Data will be supplied in accordance with the principles noted in Part 19 above. The IDC will take no action to fill in missing data (i.e., to supply data in accordance with some convention to fill gaps) or decimate it: data will be delivered as it occurs in the archives. (The IDC will inform the requestor of the incidence of gaps, however.)

The time to satisfy the request will depend upon the magnitude and complexity of the request and the currency of the data requested. Simple requests (i.e. those involving no more than a single, recent, time period and little sifting on parameter values) will be satisfied within three working days; complex requests may require as much as 10 working days (or longer, for large volumes of data). (Requests for hard-copy material, such as true copies of arcnived messages kept in the original form, are complex.)

25. Communications

The IDC will maintain reliable communications with reporting stations and other IDCs through a number of different media, ranging from the WMO/GTS to direct computer-to-computer links as required by data volume and ease of use.

In addition to data links, the IDC could maintain voice links to each of the reporting stations, and to other IDCs. These voice links would not be used for routine traffic, but for the purpose of clarifying confused or garbled transmissions, and for requesting retransmission of missing messages. They will also be used by the IDCs when necessary to reconcile differences in Event Lists and Final Bulletins.

26. Data Validation

The IDC will exchange input files with all other IDCs every day, to confirm consistency of input. This exchange should be carried out two days after receipt of the data in order to reduce the number of differences due to missing messages and delays in transmission, and also to allow time for the correction of obviously garbled messages.

The format for exchange of input shall be a character-for-character copy of the messages as received or corrected (from ZCZC through STOP), ordered by time of transmission and originating station, and with a leading blank inserted on each line. The exchange should take place by terminal-to-computer or computer-to-computer link, not via WMO/GTS. The exact procedure for accomplishing the exchange will be defined by the IDCs involved.

In case the input is not identical, the procedures given in Part 26.1.4 (Differing input) are to be followed.

26.1 Procedures for Correcting Messages and Obtaining Missing Messages

26.1.1 Missing messages

When an IDC suspects that it has not received a message, it will first enquire of the other IDCs whether or not they have received it. If any have, it will request a copy from one of them (via terminal-to-computer or computer-to-computer link); if none has received it, and if retransmission has not been requested during the previous 24 hours, it will request retransmission by the originator.

26.1.2 Garbled messages

A garbled message is one that is obviously in error, either because the automatic decoding process has failed, or because its content is inconsistent or out of limits. Upon receiving such a message an IDC will first enquire of the other IDCs whether or not the copy they received was garbled. If one of the IDCs has received a correct copy, then the message will be requested (via terminal-to-computer or computer-to-computer link) from that IDC. If all IDCs received garbled versions, then the action taken will depend upon the nature of the error. If the error is a simple typographical error, and if all IDCs agree on the same interpretation, then the IDC interpretation shall be taken as correct (but the final bulletin shall report both the original data and the corrected data). In all other cases, a correction (or retransmission of the entire message) shall be requested of the originator.

26.1.3 Multiple messages

When a message is received more than once, either as a result of multiple processing within the WMO/GTS or as a result of a specific request for retransmission, the latest copy shall be considered as the correct one. ("Latest" means bearing the latest time of transmission, and, of several with the same time of transmission, that one having the latest time of receipt.)

26.1.4 Differing input

During the two days between receipt and comparison of input the IDCs will be able to obtain missing messages and to correct garbled messages. Nevertheless, differences in input will arise: for example, lost lines, unreceived correction messages, and undetected transmission errors all will occasionally occur. In the case where one IDC has not received all the data that another IDC has received, and detects this situation as a result of the daily comparison of input, it will normally accept the additional comparison data as correct (whether it is complete or partial messages). If there is reason to believe that the additional data is erroneous, then confirmation will be sought from the originator. In the case where two IDCs have apparently correct, but different, versions of the same message, both versions should be rejected, and retransmission by the originator should be requested.

Annex A7-I

Level 1 Data

1. Introduction

The format for Level 1 (parameter) data has been specified in some detail on pages 22-30 of CD/43/Add.1, but some problems with those specifications have come to light in the wake of the WMO experiments of October 1980 and November/December 1981. Three types of difficulties were experienced:

(a) improper handling of essential information (e.g., reporting interval and downtime information) when it is enclosed in double parentheses (i.e., when it looks like commentary) (It should be noted that CD/43/Add.1, on page 23, mentions the undesirability of treating reporting interval and downtime as comments.)

(b) the fact that some phase identifiers (e.g., MIR) duplicate station names

(c) the lack of definitive event delimiters.

It has been necessary to modify the specification given in CD/43/Add.1 very slightly to overcome these problems. The modifications occur as changes to items 6 and 7 in the description of the format, a new item 8 (event delimiter), and a new name (MIRZ) for parameter group 37-38-39 (maximum amplitude of IRZ).

2. Description of the format

The proposed format, which is described in detail in Tables A7-I(1) through A7-I(4), is in most respects identical to the International Seismic Code. However, the following deviat ons should be noted:

(1) Numbering

The messages originating from each national facility will be consecutively numbered starting at the beginning of each calendar year. The general form of the number is Nyn where N is a prefix, y is the last digit of the calendar year and n is a number of 1 to 5 digits.

(2) Additional phase identifiers

As described in detail in Tables A7-I(1) and A7-I(2), several new phase identifiers will be needed compared to the International Seismic Code. Each of these is to be followed by the corresponding arrival time, period and amplitude in accordance with standard practice. Note that all the amplitudes of these new phases will be quoted in nanometers (nm).

(3) Identifiers for parameters

Again referring to the Tables A7-I(1) and A7-I(2), a number of new identifiers corresponding to specific computed parameters will be needed.

(4) Later phase information

For each later phase, the maximum amplitude (quoted in nm) and corresponding period that is associated to the phase will be reported. For horizontal instruments the component on which the measurements were made might be specified as a suffix (E or N) immediately following the phase identifier. However, care must be taken not to exceed the maximum length (5 characters) of a phase identifier.

Additional comments

(5) Grouping of readings

Readings from short and long period instruments for the same phase should be grouped together. When the time of arrival is determined more accurately on the SP instrument, the arrival time on the LP instruments need not be given, but the long period maximum amplitude identifier should be followed as usual by its associated arrival time, period and amplitude.

(6) Reporting interval

The time interval covered by the transmitted message should be specified using the identifiers BEG (beginning) and END; for example:

((BEG APR01 120000 END APR02 120000))

Note: In case of a station transmitting a group of messages, e.g., once per day, the first message may contain the reporting interval for the entire group. If so, the number of messages (NM) in the group should be appended as, e.g.,

((BEG APR01 120000 END APR02 120000 NM7))

(7) Down-time information

If a station has been out of operation, this time interval should be reported as OUT (date, time) followed by TO (date, time). This reporting should be made as soon as possible after the station is back in operation.

((OUT SEP02 191530 TO SEP02 223515))

Partial outages are reported with a component identifier following the downtime identifier OUT:

((OUT LPZ MAY02 1330 TO MAY02 1600))

Additional explanation may be included in brackets as found necessary.

(8) Event delimiter

In ISC (International Seismic Code), the start of a new event is signalled by the occurrence of one of six accepted first arrival phase names. In effect, these phase names are used as event delimiters.

The protocol for parameter reporting defined in CD/43 allows other phases to be reported as initial arrivals, for example, initial S phases, body waves on long-period instruments with phase identifiers identical to those reported from short-period instruments, and Rayleigh and Love waves not associated to any short-period arrivals. These initial phases conflict with the ISC convention.

A repetition of the station identifier should be used between events as an event delimiter when reporting non-ISC-standard initial phases. (The ISC-standard initial phases are P, PDIF (or DIF), PKP, PN, PG, and PB.)

Table A7-I(1)

Proposed identifiers for Level 1 short period parameters

Type of Wave	Component	Parameter	Proposed Identifier
P	Vertical	(a) Standard parameters - stations of types I, II and III.	
		1. Arrival time	*
		2. First-motion sign and clarity (if readable)	*
		3. Amplitudes A_i ($i=1,\dots,4$)	
		4. Arrival times corre sponding to each A_i	M1X,M2X,M3X,M4X**
		5. Periods corresponding to each A_i	
		6. Noise amplitude, A_N	NA
		7. Period corresponding to A_N	NT
		8. Secondary phase description:	
		Amplitude	*
		Period	*
		Arrival time	*
		9. Complexity	CMPX
		10. Spectral moment, ratio or vector	SPMM, SPRT, SPVT

S	Horizontal	11 Arrival time	*
		12 First-motion clarity	*
		13. Maximum amplitude, A_M on each horizontal component	
		14. Arrival times corresponding to each A_M	MSE, MSN**
		15. Periods corresponding to each A_M	
		16. Secondary phase description:	
		Amplitude	*
		Period	*
		Arrival time	*
T	Vertical	53. T-phase description	
		Amplitude	*
		Period	*
		Arrival time	*
P	Vertical	(b) Additional standard parameters (type III stations only)	
		17. Apparent slowness	*
		18. Epicenter azimuth and distance	*, DIS
		19. Epicenter latitude and longitude	LAT, LON
		20. Origin time	OT
		21. Magnitude m_b	MB

* Form employed in the International Seismic Code should be used.

** Each phase identifier is followed by arrival time, period (T) and amplitude (A) according to standard conventions.

Table A7-I(2)

Proposed identifiers for Level 1 long period parameters

Type of Wave	Component	Parameter	Proposed Identifier
P	Vertical	(a) Standard parameters - stations of types I, II and III.	
		22. Arrival time	*
		23. First-motion sign and clarity	*
		24. Maximum Amplitude, A_M	
		25. Arrival time corresponding to A_M	MLP**
		26. Period corresponding to A_M	
		27. Noise amplitude, A_N	NLPA
		28. Period corresponding to A_N	NLPT
		29. Secondary phase description:	
		Amplitude	*
		Period	*
		Arrival time	*

S	Horizontal	30. Arrival time	*
		31. First-motion clarity	*
		32. Maximum amplitude, A_M on each horizontal component	
		33. Arrival times corresponding to each A_M	MSLPE, MSLPN**
		34. Periods corresponding to each A_M	
		35. Secondary phase description:	
		Amplitude	*
		Period	*
		Arrival time	*
LR	Vertical	36 Arrival time	LRZ
		37. Maximum amplitude, A_M	
		38. Arrival time corresponding to A_M	MLRZ**
		39. Period corresponding to A_M	
		40. Maximum amplitude for periods near 10, 20, 30 and 40 s	
		41. Arrival time corresponding to amplitudes for the above periods	M1L,M2L,M3L,M4L**
		42. Actual observed periods (item 40)	
		43. Noise amplitude, A_N	NLPA
		44. Period corresponding to A_N	NLPT

LQ	Horizontal	45. Arrival time	LQ
		46. Maximum amplitude, A_M on each horizontal component	
		47. Arrival times corresponding to each A_M	MLQE, MLQN**
		48. Periods corresponding to each A_M	
		(b) Standard parameters - type III stations only.	
P	Vertical	49. Apparent slowness	SLOLP
		50. Epicenter azimuth	AZLP
LR	Vertical	51. Magnitude M_S	MS
S	Horizontal	52. Magnitude m_{SH}	MSH

* Form employed in the International Seismic Code should be used.

** Each phase identifier is followed by arrival time, period (T) and amplitude (A) according to standard conventions

Table A7-I(3)

Sample telegraphic text for the transmission of Level 1 data

SEISMO N82351((BEG SEP22 180000 END SEP23 240000 NM8))

ARR SEP22

IPCU 1919020

M1X19035 T3A60 M2X19112 T3.2 A53.1
M3X19160 T3.5A29.8 M4X19233 T3.5 A27.2
MLP19060 T6A144
NT1.0 NA5.1 NLPT8 NLPA15

E PP 2247 T3.6A18.2
T8 A108

ES 30025 MSE 30080 T4A75.2
MSN 30080 T4A61.0
MSLPE 30090 T9A216
MSLPN 30090 T9A135

ESS 3711 T4.7A61.7
T12 A192

LRZ 4841 MLRZ5407 T22A271
M1L5637 T10A135 M2L5311 T20A200
M3L5203 T30A105 M4L5012 T40A98
NLPT20 NLPA12

LQ 4251 MLQE4302 T21A220
MLQN4302 T21A172

CMPX 23.02 SPMM 2.45

SLO 4.8 AZ226 DIS94 LAT-35 LON-120 OT190541 MB6.5

SLOLP 4.8 AZLP221 MS6.4 MSH6.6

ARR
S 2358100
MSE 58182 T2.8 A46.7
MSN 58182 T2.7 A53.2

STOP

Table A7-I(4)

Explanation of the text in Table A7-I(3)

SEISMO - identification of type of data (seismic)

N82351 - message no. 2351 during 1978 for the station(s) BEG SEP22 180000 END SEP23 240000 NM8 - This is the first message in a group of 8 covering the time interval indicated (UTC).

ARR - station name

SEP22 - date of recorded event (22 September)

IPCU 1919020 - first-motion clarity (I), type of wave (P), direction of first motion (C - compression on short-period seismograph; U - compression on long-period seismograph), arrival time (19h19m02.0s) in component Z

M1X19035 - time of arrival (19m03.5s) for P-wave first amplitude, A_1, in component Z

T3A60 - period (3 seconds) and amplitude (60 nm) for amplitude A_1 in component Z

M2X19112 T3.2A53.1 - time of arrival, period and amplitude for amplitude A_2 in component Z

M3X19160 T3 5A29.8 - time of arrival, period and amplitude for amplitude A_3 in component Z

M4X19233 T3 5A27.2 - time of arrival, period and amplitude for amplitude A_4 in component Z

MLP19060 T6A144 - time of arrival, period and amplitude on LP seismograph, component Z

NT1.0 NA5.1 - period and amplitude of noise on short-period seismograph, component Z

NLPT8 NLPA15 - period and amplitude of noise on long-period seismograph, component Z

E PP 2247 T3.6A18.2)
T8 A108) - time of arrival, periods and amplitudes of secondary longitudinal PP wave in component Z (on short and long period instruments, respectively)

ES 30025 - first-motion clarity (E), wave type (S), arrival time, (component not indicated)

MSE 30080 T4A75.2 - time of arrival, period and amplitude for maximum amplitude of short period S wave in component E

MSN 30080 T4A61.0 - time of arrival, period and amplitude for maximum amplitude of short period S wave in component N

MSLPE 30090 T9A216 - time of arrival, period and amplitude for maximum amplitude of long period S-wave (component E)

MSLPN 30090 T9A135 - time of arrival, period and amplitude for maximum amplitude of long period S-wave (component N)

E SS 3711 T4.7A61.7)
T12 A192) - clarity and time of arrival, periods and amplitudes for secondary shear phase (SS) (component not indicated)

LRZ4841 - time of arrival of Rayleigh wave in component Z

MLRZ5407 T22A271 - time of arrival, period and amplitude of maximum phase in Rayleigh wave in component Z

M1L5637 T10A135 - time of arrival and amplitude in Rayleigh wave for 10 second period in component Z

M2L5311 T20A200) - arrival times and amplitudes in Rayleigh wave

M3L5203 T30A105) for, respectively, 20, 30 and 40 second

M4L5012 T40A98) periods in component Z

NT20 NA12 - amplitude of noise for 20-second period on long-period vertical seismograph

LQ 4251 - time of arrival of Love wave in component E

MLQE4302 T21A220 - time of arrival, period and amplitude of maximum phase in LQ wave in component E

MLQN4302 T21A172 - time of arrival, period and amplitude of maximum phase in LQ wave in component N

CMPX 23.02 - 'complexity' parameter in P wave recording

SPMM 2.45 - 'spectral moment' parameter for P waves

SLO 4.8 - apparent slowness (s/degree)

AZ226 - azimuth from station to epicenter (degrees)

DIS94 - epicentral distance (degrees)

LAT-35 - latitude (degrees) of epicenter (- = south)

LON-120 - longitude (degrees) of epicenter (- = west)

OT190541 - origin time (19h 05m 41s)

MB6.5 - magnitude, determined for short-period P wave

SLOLP 4.8 - apparent slowness of long period P (s/degree)

AZLP 221 - azimuth to epicenter from LP recordings (degrees)

MS6.4 - Rayleigh wave magnitude on LPZ seismograph

MSH6.6 - S-wave magnitude on long-period horizontal seismograph

ARR - station code, repeated to serve as event delimiter

S 2358100 - phase (S) and arrival time (23h 58m 10.0s) (component not indicated)

MSE 58162 T2.8 A46.7 - time of arrival, period and amplitude for maximum amplitude of short period S in component E

MSN 58162 T2.7 A53.2 - time of arrival, period and amplitude for maximum amplitude of short period S in component N

Annex A7-II

Level 2 Data

1. Introduction

Although an IDC should be prepared to accept any reasonable format, storing, copying and distribution of Level II data will be expedited if a standard format is used whenever possible. The following specification describes a format that is already in use. It is designed for transmitting digital waveform data via magnetic tape. The format may be generally described as a descriptive header followed by the actual wafeform samples.

2. Description of the Format

Annex A8-V describes the preferred format for exchanging digital Level II data by magnetic tape.

Annex A7-III

Form and Content of a Preliminary Event List

A preliminary event list contains events that are listed as soon as there is enough information to define the event. The preliminary nature of the list is emphasized by reporting fewer parameters and less precision than are reported on a final bulletin. Preliminary event lists are prepared as follows:

(1) use the format described in Annex A7-V ("Bulletin Format")

(2) list events in chronological order, with automatically defined and manually defined events in the same stream

(3) time to the nearest second, latitude and longitude to the nearest hundreth of a degree and the depth to the nearest 10 km, magnitude to the half magnitude

(4) station list - include all stations contributing to the event

(5) event code (to be inserted after the event delimiter):

- AOK: an automatically defined event that has been accepted by reviewer
- ARJ: an automatically defined event that has been rejected by reviewer
- ARM: an automatically defined event for which a reviewer has proposed modifications (an event of this type should always be accompanied by a corresponding RMA)
- RMA: a reviewer's modification of an automatically-defined event (an event of this type should always be accompanied by a corresponding ARM)
- RDE: a reviewer-defined event (i.e., one that does not correspond to any automatically defined event)

(6) there may be more than one event given for one time (two reasons: the time granularity is coarse, and the possible existence of ARM/RMA pairs with the same time)

(7) all events with code different from AOK should be accompanied by explanatory commentary ((enclosed in double parentheses)) following the event code.

((Each line of commentary should be enclosed))
((in double parentheses)).

Annex A7-IV

Form and Content of a Final Bulletin

The final bulletin 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 (on the same day the first part is transmitted), and is a complete bulletin, containing both basic and detailed information, as specified in CD/43. The second part of the bulletin also contains all unassociated data, and a copy of the preliminary event list for the same day (for comparison purposes).

Both parts of the bulletin contain entries for events that have been undefined, together with the remark "deleted".

The precision of reporting of values in both parts of the final bulletin shall conform to accepted standards.

1. First Part (WMO/GTS)

Bulletins transmitted by the IDCs over the WMO/GTS will be prepared as follows:

(1) use the format described in Annex A7-V ("Bulletin Format")

(2) list events in chronological order, with automatically defined and manually defined events in the same stream

(3) give all parameter values to standard precision, and include error estimates in parentheses where appropriate

(4) include the number of defining stations, but do not include the station list that appeared in the PELs

(5) event code (to be inserted after the event delimiter):

- AOK: an automatically defined event that has been accepted by reviewer
- ARJ: an automatically defined event that has been rejected by reviewer
- ARM: an automatically defined event for which a reviewer has proposed modifications (an event of this type should always be accompanied by a corresponding RMA)
- NEV: an event that did not appear on an earlier PEL or bulletin for this date (usually because of the later arrival of defining data)
- RMA: a reviewer's modification of an automatically-defined event (an event of this type should always be accompanied by a corresponding ARM)

- RDE: a reviewer-defined event (i.e., one that does not correspond to any automatically defined event)

- UND: an "event" that has been undefined as a result of later analysis; no event parameters other than time need be transmitted for an event that has been undefined

(6) there may be more than one event given for one time

(7) all events with code different from AOK should be accompanied by explanatory commentary ((enclosed in double parentheses)) following the event code.

((Each line of commentary should be enclosed))
((in double parentheses)).

Example SEISMO N30002 IDCA((BEG MAY01 0000 END MAY02 0000))((FINAL BULLETIN))

```
:: AOK
  003654.0 36 48N 1.63E DEP38
  N7
  MB 4.1 N3
:: UND
  0049
:: RDE
  ((DEFINING ARRIVALS WERE CAUGHT BY))
  ((REJECTED EVENT AT 0049))
  010338.3  44.57N  81 29E  DEP33
  N4
  MB4.7 N3
:: ARM
  ((REVISION OCCURS AS EVENT AT 0112))
  0109
:: RMA
  ((ARRIVALS FROM TOM BELONGING TO))
  ((EVENT AT 0104 WERE MISASSOCIATED))
  011237.6   1.42N  123.26E  DEP332
  N12
  MB5.1 N4
:: NEV
  ((DEFINING ARRIVALS FROM ONO AND TWO WERE))
  ((RECEIVED AFTER PEL WAS PREPARED))
  040403.5 29.39N 70.15E DEP0
  N5
  MB4.6 N2
STOP
```

2. Second Part (mailed)

The complete bulletin (the version that is mailed to all participants) will be prepared as follows:

1) A time-ordered, detailed listing of all events, using the format described in Annex A7-VI.

2) A time-ordered listing of unassociated arrivals, giving station, code, phase name (if supplied), time, and any other reported parameters.

3) A copy of the Preliminary Event List for the same day.

Annex A7-V

Bulletin Format

The following is a proposed format for the exchange of parameter event-oriented information via the WMO/GTS.

KEYWORD	*DESCRIPTION*
SEISMO	Start of seismic message. (Ends with STOP.)
PEL [BULL]	Preliminary event list [final bulletin]. (PELO and PELO are also acceptable codewords for a PEL.)
Nnnnn	Message number. (nnnn is numeric.)
identifier	Site issuing the bulletin.
BEG...END...	Bulletin contains events between dates and times listed. Format may be either of the following: 820501 1200 or 82MAY01 1200
date_of_event	Dates folllow the same rules as in the International Seismic Code.
	Event delimiter.
event_code	Three-character code giving the type of event (automatic or manual, original or revised).
((commentary))	Commentary describing the reasons for rejection or revision of an event. ((Required for all event_codes except AOK.)) The double parentheses are required.
time	Origin time, to the minute for PEL, to standard precision (with error estimate in parentheses) for BULL.

lat	Latitude, to the degree for PEL, to standard precision (with error estimate in parentheses) for BULL
long	Longitude, to the degree for PEL, to standard precision (with error estimate in parentheses) for BULL.
DEPnnn	Depth of focus. nnn is numeric (kilometers) (with error estimate in parentheses) for BULL; it is D (deep) or S (shallow) for PEL
Nnnn	Number of defining stations (BULL only). nnn is numeric.

The following is used only in PEL's:

A list of the stations contributing to the event (station codes, separated by spaces).

NOTES

(1) Keywords appearing in UPPERCASE, and ::, are to be entered exactly as they appear; keywords appearing in lowercase are descriptive of the contents of the field.

(2) Error estimates should always be given in the same units as the parameter to which they refer.

(3) The event delimiter (::) is required for each event.

(4) Any number of newlines is permissible.

Annex **A7-VI**

SAMPLE DETAILED EVENT LISTING FROM A FINAL BULLETIN

Description of the contents in the eventlist

```
780116
 52857.8+-  3.1 35.0N+- 0.1 138.6E+- 0.1  73KM+-  29 BASED ON  6 STAT.
HONSHU, JAPAN
NUMBER OF ASSOC  SP-TIMES 15 NUMBER OF ASSOC. LP-TIMES  7
MB       . 4 1 BASED ON  3( I ) STAT  3( II)  STAT 2(III) STAT 33( IV) STAT
MS       . 4 2 BASED ON  6( I ) STAT  3(III)  STAT
COMPLX   : 1.13   STD:      0.03 BASED ON  2 VALUES
TMFI     . 1.05   STD:      0.10 BASED ON  2 VALUES
TMFC     : 0.92   STD:      0.02 BASED ON  2 VALUES
SPECTRAL VECTORS                 BASED ON  2 STAT.
                INITIAL PHASE             CODA
    MEAN:          0 -14 -27 -40 -52        0 -14 -29 -47 -51
    STD :          3   9  12   9   0        5  12  12   0   0

MAJO P   (P   )  52923.0  -0.5*  1.5 348.8 168.1 13.55                    2 0.95
     REPORTED:                   5.1
CHTO P   (P   )  53615.8   0.6* 38.6 255.6  57.0  8.35       9.6 1.06 4.6 1 0.20
COL  P   (P   )  53802.0   0.4* 52.0  31.3 272.5  7.49                    2 0.20
WRA  P   (P   )  53819.0  -3.7  54.8 184.9   4.3  7.30       4.0 0.90
KAAO P   (P   )  53830.5  -0.5* 56.0 291.1  68.0  7.16       9.1 1.06 4.6 1 0.15
KAAO     (XP  )  53959.5   0.6  56.0 291.1  68.0  7.20      13.2 1.41
ASP  P   (P   )  53849.0  -0.2* 58.6 185.0   4.5  6.95                    2 0.28
MBC  P   (P   )  53852.5  -0.1* 59.1  15.5 290.7  6.91      13.0 1.00 4.8 1 0.05
YKA  P   (P   )  53949.3   6.4  66.7  29.0 301.2  6.32
     REPORTED:                             294.7  6.50
WB2  P   (P   )  54037.2   3.6  75.1 336.4  43.4  5.89       7.4 1.00
     REPORTED.                  74.0        49.0  6.04                4.6
DUG  P   (P   )  54105.7   3.1  80.4  47.4 307.9  5.31
ANMO P   (PP  )  54506.7  -0.9  87.6  48.2 311.9  8.08       2.1 1.00
SPA  P   (PKP )  54748.7  -0.9 124.9 180.0 137.7  1.95
ARC  P   (PKP )  54840.0   2.3 147.4  63.1 310.3  3.57
ZOBO     (PP  )  55216.4   0.1 149.7  58.8 313.1  5.72       3.5 0.94
        CMPLX                 TMFI                TMFC
KAAO     1.15       0.02       1.12       0.07     0.91       -0.01
ANMO     1.11      -0.02       0.98      -0.07     0.94        0.02
MAJO LZ  (LZ  )  53020        34    1.5 348.4 168.1         10129.0  18.     6-0.09
     REPORTED:                              135.0
TATO LZ  (LZ  ) 53855      15      17.9 240.4  51.9          1004.0  21. 4.0 1 0.45
     REPORTED:                              55.0
GUMO LZ  (LZ  ) 54035      58      22.1 163.6 346.2           998.0  25. 4.2 1 0.88
     REPORTED:                               1.0
CHTO LZ  (LZ  ) 55225     -16      38.6 255.6  57.0           504.0  22. 4.2 1 0.78
     REPORTED:                              50.0
CTAO LZ  (LZ  ) 55640     -17      55.3 171.2 352.4           215.0  26. 4.1 1 0.53
     REPORTED:                             343.0
KAAO LZ  (LZ  ) 60240     -48      56.0 291.1  68.0           353.0  20. 4.4 1 0.43
     REPORTED:                              60.0
MAIO LZ  (LZ  ) 60925     126      62.5 296.5  65.3           290.0  21. 4.4 1 0.48
     REPORTED:                              65.0
```

Line		
1-13		contains the event parameters.
15-32		contains information about the shortperiod observations defining the event or associated to the event.
34-36		contains information about stations reporting identification parameters.
38-51		contains information about the longperiod observations associated to the event.
1	780116	Date yymmdd
2	52857.8+- 3.1	Origin time with error estimate
	35.0N+- 0.1 138.6E+- 0.1	Epicenter with error estimate
	73KM+- 29	Depth with error estimate
	BASED ON 6 STAT.	Number of shortperiod observations defining the event
3	HONSHU, JAPAN	Region name calculated with Flinn-Engdahl method.

4	NUMBER OF ASSOC.SP-TIMES 15	The number of shortperiod observations associated to the event including the defining observations.
	NUMBER OF ASSOC. LP-TIMES 7	The number of associated longperiod observations.
5	MB: 4.1	The estimated shortperiod magnitude m_b.
	BASED ON 3(I) STAT 3 (II) STAT 2(III) STAT 33(IV) STAT	The number of observations in the each category used in the magnitude calculation. See report by Elvers (1980) for further explanation
6	MS: 4.2	The estimated longperiod magnitude M_S
	BASED ON 6 (I) 3(III) STAT	The number of observations in the each category used in the magnitude calculation. See report by Elvers (1980).
7	COMPLX: 1.13 STD: 0.03 BASED ON 2 VALUES	The calculated complexity with standard deviation and the number of observations used.
8	TMFI : 1.05 STD: 0.10 BASED ON 2 VALUES	The same for the third moment frequency for initial part.
9	TMFC : 0.92 STD: 0.02 BASED ON 2 VALUES	The same for the third moment frequency, coda
10-13	SPECTRAL VECTORS	Spectral ratios and the number of observations used in the calculation. The mean values and the standard deviation are given. For further explanation over the identification parameter, see report by Israelson(1980).
15	MAJO P (P)	The station code and the reported phase name are given. Within brackets the phase associated to this arrival in the association procedure. Phasenames follow the rules in the Earthquake Data Telegraphic Format.
	52923.0 -0.5 *	The reported arrival time to the station MAJO and the calculated time residual. The asterix (*) after the time residual denotes a defining observation.

	1.5	The calculated distance
	348.8	Calculated azimuth event-station
	168.1	Calculated azimuth station-event
	13.55	Calculated slowness
	2 0.95	This observation is defining and therefore used in the magnitude estimation. It is put into class 2 with a plausibility of 0.95.
16	REPORTED	For stations reporting azimuth, slowness, distance and/or magnitude a line is inserted with the reported parameter for comparison.
	5.1	This observation was marked as originating from local event and the distance put to 5.05. This is reported here.
17	CHTO P (P) 53615.8 0.6x 38.6 255.6 57.0 8.35	Station code, phasename, arrival time, time residual, defining observations, distance, two azimuths and slowness as above.
	9.6 1.06	Reported amplitude and period for this arrival.
	4.6	The estimated station magnitude.
	1 0.20	This arrival has reported amplitude and therefore is put into category I with a plausibility of 0.20.
27	REPORTED	NB2 reports azimuth, slowness, distance and also a magnitude. These reported parameters are found here for comparison.
34-36		These lines contain the reported identification parameters from individual stations used in the calculation except the spectral ratios. Standard deviations are also given.
38-51		All parameters for the longperiod associated observations are listed in exactly the same way as the shortperiod data. The times are given in seconds and no slowness is reported.

Appendix 8

Preliminary instructions for a comprehensive experimental exercise of the global system

Appendix 8

PRELIMINARY INSTRUCTIONS FOR A COMPREHENSIVE EXPERIMENTAL EXERCISE OF THE GLOBAL SYSTEM

TABLE OF CONTENTS

ANNEXES:

PREFACE

This appendix has been written with the intent of condensing all the information on international seismic data exchange contained in the first (CCD/558), second (CD/43) and third reports of the Ad Hoc Group into one relatively short document. It describes the procedures which have been established by the Group for the preparation, exchange and processing of Level 1 data, and for the preparation and exchange of Level 2 data.

Level 1 data are basic parameters of detected seismic signals which are to be routinely reported without delay. The instructions for the preparation and exchange of level 1 data are given here in sufficient detail that the only other document required is a copy of the WMO/GTS Manual, which can be consulted at the participant's national GTS center. The processing procedures to be carried out at the International Data Centers are described in great detail in Appendix 7 of the third report, and those countries acting as such Centers should use Appendix 7 rather than the summary of its contents given in chapter 3 here. The sections of chapter 3 on data acquisition and comparison, and on bulletin distribution should, however, be of interest to all participants in tests of the global data exchange system.

Level 2 data is data transmitted in response to national requests for additional information, mainly waveform data, for events of particular interest. Such requests should be made through one of the International Data Centers. Chapter 4 of this document proposes procedures and formats for the exchange of digital waveform data. Various national investigations have suggested means by which non-digital waveform data might be exchanged. The various methods of Level 2 data exchange have not yet been properly tested and more experience in this area is required.

CHAPTER 1

Preparation of Level 1 Data

1.1 Introduction

Level 1 data are basic parameters of detected seismic signals which will be routinely reported with minimum delay. Existing seismic networks are primarily aimed at detecting and locating events; however, since the global system proposed by the Ad Hoc group has the additional task of providing identification data, it has been found necessary to extend established seismological practice towards the determination of identification parameters.

The parameters to be reported are specified in tables 1 and 2 of Annex A8-III, and detailed instructions for their measurement are given in sections 3 and 4 of this chapter. At stations which record data digitally, it may be possible to automate the extraction of some of the specified parameters, though the Ad Hoc group has not yet decided on standard procedures to carry out such automation. Section 5 of this chapter suggests procedures which might be applied to digital data for automatic parameter extraction.

All seismic events registered by any station in the network should be reported by that station in terms of the specified level 1 parameters. However, in order to keep the volume of data at an acceptable level, the Ad Hoc group has recommended an abbreviated form of reporting that would be allowable for events classified by the station's analyst as:

- local earthquakes (within 160 km)
- events belonging to an earthquake sequence (e.g. more than 10 events a day from the same place).

1.2 Operation of Contributing Stations

The proposed international data exchange is a decentralized system. Each station should prepare and edit its own data as carefully and completely as possible. Tasks at each station thus include amongst others:

- Determination of arrival times of seismic phases in Universal Co-ordinated Time (UTC)
- Reading and interpreting seismic phases
- Correcting for time drifting of the clock
- Correcting for instrument response
- Maintaining and ensuring calibration integrity
- Reporting down time intervals

1.3 Principles for Reporting Level 1 Data

The proposed level 1 data are listed in tables 1 and 2 of Annex A8-III. Some of the parameters would be reported only by seismic array stations. The general principles of CCD/558 and CD/43 concerning level 1 data are as follows:

(a) All recorded events should be reported from the participating stations with minimum delay.

(b) Each reporting should consist of a COMPLETE set of parameters as specified in section 1.4 and tables 1 and 2 of Annex A8-III, to the extent that these are measurable.

(c) For some of the specialized parameters in tables 1 and 2 of Annex A8-III (such as items 9 and 10 of table 1), some stations might prefer, for practical reasons, to transmit these data to the international centers on a weekly or monthly basis as agreed, or possibly only on request.

The first requirement (a) above applies without any exception. For practical reasons of handling a manageable amount of data the second requirement (b) can be relaxed in certain cases, and abbreviated reporting would be allowed. The form of such abbreviated reports, and the circumstances under which they are allowed, are described in 1.3.7 below.

The level 1 data as specified in tables 1 and 2 of Annex A8-III comprise a number of basic parameters, the most important of which are signal arrival time, first motion, amplitude, period and magnitude. It is essential that these be measured in a standardized manner and to a fixed precision.

1.3.1 Signal Arrival Time

On a graphic record, a signal arrival is defined as a marked change in amplitude, phase or frequency. The corresponding time reading is reported in Universal Co-ordinated Time (UTC) to the nearest 0.1 seconds for short-period readings and to the nearest second for long-period readings. Each station should maintain a timing accuracy to within a tenth of a second relative to UTC.

Because of the high accuracy of time measurements the problem of instrumental time delay must be noted. As an example, for WWSSN (World Wide Standardized Seismograph Network) SP instruments at 1 Hz, phase delay is about 0.3 seconds and group delay time is about 0.4 seconds. Corrections for these delays should be made before reporting arrival times.

1.3.2 First Motion Sign and Clarity

Direction (or sign) of the first motion on vertical short- and long-period instruments should be reported. For complicated or weak signals, the direction of the first motion may be in doubt; if so, it is not to be reported. Theoretically the first onset should have the same sign on short-period (SP) and long-period (LP) instruments. However, due to different noise conditions, frequency response and magnification of SP and LP recordings the first motions do not need to agree, particularly for multiple events starting with weak arrivals. In the case of a discrepancy in the directions the reasons should be checked by the operator before the information is reported.

If possible, the first motion on the LP horizontal components should also be reported. The following first motion notations should be used:

C - SP compression (Up)

D - SP dilatation (Down)

U - LP compression

R - LP dilatation

V - LP movement on the N-S component, direction to the North

Y - LP movement on the N-S component, direction to the South

E - LP movement on the E-W component, direction to the East

W - LP movement on the E-W component, direction to the West

The clarity parameter is used to indicate whether a recorded seismic signal represents a clear onset. If the signal onset can be identified within +/- 0.2 seconds for P waves or +/- 1 second for S waves, the clarity notation i is used, while if the onset identification is less accurate, the clarity notation e is to be used.

1.3.3 Signal Amplitude Measurements

Amplitude is determined from the maximum signal deflection on the seismogram trace and then converted to ground motion in nanometers using the instrument response or amplification curve. Trace amplitude is measured as the center-to-peak (or trough) deflection from the median line, or alternatively, for symmetric signals, by halving peak-to-trough deflection. For SP signals, amplitudes are measured to a precision of 0.1 nanometers, for LP signals to 1 nanometer. Note that in formatting WMO messages, SP amplitudes are reported in nanometers, but that LP amplitudes are reported in micrometers. This is a requirement of the International Seismic Code (see Annex A8-II).

1.3.4 Signal Period Measurements

Signal period corresponding to each amplitude observation is measured at median line crossings or between neighbouring peaks or troughs. This parameter is reported to the nearest 0.1 seconds and 1 second on SP and LP instruments respectively.

1.3.5 Noise Measurements

For each event, the maximum noise amplitude at frequencies between 0.5 and 1 Hz should be measured and converted to ground motion in nanometers. The corresponding period should also be measured and reported. The maximum is selected over a time interval preceding the first signal onset and covering 30 seconds for SP records and 1 or 5 minutes (for body and surface wave arrivals respectively) for LP records.

1.3.6 Additional Standard Parameters

Complexity, spectral moment, spectral ratio and spectral vector may be reported. There are at present no standards for calculating these parameters, and stations computing them should describe the method they use.

Array stations may report apparent slowness and azimuth. Slowness should, if reported, be determined with a precision of 0.1 seconds/degree. Azimuth should be reported to 0.1 degrees or to the accuracy that is judged to be realistic in each case. Note that the azimuth corresponds to that from the station to the epicenter, measured in degrees East of North.

Array stations may deduce, and report, epicenter latitude, longitude, origin time and magnitude from the measured arrival time, slowness and azimuth. It should be noted however that the data centers will use the measured parameters rather than the location deduced in this manner.

1.3.7 Abbreviated Reports

As described above under 1.3, abbreviated reporting is permitted under certain circumstances. For events which can be classified by the station analyst as:

(i) Local earthquakes or quarry blasts

(ii) Belonging to an earthquake sequence (e.g. more than 10 events a day from the same place).

An abbreviated report would be allowable. This would comprise reporting of P and S arrivals, maximum amplitude within the first six seconds, the associated period, and, for earthquake sequences, an association of the arrival to the specific sequence. A "local" magnitude ML or the signal duration DUR of the short-period recording may be reported as well as amplitude and period of local events.

1.4 Procedures for Extracting Level 1 Parameters

A sample analyst worksheet for use in the tabulation of level 1 parameters is given in Annex A8-I.

1.4.1 Short Period Parameters

The time of the first arrival and its first motion and clarity should be determined. The first arrival should always be identified by one of the standard symbols given in the International Seismic Code (Annex A8-II) for initial phase identification. Acceptable first arrival phase identifications are:

P, PDIF, PKP, PN, PG and PB(P*).

Note that PN, PG and PB are also acceptable secondary arrivals.

Ground amplitudes A_1 are to be measured as the maximum deflection within the time intervals 0-6 seconds, 6-12 seconds, 12-18 seconds and 18-300 seconds, on the SP vertical seismograms, where the time intervals are relative to the time of first arrival. In many cases the signal may be of such short duration that reasonable measurements cannot be made during the later time intervals.

The times and associated dominant periods corresponding to each A_1 are also to be measured. Figure 1 illustrates the method for measuring each A_1 and the matching time and period. The codes to be used for measurements in the time intervals given above (0-6, 6-12, 12-18 and 18-300 seconds) are M1X, M2X, M3X and M4X respectively.

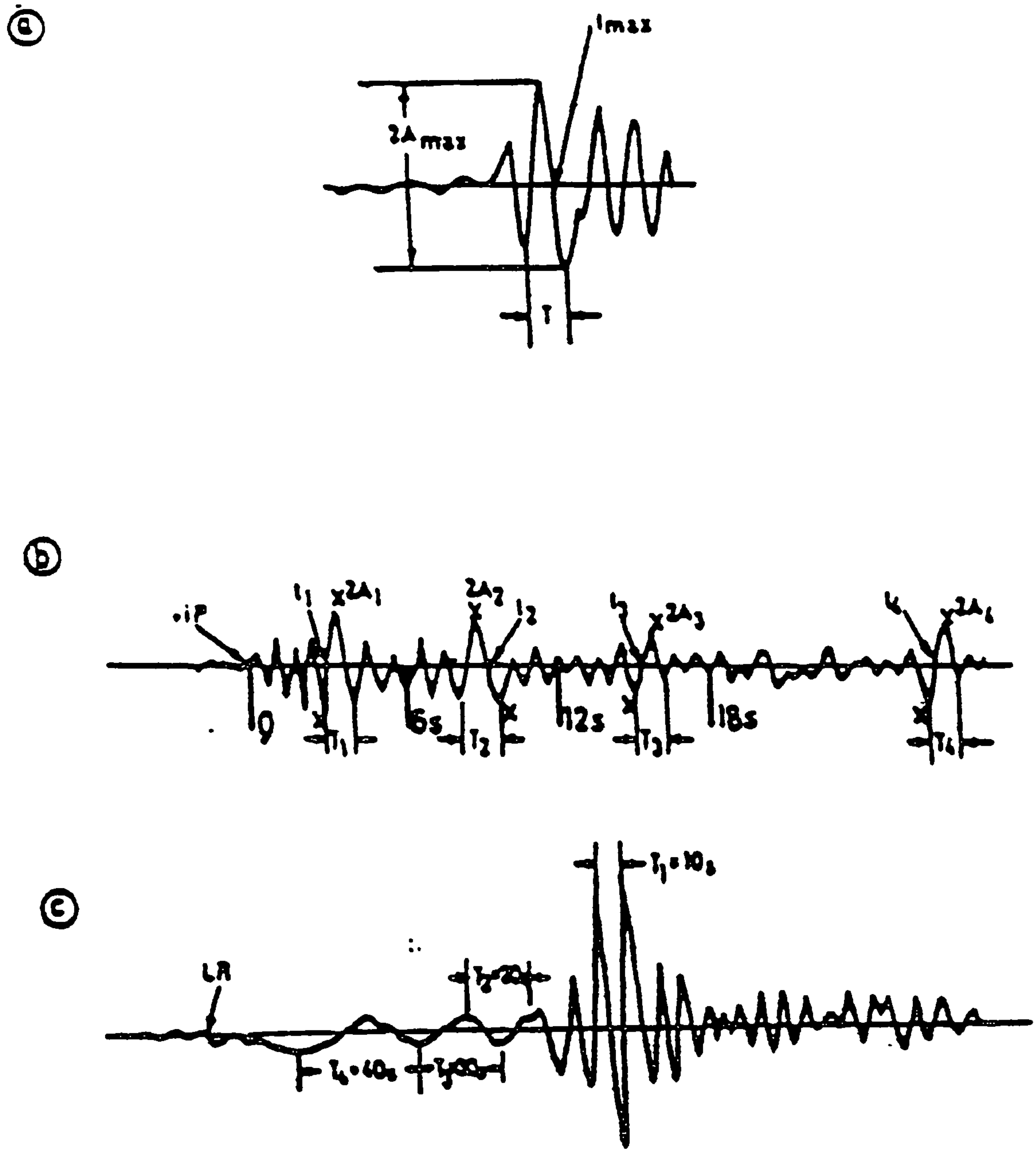


FIGURE 1 : Illustration of rules for measuring:

(a) wave amplitude, period and time of maximum oscillation
(b) kinematic and dynamic parameters of SP records
(c) spectral parameters of LP records

[Reproduced from Figure A3.1 1 of CD/43/Add.1, page 14]

The seismic noise amplitude and period should be measured as described in 1.3.5.

Secondary phases should be reported wherever possible. If identified as a particular seismic phase, the standard notation as given in the International Seismic Code should be used. Arrival times of clear, but unidentified secondary phases should also be reported. Hour is reported only if it differs from that of the preceding phase. For each reported phase, the maximum amplitude and corresponding period should be measured and reported. It is important that a special effort be made to report the depth phases pP and sP.

Complexity, spectral parameters and array slowness and azimuth may be reported by stations equipped for their measurement, according to 1.3.6.

If S is observed, its clarity, maximum amplitude, arrival time and the corresponding period should be measured on both the North-South and East-West components. The maximum amplitude is measured within the first 10 seconds of S. The arrival times given on the two horizontal components should not differ by more than one half signal period, so that the amplitudes can be combined vectorially.

1.4.2 Long Period Parameters - Body Waves

Readings should preferably be grouped by event, rather than by instrument, and readings of a particular phase from different instruments should be grouped together.

When discernible, phase identification, arrival time, first motion and clarity should be reported from the LP vertical component even if a SP initial arrival has been reported. The maximum amplitude and corresponding period (one measurement only) should also be given, together with the amplitude and period of the noise. The latter should be measured within 1 minute before the first onset on the LP vertical component.

Secondary phases as measured on the long-period vertical should be reported in the same manner as for short-period data, described in 1.3.

If visible on the horizontal long-period component, S should be identified and the arrival time measured on one of the components only. The clarity of S on the same component should also be given. The maximum amplitudes, and corresponding arrival time and period should be measured separately on each horizontal component, within the first 40-60 seconds. These measurements should be carried out at times differing by no more than one half signal period.

1.4.3 Long Period Measurements - Surface Waves

RAYLEIGH WAVES

Rayleigh wave measurements should be made from the vertical components only.

The onset time of LR and its clarity should be measured. Both these are hard to read and are strongly dependent on signal-to-noise ratio.

The maximum amplitude and the corresponding time and dominant period of the Rayleigh wave should be reported.

In addition, maximum amplitudes closest to periods of 10, 20, 30 and 40 seconds, together with the corresponding time and the actually observed periods should be measured and reported as M1L, M2L, M3L and M4L.

The largest amplitude of seismic noise in the period range between 10 and 30 seconds should be measured on the vertical component within the 5 minutes preceding the onset time of LR. The dominant period of the noise should also be reported.

LOVE WAVES

The onset time of LQ should be measured, though it is appreciated that, as for the onset of LR, it may be difficult to determine accurately.

The maximum amplitudes of the Love waves, together with the corresponding time and period, should be measured on both the NS and EW components. The measurements should be made at times which do not differ by more than one half signal period.

1.4.4 <u>Qualitative Remarks</u>

It is very important that the report is, where applicable, accompanied by remarks made by the experienced analyst qualifying the character of the event, as seen from visual inspection of the record or by more sophisticated analysis. The following detailed classification is suggested:

LA Local event within a very short distance, such that P and S cannot be separated.

LB Local event within a short distance; P and S separated by (S-P) interval less than 20 seconds, corresponding to a distance of about 160 km.

R Regional event somewhere between 2 and 20 degrees distance.

TA Teleseismic event, weak, a simple seismogram with largest amplitudes within first few seconds.

TB Teleseismic event, seismogram is made up of more than one discrete arrival.

TC Teleseismic event with a complex waveform made up of many arrivals (phases) of different amplitude, onsets difficult to interpret.

1.5 <u>Level 1 Parameter Extraction (Digital Stations)</u>

The availability of digital seismic data renders the automatic extraction of Level 1 parameters possible. Considerable advances have been achieved in recent years in the automatic detection and timing of digital seismic signals. However, routine application of such techniques using large volumes of data has been confined thus far to the operation of local seismic monitoring networks. In addition, many of the existing routine algorithms are applied exclusively to short-period vertical recordings, and have not been standardized even in such limited applications.

Two prime considerations to be kept in mind when considering automatic Level 1 parameter extraction are the following:

(i) Automatic processing of digital signals cannot duplicate the rather complex processes involved in manual analysis. Instead, it must rely on strategies which are well suited for machine processing, but impossible to achieve manually, such as digital filtering of digital signals.

(ii) On the other hand, automatic processing should not lead to a redefinition of Level 1 parameters as described above. Instead, the final product should be consistent with results which could be obtained manually. Consequently, any automatic parameter extraction should be intimately linked with a capability for interactive, graphical review of the results by an experienced analyst, and provision made for acceptance, correction or rejection of the results by the analyst.

An automatic parameter extraction procedure which yields a well defined output consistently in agreement with manual extraction on the same signals can then be standardized in the form of a complete algorithmic definition of the process, and thus offers the advantage of yielding systematic and consistent results which can be duplicated exactly.

Continued research in automatic Level 1 parameter extraction should be vigorously pursued, starting with those parameters which are most amenable to digital treatment, such as amplitude and period measurements in specific frequency bands. In addition, provision should be made for a clear indication of which parameters have been extracted automatically, and which are the results of human intervention.

Table A7-I(1)

Proposed identifiers for Level 1 short period parameters

Type of Wave	Component	Parameter	Proposed Identifier
P	Vertical	(a) Standard parameters - stations of types I, II and III.	
		1. Arrival time	*
		2. First-motion sign and clarity (if readable)	*
		3. Amplitudes A_i ($i=1,\dots,4$)	
		4. Arrival times corre sponding to each A_i	M1X,M2X,M3X,M4X**
		5. Periods corresponding to each A_i	
		6. Noise amplitude, A_N	NA
		7. Period corresponding to A_N	NT
		8. Secondary phase description:	
		Amplitude	*
		Period	*
		Arrival time	*
		9. Complexity	CMPX
		10. Spectral moment, ratio or vector	SPMM, SPRT, SPVT

CHAPTER 2

Exchange of Level 1 Data

2.1 Introduction

The object of this chapter is to show how to exchange seismic bulletins internationally by means of the Global Telecommunication System (GTS) of the World Meteorological Organization (WMO). It has been compiled specifically for use by members of the Group of Scientific Experts (GSE), but the instructions are applicable by individuals at the national or station level. It is assumed that the reader has available a copy of the WMO/GTS Manual.

The elements of an International Seismic Data Exchange (ISDE) are depicted in Figure 2. Short experimental exchanges made during 1980, 1981, and 1982 demonstrated that the GTS would meet the needs of an ISDE, and in 1983 the WMO formally approved its use for this purpose.

To facilitate the use of the GTS it is important to have a general understanding of its structure and main features: a summary of them is given in Section 2.2.1. It is also important to be aware that seismic traffic, relative to meteorological traffic, is unusual, infrequent, and irregular. Consequently, problems can arise, particularly at non-automatic GTS centres, and due allowance must be made for familiarization by GTS operators. The most important single step in starting an exchange is to consult the national GTS centre well beforehand, and to continue consultations until it is working satisfactorily.

The contents of this chapter are based on experiences gained during the three GSE-sponsored experiments. Mr. K. Yamaguchi (Secretariat, WMO/GTS, Geneva), and Mr. J.R. Neilon (President, WMO Commission for Basic Systems) gave advice during their preparation and checked that they conform with GTS practice.

2.2 The WMO/GTS

2.2.1 Functions and organization of the GTS

Complete details are given in the GTS Manual, but in summary:

The GTS is one of three functional units of the WMO's World Weather Watch, and is responsible for the regular exchange of meteorological information between member States.

- It is a world-wide communications network which operates continuously; peak loads occur at and after synoptic observations at 00, 03, 06, 09, 12, 15, 18, 21 hours UTC; these times should be avoided for seismic exchanges.

- The basic elements comprise a Main Telecommunication Network (MTN), regional networks, and national networks. The nodes of the system are located at World Meteorological Centers (Melbourne, Moscow and Washington), Regional Meteorological Centers, Regional Telecommunications Hubs, and National Meteorological Centers.

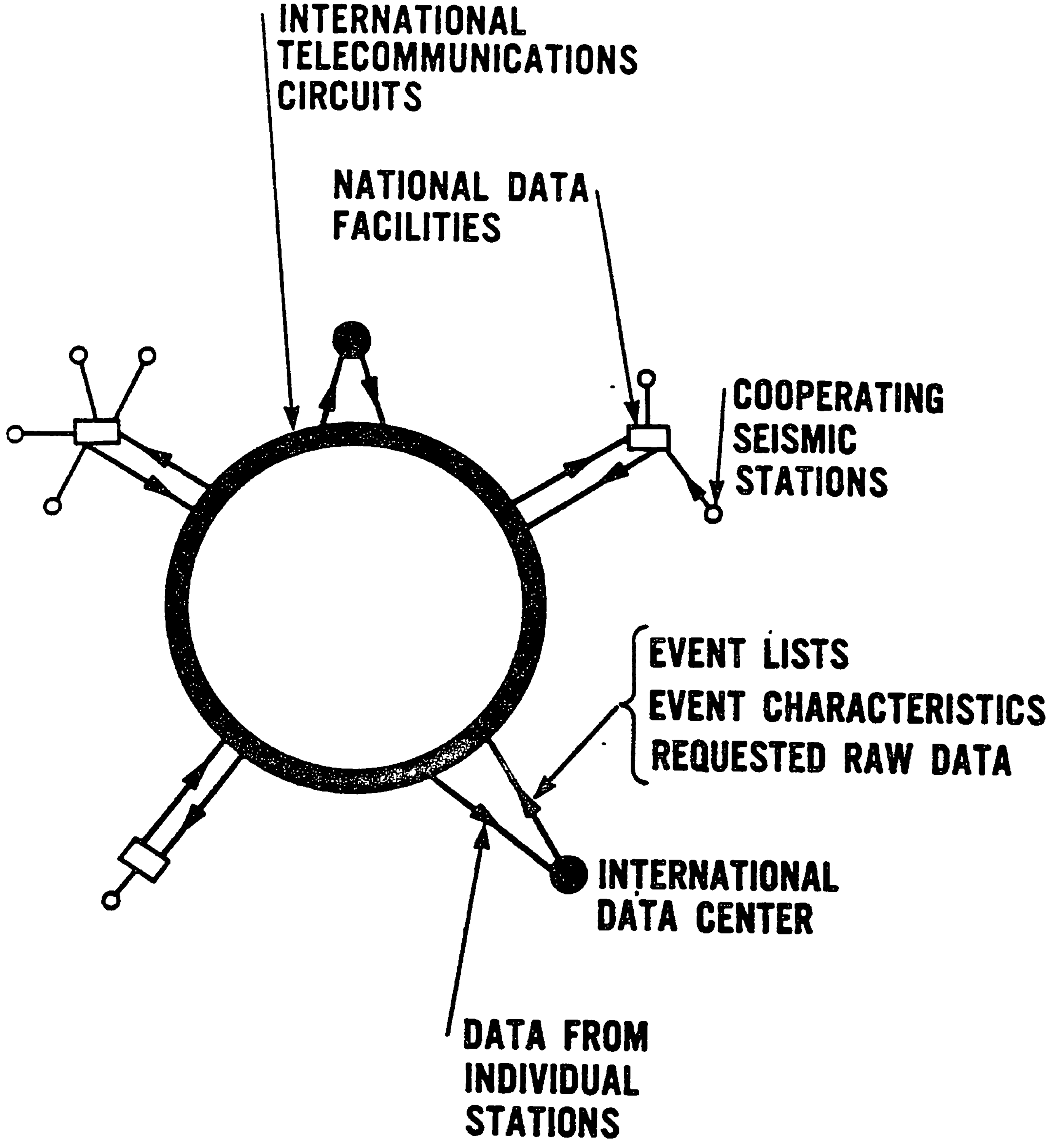


FIGURE 2 : Elements of International Seismic Data Exchange

- States provide and fund their own national centers and share the costs of communications facilities with adjacent States. The equipment at centers and the quality of communications circuits between them is not uniform. (Some centers are operated manually and others are highly automated; circuits range from 50 baud links to 9600 bits/s links).

- Rules for the format and length of messages, and codes for texts are specified by the WMO and must be adhered to strictly.

  Figure 3 depicts the GTS circuits and their composition at February 1983. Full details of the GTS are given in the WMO/GTS Manual.

2.2.2 Preparatory Arrangements

Consultation with the national GTS center is the most important step in the establishment and maintenance of effective use of the GTS for seismic exchanges. It should be carried out at least three, and preferably six months before the exchange is due to start.

- Describe the objectives; include:

  proposed commencement date

  duration of exchange

  countries taking part

  destination of outward messages

  frequency and length of outwards messages

  number and length of inwards messages

  distribution of inward messages.

- Determine how GTS messages are structured, and obtain specific header information.

- Determine how to file your messages with the GTS center (see 2.4.1).

- Agree on suitable time(s) for filing messages.

- Arrange to receive a copy of your outgoing messages, preferably showing the actual time-of-day they were sent.

- Arrange to receive any required inwards messages from other national centers.

- Discuss the best way to respond to requests for repetition of messages.

- Discuss any local practices which are specific to your GTS center i.e., those which are not laid down by WMO/GTS. (The concern here is about procedures which may cause the loss of outgoing or incoming seismic messages or interference to other traffic.)

2.2.3 Structure of messages

These GTS definitions should be noted:

- Meteorological message - A message comprising a single meteorological bulletin, preceded by a starting line and followed by end-of-message signals.

- Routine meteorological message - A meteorological message transmitted according to a predetermined plan.

- Non-routine meteorological message - A meteorological message for which there is no predetermined distribution plan.

The words "message", "routine", and "non-routine" will be used with the above meanings. Also, the word "meteorological" has been replaced by the word "seismic" to avoid confusion; and standard communications control symbols (as used in the GTS Manual) are replaced by:

<CR> carriage return (<)
<LF> line feed (=)
<SP> space (->.)
<LS> letter shift (↓)
<FS> figure shift (↑)

2.2.4 Alphabets

Communications alphabets comprise the usual letter alphabet, the digits (0-9), control characters (e.g. carriage returns), and other symbols (e.g. the question mark?). The GTS accepts two alphabets:

(a) International Telegraph Alphabet No. 2

(b) International Alphabet No. 5.

Alphabet No. 5 is 7-level and so it has more characters than Alphabet No. 2 (5-level). Only characters for which corresponding characters exist in both alphabets are allowed; the seismic code takes this into account.

Message formats are given here in alphabet No. 2. Alphabet No. 5 does not require control characters to change from letters or numbers to the other case, and it has simple opening and closing operations. Otherwise, the message formats are the same. Alphabet No. 5 is used mostly on high speed segments of the Main Telecommunication Network, but consult the national GTS center to find out which alphabet should be used.

Full descriptions of Alphabets No. 2 and No. 5 are given in the WMO/GTS Manual.

2.3 Message Formats

2.3.1 General format of routine seismic messages

A routine seismic message shall comprise:

- A starting line
- An abbreviated heading
- A text (seismic bulletin)
- End-of-message signals.

There shall be only one seismic bulletin per seismic message.

2.3.2 Starting line

The format of the starting line is

<CR><CR><LF><LS>ZCZC<SP><FS>nnn<SP>CLLLL<SP><SP><SP><SP><SP>

which when printed will appear as

ZCZC nnn CLLLL

The symbols mean:

ZCZC

nnn a 3-digit number giving the transmission sequence of messages from one center to the next

CLLLL classification and identification group (see WMO/GTS Manual).

For seismic messages for global exchange C = 1

L1L2 indicate the originating (GTS) center

L3 = 5; it is always used in combination with C and for seismic data CL3 = 15

L4 is allocated by the respective Regional Telecommunications Hub, it combines with L1L2 to identify individual bulletins.

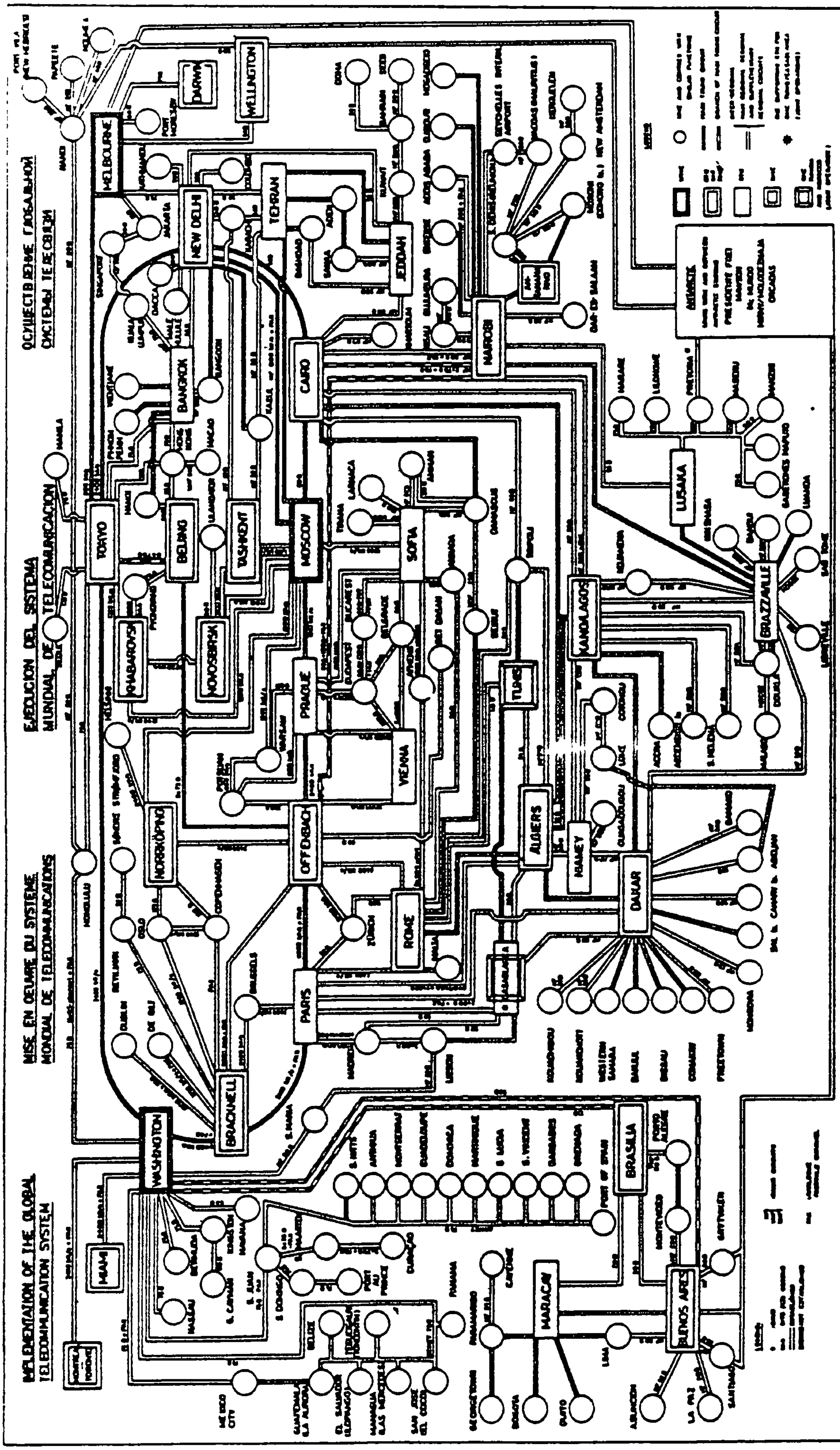
2.3.3 Abbreviated heading

The format of the abbreviated heading is

<CR><CR><LF><LS>TTAA<FS>ii<SP><LS>CCCC<SP><FS>YYGGgg(<SP><LS>BBB)

which when printed will appear as

TTAAiiCCCCYYGGggBBB.


IMPLEMENTATION OF THE GLOBAL TELECOMMUNICATION SYSTEM
MISE EN OEUVRE DU SYSTEME MONDIAL DE TELECOMMUNICATIONS
EJECUCION DEL SISTEMA MUNDIAL DE TELECOMUNICACION
ОСУЩЕСТВЛЕНИЕ ГЛОБАЛЬНОЙ СИСТЕМЫ ТЕЛЕСВЯЗИ
WASHINGTON
BRACKNELL
PARIS
OFFENBACH
NORRKÖPING
PRAGUE
VIENNA
ROME
MOSCOW
SOFIA
TOKYO
BEIJING
TASHKENT
KHABAROVSK
NOVOSIBIRSK
BANGKOK
NEW DELHI
MELBOURNE
WELLINGTON
DARWIN
TEHRAN
JEDDAH
CAIRO
NAIROBI
LUSAKA
BRAZZAVILLE
KANO/LAGOS
TUNIS
ALGERS
NIAMEY
DAKAR
CASABLANCA
MIAMI
MARACAY
BRASILIA
BUENOS AIRES
ANTARCTIC

The symbols mean:

TT Data designator; for seismic data TT = SE (see WMO/GTS Manual)

AA Geographical designator indicating the country of origin of the message (see WMO/GTS Manual)

ii a number with 1 or 2 digits which indicates how the messages are distributed; ii = 1-19 for global distribution

CCCC International 4-letter location indicator for the GTS center originating the message.

YYGGgg date-time group giving the day of the month (YY) and the origin time at the GTS center; GG = hour, gg = minute

BBB an indicator for late, corrected or amended messages. [Note: for seismic messages only the CORRECTION indicator COR may be applied. In normal, routine transmissions this is NOT used.]

Annex A8-VI shows the approved Starting Line and Abbreviated Heading for all countries using the WMO/GTS at December 1983.

2.3.4 Text

There are three types of routine seismic text:

- Lists of Level I phase data sent by seismic centers or stations
- Event lists sent by international data centers
- Requests for repeat transmissions sent by an international data center, described separately in 2.5.

All routine texts begin with the word SEISMO, and end with the word STOP. The recommended codes are given in Annexes A8-II and A8-III, which include examples of messages. The only code approved formally by the GTS is the International Seismic Code (Annex A8-II) but the additions (Annex A8-III) have been used successfully during GSE experiments.

GTS instructions for compiling text are:

- Text shall be in one code only
- Text shall begin on the first line after the abbreviated heading and shall be transmitted in consecutive lines
- Individual reports shall start at the beginning of a new line
- The end of a report shall be indicated by = (Signal No. 22); the signal follows the last group with no intervening space
- Full use should be made of the capacity of a teleprinter line (69 characters).

[Note: seismic data and formats do not produce constant-sized groups, and text is hard to comprehend if all available 69 characters per line are used. The last GTS instruction does not have to be observed strictly, so the text may be formatted as in the examples given in Annexes A8-II and A8-III.]

2.3.5 Message Numbers

The International Seismic Code, described in Appendix A8-II, includes provision for a message number immediately following SEISMO. This message number is part of the text of the seismic message and should not be confused with numbers appearing either in the starting line (see 2.3.2 above) or abbreviated heading (2.3.3).

It is considered essential that each contributor of level 1 data assign unique and sequential message numbers to each seismic message, in order that the International Data Centers (IDCs) may be made aware of missing messages.

The sequence should preferably start with a message number 1; if this is for any reason inconvenient, the IDCs should be notified. If data from more than one seismic station are to be filed independently through one national GTS center, each station should use a different sequence pattern (e.g., station A sequence starts with N3001, station B starts with N35001).

The importance of these message numbers in ensuring that IDCs realize that messages have been sent, but not received, cannot be over emphasized.

Absent message numbers are the prime justification for retransmission requests (see 2.5).

2.3.6 End-of-Message Signals

These are the communications signals needed after the text to terminate the message.

The format is:

**<LS><CR><CR><LF><LF><LF><LF><LF><LF><LF><LF>NNNN<LS><LS><LS><LS>
<LS><LS><LS><LS>**

which when printed appears as

NNNN

eight lines below the word STOP.

2.3.7 NIL Messages

The GTS provides for a NIL message to be sent when a routine message is not available at the regular time for transmission. However, though desirable, it is not essential for seismic bulletins to be sent at the same pre-set time each day, so a NIL message is not needed for this purpose. In the unlikely event that no seismic phases are recorded in a day, the provisions for message sequence numbers, reporting period, and downtimes give all the requisite information and NIL messages are not called for at present by the GSE.

2.3.8 Length of Seismic Messages

The maximum length of messages is 3800 characters. No minimum length is specified.

The count includes the characters in the starting line, the abbreviated heading, and the end-of-message signals. These amount to at least 76 characters and there may be more depending on local practices.

The count also includes all "invisible" characters (the non-printing functions such as carriage-returns, figure-shifts), seismic messages have a high percentage of "invisible" because the text is a mixture of letters and figures. It is highly desirable that equipment used to prepare messages provides an actual count; as a rough approximation the text should not exceed 2100 alphanumerics.

2.4 Transmission of Messages

2.4.1 Filing of messages

The means of transferring data from the station analyst's list to a GTS center varies widely from place to place. In some places the seismic and GTS centers are co-located, in others they are not; communications equipment at seismic centers ranges from a manuscript form to a computer. Similarly, on the receiving side, some seismic centers can receive inwards messages only by mail several days after the event. In these circumstances it is not practicable to give specific instructions which will meet every requirement. Only some of the more common matters are discussed; and in all of them detailed arrangements must be made locally.

2.4.2 Optimum Time for Filing Messages

In principle, the intervals 04-06, 10-12, 16-18, and 22-00 hours UTC carry the least meteorological traffic. However, the optimum intervals should be arrived at through discussion with the local GTS center; there may be certain times when local or regional meteorological exchanges impose a high load.

Even during optimum intervals occasional interruptions can be expected owing to the priority given to meteorological messages. This is likely to occur only very occasionally during extended transmissions. If a message is interrupted (that is, if the end-of-message group NNNN has not been sent) the message must be re-started at the beginning (that is, from ZCZC).

2.4.3 Teleprinter Messages and Links

Many connections are by standard telex links. The use of pre-punched paper tape (5 hole) allows the contents of the message to be checked before transmission and it is a very reliable medium. However, it takes about eight minutes to send a 3800 character message and if several messages are sent in a batch disconnections are possible.

Practices such as the following should be noted when using a telex line:

(a) The line will be opened automatically if no signals are sent within 20 seconds or so.

(b) The line will be opened automatically if 30 or so identical characters are sent successively.

The format and procedures for seismic messages take these into account but they should be allowed for when creating a telex tape of more than one message. The gap in the tape between messages should not (using the figures above) last longer than 20 seconds. nor contain 30 or more spaces.

The physical connection between national seismic and GTS centers, over normal telephone lines, may be by

(a) teleprinter to teleprinter

(b) teleprinter to computer

In (a) a seismic telex is connected to a meteorological 'inwards' telex which produces a paper-tape copy of the message, the paper tape is torn off and becomes the input for an 'outwards' GTS telex. This 'torn-paper-tape' system is used at many GTS centers, mainly on the low speed circuits. For seismic purposes its big drawback is the dependence on an operator recognizing the isolated SEISMOs in the inwards streams of meteorological messages.

In (b) a seismic telex is connected directly to a GTS computer, and messages can be held in a buffer before being inserted into the GTS. This is a reliable, inexpensive method, the only minor drawback being the relatively low speed on the telex line.

In (a) and (b) special arrangements have to be made with the GTS center for relaying incoming SEISMOs to the national seismic center. Inexpensive automatic devices such as selective calling units and associated receivers allow nominated messages (in this case SEISMOs) to be received at particular places (in this case at the seismic center).

2.4.4 Computer Messages and Links

If the national seismic and GTS centers are equipped with computers which can inter-communicate, links may be made via dial-up telephone lines, or via dedicated lines. Both types of link offer all the advantages of ease of composing, formatting and correcting inputs, and automated transfers; the use of dedicated lines may not be warranted if the volume of traffic is low.

2.5 Retransmission of Messages

2.5.1 Retransmission Requests

The various IDCs will compare the WMO/GTS messages they have received, according to the procedures described in 3.2.5. If it appears from the message numbers described above in 2.3.5 that a given message from a contributor has not been received by any of the IDCs, or if the message received seems to be either incomplete or garbled, one of the IDCs will request retransmission of the message in question.

Requests for retransmission will be broadcast over the WMO/GTS at a fixed time each day, and may cover a number of apparently missing messages from several different contributors. The format of a retransmission request is illustrated by the example given in Annex A8-IV.

2.5.2 Special Procedures for Retransmission

Requests for retransmission should be complied with as soon as possible, at the next time of regular transmission by the contributor. In order to avoid confusion over the out-of-sequence message numbers that this might occasion, it would be desirable to insert a one line comment immediately after the first line (SEISMO etc) of the message text, of the form :

((RETRANSMISSION OF Nxxx, AS REQUESTED))

It is however appreciated that, particularly in cases where the national seismic and GTS centers are geographically separated, such editing of messages may be difficult to achieve It is also understood that some seismic centers can receive inwards messages from the national GTS center only by mail several days after the event, and that delays in complying with retransmission requests may occur.

2.6 Additional Information Requested of Participants

Each participant in the International Data Exchange is requested to supply, both to the conveners of Study Group 5 and to those organizations operating International Data Centers, the following information:

(1) The UTC time at which WMO/GTS messages will be sent from the national GTS center.

(2) The frequency of such transmissions (daily, daily excluding weekends, or at less frequent but fixed intervals)

(3) The codes and locations of the seismic stations from which data will be supplied.

(4) The anticipated delay between the date of level 1 data and that on which it is transmitted.

(5) A point of contact, preferably a single person, and a telex or telephone number. For the latter, an indication of the UTC times of day at which the point of contact is available is desirable.

This information should be supplied at least one month before the commencement of the experiment. Changes in this information (addition of new stations, etc.) are best provided in WMO/GTS messages using the comment facility provided by the international seismic code.

CHAPTER 3

Procedures for Prototype International Data Centers (IDCs)

3.1 Introduction

Detailed seismological and operational procedures have been developed for IDCs and applied successfully during the experiment carried out during October and November of 1982. These procedures are described in detail in Appendix 7 of the Third Report of the Ad Hoc Group. This chapter therefore consists mainly of a brief summary of that contents of the appendix, with some new material which has been considered necessary in the light of the application of the procedures given therein during the 1982 experiment.

3.2 Data acquisition and comparison

3.2.1 Logging of WMO/GTS messages

Each IDC is assumed to have a reliable (preferably computer-computer) connection to the national GTS centre. The time of receipt of each message at the national GTS centre should be recorded, as unduly long transmission times may indicate problems somewhere on the WMO/GTS. The general form of the message logs to be maintained by an IDC is given in 5.20 of Appendix 7. The information required for the message logs, as they relate to WMO/GTS messages, are obtained from the abbreviated heading (see 2.3.3) and message number (2.3.4). This information will, provided that the procedures described in Chapter 2 for the exchange of Level 1 data are strictly adhered to by the contributors, be unique and sufficient.

The following table, listing the first messages received from Australia, Japan and the United Kingdom on the third day of the 1982 experiment, is an example of a message log:

Month	Abbreviated Heading	Message #	Time of Receipt	# Lines
OCT	SEAU1 AMMC 262215	N2016	262241	115
OCT	SEJP1 RJTD 270400	N001	270411	21
OCT	SEUK1 EGGR 271000	N2022	271009	79

Taking the first entry as an example, the abbreviated heading contains the unique identifier of the contributor (SEAU1 AMMC is Melbourne, Australia) and the day dd (of the month) and the hour hh and minute mm of transmission in the form ddhhmm (=262215). The month to which dd refers must be added by the IDC as it is not supplied in the heading. The unique message number assigned by the contributor, which immediately follows SE1SMO in the first line of the text, is given in the third column and the time of receipt at the national GTS centre to which the IDC is connected appears in the fourth column.

The final column may be considered optional; it is the number of lines (excluding blank lines) from the starting line through the end of the message, denoted by NNNN. While comparisons between IDCs of the number of lines is to be by no means considered a substitute for the exact comparison of messages described below in 3.2.4, differences in its value between IDCs can act as an early indication of incomplete messages.

3.2.2 Logging of other messages

Messages may be received at the IDC's by means other than the WMO/GTS. Examples of such messages may be confirmatory air mail copies of WMO/GTS messages sent by contributors of Level I data to the IDCs and Level II data requests. All messages, whatever their source and means of transmission, should be logged at the IDCs in a form consistent with that suggested in section 5.20 of Appendix 7.

3.2.3 Interconnection of IDCs

A reliable and efficient means of transferring fairly large volumes of data between IDCs is essential to ensure compatibility and completeness of data archives and to make agreement on a final bulletin possible. The most suitable form of such a connection would be a direct computer to computer link. Such a connection was established between Sweden and the United States for the 1982 experiment, using a relatively cheap commercial packet-switched network. Several million characters of information were successfully transferred between the United States and Sweden using this link.

An electronic mail system was found to be particularly valuable during the 1982 experiment and is considered much superior to voice telephone connections, particularly for the purposes of discussion.

The interconnection between IDCs should be established and thoroughly tested well before the commencement of any experiment.

3.2.4 Inter-IDC exchange of WMO/GTS messages

It is essential that each IDC has a complete and identical set of all WMO/GTS messages. In order to achieve this objective, it is not, however, necessary that each IDC transmits all the messages it has received to all other IDCs. The most suitable procedure is that each IDC acts in turn, for a time interval of one week, as the COMPARER. The other IDCs send, daily at preset times, copies of all messages that they have received during the previous day, from 0000 to 2400 UTC, to the COMPARER. They should at the same time send copies of their message log, of the form described above in 3.2.1, for the same time interval.

3.2.5 Comparison of WMO/GTS messages

The IDC which is functioning as the COMPARER first acknowledges receipt of all messages sent to it by the sending IDCs. Initially, it compares the message logs in order to uncover transmissions which were not at all, or only partially, received by itself or any of the senders. If a sender has a message that the COMPARER does not, COMPARER adds that data to its input. If COMPARER has received, either directly or from one of the senders, a message that another IDC does not, it sends a copy of that message to the IDC in question. Receipt of such messages should be acknowledged by the IDCs.

The COMPARER now carries out an exact character-by-character check of the contents of each message as received by all IDCs. While this could be carried out by eye, it is preferable to do this using automatic file comparison programmes which are now provided by many computer operating systems. The same message as received at different IDCs should differ only by the starting line (see 2.3.2) which is attached by the receiving national GTS centre.

If after comparison of each message as received at all IDCs, the best version still appears from its structure or text to be incomplete, retransmission is requested from the contributor of the message in question. If a message is missing (none of the IDCs received it, and message sequence numbers (see 2.3.5) indicate that it was sent), retransmission is requested.

The IDC which is functioning as COMPARER prepares a reconciliation report listing differences in copies of all messages and recommending appropriate action in each case. Only COMPARER requests retransmission.

It should be noted that the functions of the COMPARER apply not only to WMO/GTS messages containing Level I parameters, but also to Preliminary Event Lists (see 3.5.1 below) and Final Event Bulletins (3.5.3).

3.2.6 Procedures for requesting retransmission of WMO/GTS messages

Direct point-to-point, rather than broadcast, transmission of messages is theoretically possible but practically difficult to achieve over the WMO/GTS. For this reason it is not desirable that retransmission requests are issued directly and solely to the originator of the missing or incomplete message.

The most practical method is that the COMPARER sends, at a fixed time daily (if necessary) a broadcast message, or messages, listing the GTS code of the contributor and the numbers of the missing or incomplete messages for that contributor. An example of such a retransmission request is given in Annex A8-IV.

Each COMPARER is responsible for requesting retransmission only of messages which should have been received during the (one week) time interval for which it was functioning as COMPARER. This means that an IDC which is no longer functioning as a comparer of currently incoming Level I data messages may still request retransmission of messages expected during its period(s) of duty as COMPARER. In the event that no retransmission request has been complied with for more than one week, the IDC currently functioning as COMPARER will directly contact the contributor in question by telephone or telex.

3.3 Bulletin generation - Level I data

The first two reports of the Ad Hoc Group (CCD/558 and CD/43) described only briefly the procedures suggested for the definition of seismic events and the association of Level I data leading to an output seismic bulletin. Chapter 7 of the third report, and the corresponding appendix, define these procedures much more precisely. The specifications given in that appendix attempt to describe the steps taken to generate an event bulletin from Level I data in sufficient detail that computer codes based upon their principles 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 stated in section 6.5 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"

The following subsections (3.3.1 through 3.3.10) briefly summarize the chief points of Appendix 7. The appendix itself indicates where changes or additions to the principles laid down in CD/43 have been made and justifies these actions.

3.3.1 Event definition

The following phases may be used for event definition and are designated as defining phases:

Teleseismic P (25<distance<100 degrees)

PKP (intial DF branch only)

Local P and S (distance<25 degrees)
(even in the absence of local travel time-tables)

One of the following two 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 observations at arrays more than 20 degrees apart.

Defining observations used by these criteria must consist of single station or array observations of defining phases, with final residuals (after convergence of the location procedure) of less than 1.5 a priori standard deviations. These a priori standard deviations are:

Teleseismic P	1 second
Local P, including Pn, Pg and P*	3 seconds
Local S, including Sn, Sg and S*	5 seconds
PKP (DF branch only)	1.5 seconds
Array observations: slowness vector	
Teleseismic	1.5 seconds/degree
Local	3.0 seconds/degree

Local S and the crustal phases Pn, Pg, P*, Sn, Sg and S*) may be used as defining only if reported as such. P and PKP observations must have been reported as primary arrivals identified as P, PKP (for association as PKP only) or without phase identification.

3.3.2 Initial epicenter determination

Starting solutions for the association and location procedure may be provided by array observations, "local" arrivals, or combinatorial approaches, as detailed in section 3.5 of Appendix 7. Each hypothesis thus provided is tested by searching for arrivals consistent with the initial location: these are then passed to the hypocentral location programme.

If the solution converges, the event is accepted, provided that it satisfies the event definition criteria given above in 3.3.1 and also satisfies certain rules, detailed in Appendix 7, section 3.5, applied in extending the group of defining arrivals beyond those used in generating the starting solution.

3.3.3 Hypocentral location technique

The arrival times consistent with the initial hypothesis are passed to a hypocentral location program which minimizes, in a least-squares sense, the difference between theory and observation. Truncation of the set of observation may be necessary to achieve convergence; the rules for carrying this out are given in section 3.6 of Appendix 7.

3.3.4 Depth determination

Special attention should be paid to depth determination in view of the importance of such estimates for event identification. Depth is initially provided from the hypocentral location program using only the defining phases specified in 3.3.1. A search is then made for possible depth phases, followed by relocation now including pP and sP as defining observations. A depth phase may only become defining if it has satisfied fairly stringent conditions described in section 3.7 of Appendix 7.

3.3.5 Removal of arrivals from further consideration

Arrivals corresponding to events with five or more defining observations at four or more stations (note that this is slightly greater than the event definition criteria) should be flagged such that they may not be used as defining observations for later events, provided that they satisfy certain requirements detailed in section 3.8 of Appendix 7.

Non-defining secondary phases may also be flagged as predicted, provided that they satisfy the same conditions required for defining phases. The following secondary phases are flagged for all events, if associated as such:

PKP(BC), PKP(AB), PP

For large events with more than 10 arrivals at distances greater than 25 degrees, the following secondary phases should also be flagged, subject to the same restrictions:

PcP, PKKP (all branches), PKPPKP (all branches), SKP (all branches)

None of the secondary phases affect the location of the event.

3.3.6 Association of short-period data

Arrivals may be associated to an event so that they appear in the event listing even if they are neither predicted nor flagged according to the conditions given above. The requirement for association is simply that the arrival time residual lie in the range (-5 to +10 seconds). Note that arrivals may be multiply associated if they are not flagged as being predicted. However, associated but unpredicted arrivals may later become defining, whereas predicted arrivals may not.

Defining arrivals need not necessarily be predicted by the same event, and in such a case are free to become defining to a later event. If they are also predicted by the later event, they may no longer be defining arrivals for the earlier event, and this may then lead to the earlier event being deleted if the event definition criteria are no longer satisfied.

3.3.7 Association of long-period data

The procedure for association of long-period surface wave data is described in section 3.12 of Appendix 7. This section includes methods by which multiple associations are resolved. Azimuth estimates, obtained from Rayleigh waves recorded on long-period horizontal components, are particularly valuable in this procedure.

3.3.8 Consistency checks

Appendix 6.1 of CD/43 recommends the application of statistical procedures involving not only stations which have reported signals but also those which have not. This information is combined with a priori estimates of detection capabilities of the individual stations for events in various regions, in order to establish whether or not a certain association of arrival times fulfils a preset probabilistic requirement for defining an event.

This method should be applied to the association of both long- and short-period data. In practice this technique occasionally causes problems, and refinements and changes to the method are currently being studied.

3.3.9 Magnitude calculation

Individual station body-wave magnitudes are to be computed using the amplitude and period observations, corrected for distance by the Gutenberg-Richter amplitude-distance relation, for defining arrivals only.

Individual station surface-wave magnitudes should be calculated using the "Prague" formula as suggested in CCD/558.

Event magnitudes should be computed from the individual station magnitudes both by simple averaging and also, since this may often be strongly biased too high, by maximum likelihood techniques.

3.3.10 Association of identification parameters

Identification parameters (complexity, spectral ratio 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 will not be computed unless specifically requested.

3.4 Bulletin comparison and distribution

3.4.1 Preliminary event lists

After a fixed time interval, each IDC prepares a Preliminary Event List (PEL) which it then transmits in abbreviated form (see Annex A7-III to Appendix 7) to all participants over the WMO/GTS and to the other IDCs over computer-to-computer links. Since inter-IDC exchange and comparison of Level I data messages (see 3.2.4 and 3.2.5 above) has already been carried out, and the same basic procedures (see 3.3 above) have been applied to all the data received, these PELs should be very similar.

Chapter 7 of the third report recommends that the time interval between the preparation and transmission of the PELs, and the day for which the PEL lists events, should be two days. In practice this time interval will primarily be decided by the speed with which Level I data is measured, formatted and transmitted, and a slightly longer time delay may prove necessary.

The chief aim of the PEL is, firstly, to provide a basis for participating countries to report further Level I data, and, secondly, to enable the various IDCs to initiate discussions leading to agreement upon, and publication of, the final event bulletin.

One change from the PEL format described in Annex A7-III of Appendix 7 of the draft third report is considered desirable. The origin time should be specified to the nearest second, the latitude and longitude to the nearest hundredth of a degree, and the depth to the nearest 10 km. During the 1982 experiment with synthetic data it was found that the much less precise specifications (to nearest minute, degree, and depth given simply as S for shallow or D for deep) were not adequate for the purposes of initiating discussions on a final bulletin.

3.4.2 Reconciliation of preliminary event lists

After all PELs have been transmitted and received by all IDCs, negotiations commence with the aim of converging on a final event bulletin. While this is taking place, additional Level I data for the day in question may still be arriving, and the process of exchange and comparison of these Level I data messages continues in parallel with the bulletin discussions.

After some cut-off time (suggested as 7 days in Chapter 7 of the third report), no further Level I data will be considered for use in the final bulletin.

An electronic mail system, as described in 3.2.3, is virtually essential for the inter-IDC discussions as many exchanges may be required before agreement on the final bulletin is reached.

3.4.3 Final event bulletin

After consensus has been reached between all IDCs, the final joint bulletin is prepared and distributed. An abbreviated version, containing basic event parameters only, is transmitted over the WMO/GTS by each IDC. The full bulletin, including a complete description of all Level I parameters associated to each event, as well as a list of all unassociated arrivals for the time period covered by the bulletin, is distributed by mail to all participants. The formats of the final event bulletin are given in Annexes V and VI of Appendix 7 (WMO/GTS and full versions respectively).

CHAPTER 4

Exchange of Level II Data

Level II data consists of waveform data, whether digital or graphical, "segmented" or "continuous". The principal and most widely used medium for the transfer of digital waveform data is magnetic tape. Other modes of exchange, such as land or satellite telephonic transmission, are routinely used. Although CD/43 makes note of the fact that an IDC "should be equipped to handle waveform data supplied in any reasonable format", experience has shown that some degree of standardization is desirable.

4.1 Tape Format for Exchange/Storage of Level II Data

The most stringent requirement to be placed on the design of a standard tape format for Level II data exchange is that the tape format itself should be clearly specified and adhered to. Tape records must be included which contain enough descriptive information for data reconstruction, and documentation must be provided which should permit development of a computer program for tape reading and writing on as many different machines as possible.

A tape format for data exchange and storage is proposed in Annex V; it results from an intensive effort to define a durable format for tapes used to archive digital seismic data. The principal feature of this format is that it has been written to conform to a particular standard, namely ANSI standard X3.27-1978. Preliminary experiments indicate that this feature greatly simplifies tape transfer of information from one computer to another, possibly of different type. A possible tape data file format is also described in Annex V. Although this format is adequate for level II data exchange between a number of existing facilities, it is recommended that further experiments be conducted to examine the trade-off between compactness of the storage medium and the general convenience and availability of the medium. Specifically, it is recommended that experiments be conducted using 1600 BPI (instead of 6250 BPI) tapes, and that ASCII data representation (instead of 32-bit binary) be tested. Only with such experience can a generally acceptable format be established.

4.2 Inter-IDC Exchange of Level II Data

Requests for level II data, for example waveform data requested of one nation by another, will be relayed through the IDCs. One IDC, presumably that with the best communications with the source of the level II data, will request and acquire the level II data. This data must then be transferred to the other IDCs. For speed of transfer, and bearing in mind that direct computer-to-computer connection exists between the IDCs, data transfer by tape is not desirable and direct file transfer is preferable. Annex A7-II of Appendix 7 describes a suitable format for such file transfers. This format could also, of course, be used to transfer data from individual participants to the IDCs if direct computer-to-computer links exist between the national data center and one of the IDCs.

ANNEX A8-I

Sample Analyst Worksheet for Level 1 Parameters

NOTE: All times to be corrected for instrumental group delay.
All amplitudes to be converted to ground motion in nm.

Short Period Vertical Component

c	code	f	arrival time	period	amp.	note
				X	X	First arrival
X	M1X	X				A_1 (0-6 sec.)
X	M2X	X				A_2 (6-12 sec.)
X	M3X	X				A_3 (12-18 sec.)
X	M4X	X				A_4 (18-300 sec.)
X	NA	X	X	X		Noise amplitude
X	NT	X	X		X	Noise period
		X				Secondary phase
		X				Secondary phase
		X				Secondary phase
		X				Secondary phase
		X				Secondary phase
		X				Secondary phase
		X				Secondary phase
		X				Secondary phase
		X				Secondary phase

Short Period Horizontal Components

c	code	f	arrival time	period	amp.	note
	S	X		X	X	S-wave arrival time, clarity
X	MSN	X				S-wave maximum, N-S comp.
X	MSE	X				S-wave maximum, E-W comp.
		X				Secondary phase
		X				Secondary phase
		X				Secondary phase
		X				Secondary phase
		X				Secondary phase
		X				Secondary phase
		X				Secondary phase

Long Period Vertical Component

c	code	f	arrival time	period	amp.	note
				X	X	First arrival
X	MLP	X				Maximum amplitude A_M^*
X	NLPA	X	X	X		Noise amplitude, before P
X	NLPT	X	X		X	Noise period, before P
X		X				Secondary phase
X		X				Secondary phase
X		X				Secondary phase
X		X				Secondary phase
X		X				Secondary phase
X		X				Secondary phase
X	LR	X		X	X	Rayleigh wave onset
X	MLRZ	X				Rayleigh wave maximum
X	M1L	X				Rayleigh max (10 sec. period)
X	M2L	X				Rayleigh max. (20 sec. period)
X	M3L	X				Rayleigh max. (30 sec. period)
X	M4L	X				Rayleigh max. (40 sec. period)
X	NLPA	X	X	X		Amp. of noise before LR
X	NLPT	X	X		X	Period of same

Long Period Horizontal Components

c	code	f	arrival time	period	amp.	note
	S	X		X	X	S-wave arrival time, clarity
X	MSLPN	X				S-wave maximum, N-S comp.
X	MSLPE	X				S-wave maximum, E-W comp.
X		X				Secondary phase
X		X				Secondary phase
X		X				Secondary phase
X		X				Secondary phase
X		X				Secondary phase
X	LQ	X		X	X	Love wave onset
X	MLQN	X				Love maximum, N-S comp.
X	MLQE	X				Love maximum, E-W comp.

Additional Parameters (Array stations only)

code	value	note
SLO	(in sec./deg.)	Slowness (short-period)
AZ	(in deg.)	Azimuth to epicentre (SP)
DIS	(in deg.)	Inferred distance to epicentre
LAT	(in deg.)	Inferred latitude of epicentre
OT		Inferred origin time
MB		m_b (from M1X)
SLOLP		Slowness (long-period)
AZLP		Azimuth (LP)
MS		M_s (from MLRZ)
MSH		M_{SH} from MSLPN/MSLPE

Additional Parameters (Certain digital stations only)

code	value(s)	note
CMPX		Complexity
SPMM		Spectral Moment
SPRT		Spectral Ratio
SPVT		Spectral Vector

NOTES

X - denotes measurement not applicable
c - denotes clarity indicator (I or E)
f - denotes first motion determination (C,D etc)
code - where given, as required for parameter
amp. - amplitude

Annex A8-II

THE INTERNATIONAL SEISMIC CODE

CODE FORM

The following statement is the generalized code form for the routine reporting of basic seismic data from any number of stations, for any number of seismic occurrences:

SEISMOƀMSGNOƀINIT(1,1)ƀEVENT(1,1,1)ƀ...ƀINIT(i,j)ƀEVENT(i,j,k)ƀSTOP

where ƀ is a delimiter (usually a space), k represents the kth occurrance of an EVENT group for a given combination of i and j, and the delimited groups are either symbolic words, or dummy words representing variable collections of sub-groups.

SPECIFICATION OF SYMBOLIC AND DUMMY WORDS AND LETTERS

SEISMO Symbolic word prefixing this type of seismic message.

MSGNO Includes the ordinal number from the first seismic message of the calendar year. Used to detect the non-receipt of a previous seismic message. Should not be confused with external message number. This optional group has the form:

Nyn

where;

N is a prefix.

y is the last digit of the year of transmission of the message (not necessarily the year of the data).

n is the 1 to 3 digit ordinal number itself, based on the number of these seismic messages, originating with a particular network or agency or relayed from another, and not corresponding to individual stations in a network.

INIT(i,j) The INIT(i,j) group as shown in the generalized code form above, is a dummy group representing any legitimate combination of one or more of the following initializer groups which may occur in series with each other:

STA(i) represents the ith occurrance of a 3 to 5 character international station abbreviation. It is required for INIT(1,1) and whenever a change in station occurs.

DATE(j) represents the jth occurrance of a DATE group. The date (UTC) is based on the arrival-time of the first phase in the following EVENT group. It is required for INIT(1,1) and whenever a change in date occurs. DATE consists of the following;

mmmdd

where;

mmm — is the 3 character month identifier.

dd — is the 1 to 2 digit day of month.

Those contributors with more than one station should consider the following statement:

By allowing either j (i.e. the date) or i (i.e the station) to change more rapidly, one may order data either by space-time events (hypocenters) or by station.

SPMAG is an optional field containing the standard magnification of a recording whose short-period trace amplitudes may be included in a following event. Information on the relevant instrumentation must have been furnished to the recipient. SPMAG consists of the following:

sK

where;

s — is the short-period vertical magnification in thousands. A decimal point may be necessary.

K — is a suffix denoting this group.

LPMAG is an optional field containing the standard magnification of a recording whose long-period trace amplitudes may be included in a following event. Information on the relevant instrumentation must have been furnished to the recipient. LPMAG consists of the following:

1M

where;

l	is the long-period vertical magnification.
M	is a suffix denoting this group.

The SPMAG & LPMAG groups are always optional when the recipient is known to have a record of the current operating magnification(s) of the default instruments. Inclusion of either of these groups is optional because they serve only as a check on the values stored in the recipient's computer data bank. If the operating magnification is changed, the sender should start a new message with the new magnification and include a plane-language comment in the first EVENT field confirming that a change has occurred. Otherwise, it will be considered an error. These groups are never included when the relevant amplitudes are ground amplitudes or by stations who never send amplitudes.

The standard magnification is that magnification, at the nominal period, to which the instrument magnification factor is normalized to 1. The period to which magnifications are normalized varies with the instrument type, but is generally 1 second for short-period instruments and that period at which the instrument magnification peaks for long-period instruments.

EVENT(i,j,k) is a station-event group, i.e. all of the data from a single seismic source, as recorded and interpreted from any number of instruments at a single site, or as ascribed to a single station as in the case of slowness or phase velocity. The format of EVENT(i,j,k) is:

IFASEɃTAMPɃSFASE(i)Ƀ...ɃSFASE(n)ɃSFCɃSLOWɃCOMM

where i = 0 to n, and:

IFASE is the initial phase-time group in the form;

PHASEhhmmsss

where;

PHASE is a 1 to 5 character phase code which may include an onset prefix (accuracy indicator), and a first-motion suffix.

hh is the 2 digit hour.

mm is the 2 digit minute.

sss is the seconds and decimal fraction thereof. This group should be quoted only to the precision actually obtained in scaling, but must contain at least 2 digits. A decimal point is required only if the time includes hundreths of a second.

TAMP is the period and amplitude of the first phase based on a short-period vertical recording. This optional group has the form:

Tt.t Aaa.aaa

where;

T is a symbol prefixing the period.

t.t is the period in seconds. The decimal point is required unless the tenths are zero.

A is a symbol prefixing the amplitude.

aa.aaa is the amplitude (either double trace amplitude in millimeters or ground amplitude in nanometers). The decimal point is required to indicate a precision of less than one unit. Amplitudes should be quoted only to the pecision actually obtained when scaling, generally 2 or 3 significant figures.

SFASE(i) is a secondary phase-time group. This optional group has the form:

PHASEhhmmsss

where;

PHASE — is the 1 to 5 character phase code which may include an onset prefix (accuracy indicator).

hh — is the optional 2 digit hour, required only when the hour is not the same as the hour of the preceding IFASE or SFASE within the EVENT group.

mm — is the 2 digit minute.

sss — is the seconds and decimal fractions thereof. (same format as in IFASE)

:Up to 23 SFASE groups may be included in each EVENT group.

SFC is the undifferentiated surface-wave group. This optional group has the form:

LZ𝔟TtAaa.aa𝔟LN𝔟TtAaa.aa𝔟LE𝔟TtAaa.aa

where;

LZ — is a symbol for the vertical component group.

LN — is a symbol for the north-south component group.

LE — is a symbol for the east-west component group.

T — is a symbol prefixing the period.

tt — is the period, in whole seconds, of the surface-wave component.

aa.aa — is the amplitude (either double trace amplitude in millimeters or ground amplitude in micrometers). The decimal point is required to indicate a precision of less than one unit. Amplitudes may be reported to 3 decimal places, but should be quoted only to the precision obtained when scaling, generally 2 or 3 figures.

The vertical component group may appear alone. Conversely, the 2 horizontal components may appear without the vertical. However, both horizontal components should appear together.

SLOW — is reduced array data, consisting of either of the following optional groups:

SLOꞴs.ssꞴAZꞴaaa

or

VELꞴvv.vꞴAZꞴaaa

where;

SLO — is a symbolic indicator of slowness data.

VEL — is a symbolic indicator of phase velocity data.

ss.s — is the slowness in sec/deg.

vv.v — is the phase velocity in km/sec.

aaa — is the station-to-epicenter azimuth.

COMM — is additional information and comments. This optional group has the form:

((____))

where;

((— is a symbol indicating the onset of plain language information which may or may not be related to the data to which it is appended.

____ — symbolizes plain language information.

)) — is a symbol indicating the end of such information.

STOP — is the symbolic word ending the message.

ƀ — is the symbol for a delimiter. Delimiters in all of the above forms are shown only where they are required as group separators. A delimiter may consist of any number or combination of spaces, carriage-returns or line-feeds. Single spaces are permitted, but not required in other positions, which will be illustrated in following discussions and examples.

By using various or multiple characters for delimiters one may "columnarize" the data to improve visual legibility.

WARNING

While encoding a SEISMO message, one should keep in mind that it will be decoded by a computer program designed to cope with only a limited number of deviations from the prescibed format.

APPENDIX A

This appendix illustrates a SEISMO message, containing data from more than one station, in which the sender chose to group the data by station (i.e. the date varies more rapidly than the station). This is generally the most convenient grouping method when the data from the various stations are from different days, have been interpreted at different locations, or have been collected regionally and are then relayed to a central observatory.

This example is then followed by a detailed discussion of each group in the order in which they have been introduced in the example. We have given a number of relaxations of the format which are acceptable, but whose useage is deemed poor practice.

EXAMPLE OF TELEGRAM TEXT

```
SEISMO N812 TUC 2ØØK 3ØØØM APR3Ø IPCU17523Ø3 TØ.8 A3Ø.Ø
I5253Ø LZ T21A1ØØ LN T2ØA99 LE T2ØA1Ø1 SLO 6.84 AZ 357
DIFU235511Ø PKPCU23581Ø1 I58452 ISKPØØØ14Ø1 MAYØ1 (P)ØØ3742Ø
IPDØ2ØØ373 T2.9 A43.6 IAPØØ552 EXPØ1Ø42 IPNCRØ419226
IPB19252 ISN19558 ISB2ØØ25 ELG2ØØ6Ø ((DAMAGE VII YUMA,
ML5.8 D2.1)) IPCUØ6Ø615Ø ESØ9Ø6Ø IPCP1Ø521 IAPCP1128Ø
EXPCP1152Ø ESCP14Ø8Ø EPØ81516Ø LZ T21A4.2 ((NEW STATION
AT BLACK BUTTE 34 DEG 24 MIN 28.Ø SEC N, 1Ø6 DEG 44
MIN 44.3 SEC W, ELEV 1524 M DATA WILL SOON BE SENT BY
TEL))

ALQ 4ØØK 15ØØM APR26 IPGC1459Ø84 (( STRIP MINE EXPLOSION 31 DEG
14 MIN N, 111 DEG 2 MIN W)) APR27 EPR1752241 ES18Ø1446
LN T18A4.6 LE T19A1.3 IPDR1921367 ((LPZ,N,E OFF SCALE, LZ SCALED
FROM SPZ, DOUBLE TRACE AMPLITUDE EQUALS 72 MM AT 2Ø SEC)) EP234617Ø
((CORRECTION APR24 EP1943276 SHOULD READ EP1945276))

SRF APR23 (PN)Ø51422Ø IPG14324 ELG1517Ø IPGDØ7Ø3162 ISGØ3261
((ISMS Ø334)) IPN12133ØØ IAPN1343Ø IPB13512 ISN1443Ø STOP
```

Code	EXPLANATION OF TELEGRAM TEXT
SEISMO	is the message type identifier, and must always be the first 6 characters of this type of message.
N812	Indicates that this message is the 12th such message sent during 1978 by this station or network. The first few messages of 1978 might have contained data recorded in 1977 UTC.
TUC	is the international station abbreviation for Tucson, Arizona.
	ALQ and SRF are abbreviations for other stations being sent. As shown above, we strongly recommend introducing a

carriage-return and 2 line-feeds as a delimiter preceeding the appearance of data from additional stations, when data are grouped by station. This greatly enhances visual scanning.

Use only the international station abbreviation code and not the full name of the station. The 3 to 5 character abbreviations are assigned by the U.S. Geological Survey in cooperation with the International Seismological Centre.

2ØØK is the short period vertical magnification in thousands.

Worldwide Standardized Seismograph Stations (WWNSS), SEISMIC RESEARCH OBSERVATORY (SRO), and IRANIAN LONG PERIOD ARRAY (ILPA) stations reporting peak-to-trough short-period body-wave trace amplitudes (i.e., double trace amplitudes), in millimeters, must report their short-period vertical magnification at 1 second in multiples of thousands (K). For example, 2ØØK for 2ØØØØØ, 12.5K for 125ØØ, 6.26K for 625Ø, and 3.125K for 3125. Stations reporting center-to-peak ground amplitudes (in nanometers) must not quote magnification setting.

3ØØØM is the long-period magnification

WWNSS, SRO, and ILPA stations reporting peak-to-trough surface-wave trace amplitudes (i.e., double trace amplitudes), in millimeters, must report actual long-period magnification setting at the period at which their magnification is a maximum (i.e. 15, 25 and 25 seconds respectively). The letter M must follow the number. Both short-period and long-period magnification settings may be reported. Stations reporting center-to-peak surface-wave ground amplitudes (in micrometers) must not quote long-period magnification setting.

APR3Ø is the date group and is decoded as April 3Øth of current year.

This group is used to identify the date of the first EVENT group reported and each change of date thereafter. Thus this group need not be included with each event if there is more than one reported per day. Any of the following forms are acceptable: JANØ1, JAN1, JAN Ø1, JAN 1; SEPT22, SEP.22, etc. Months are identified only by the following: JAN, FEB, MAR or MARCH, APR or APRIL, MAY, JUN or JUNE, JUL or JULY, AUG, SEP or SEPT, OCT, NOV, and DEC.

IPCU is the initial phase identification, onset prefix (accuracy indicator), and first motion suffix(es).

P Phase code

Initial first arrival phase identifications accepted by the computer are P, PDIF (or DIF), PKP, PN, PG, and PB. PN, PG, and PB are also accepted as secondary arrivals.

Frequently, in a preliminary interpretation of a seismogram, one may not know whether a particular phase is a P or a PKP, in which case a P should be reported. However, first arrivals identified only with an onset prefix such as ( ), E( ), E, I, etc. will be assumed to be P, and converted automatically to (P), E(P), EP, IP, etc. Secondary arrivals identified as E, I, etc. will be retained as E, I, etc.: they are treated as first arrivals only if there is no associated primary phase.

I Onset Prefix (accuracy indicator)

To any phase code, one may prefix the onset codes E, I, ( ), and E( ), as long as this field will not exceed 5 characters. However, it is not necessary to include any such prefix.

Choice of E, I or ( )

For purposes of computing hypocenters, it is most useful to employ E and I to denote the accuracy of the timing of the phase for the first arrival, rather than the character of the recording (which may depend on the paper or film speed). For first arrivals with clear first motions and timing which should be accurate to within about ±Ø.2 sec, I should be used. For first arrival times with accuracies between ±(Ø.2 to 1.Ø) sec E should be used. If the uncertainty in the onset of the first arrival is greater than 1 sec, E(P), (P), (PN), etc. should be used.

The above criteria, of course, apply to readings taken from seismograph systems having comparable chronometer accuracies and drum speeds and trace widths allowing comparable resolutions.

For secondary phases onsets will seldom, if ever, be legible to within ±Ø.2 second, and criteria for use of I and E should be liberalized.

Although an onset may exhibit "nodal character", no provision has been made for such information in the onset codes. Any onset codes received as EI will be processed as E.

CU First Motion Identifications

C	short-period compression
D	short-period dilatation (rarefaction)
U	long-period compression
R	long-period dilatation (rarefaction)

The definition of long and short-period first motions is left to the discretion of each observer, however, it should be based on the instrument from which the first motion was obtained and not the apparent period of the signal. First motions obtained from intermediate-period instruments should be reported as long-period.

One may report either or both short and long-period first motions. Do not leave a blank (space) for the short when only the long is reported. The long and short need not agree with each other. If one has assigned an e(P) to a first arrival onset time scaled from a short-period instrument, one would ordinarily not report a short-period first motion.

Only clear first-motions are desired; there is no provision for a first-motion quality indicator. However, observers are encouraged to send first motions whenever possible.

The onset, phase, and first motion field is restricted to five digits; consequently the onset portion may occasionally be omitted as it is the least important. Appendix C gives a complete list of acceptable combinations comprising this field.

17523Ø is the initial phase arrival time, and is decoded as 17hr 52mn 3Ø.3sec.

The initial phase arrival times must always include the hour.

A decimal point is not necessary to indicate tenths of a second; however its use is allowed, and it is required if two decimal places are to be indicated. Likewise, arrival times may be given to the whole second. Do not fill in decimal fractions of seconds with zeros, if it will yield a false precision.

If only six digits are reported, the time is assumed to be to the nearest second, i.e. Ø1Ø2Ø3 is interpreted as Ø1 Ø2 Ø3, not as ØØ 1Ø 2Ø.3; Ø1 Ø2 Ø3.4 is interpreted correctly.

Spaces and decimal points in the arrival times are allowed.

Example:

Correct	Incorrect
17523Ø3	17523Ø3.
17 52 3Ø3	17523Ø3,
17523Ø.3 or 17523Ø,3	
17 52 3Ø.3	

Do not use 24 for an hour. Example:

SEP3Ø IPC2452123 incorrect
OCTØ1 IPCØØ52123 correct

Do not use a number larger than 59.99 for seconds unless a leap-second is involved.

Example:

OCTØ1 IPR1Ø2464.5 incorrect
OCTØ1 IPR1Ø25Ø4.5 correct
DEC31 IPD235960.3 correct for month ending in a leap second.

TØ.8 A3Ø.Ø are the period and amplitude of the short-period P body-wave

This group must immediately follow the first arrival time. The period and amplitude values must follow the letters T and A respectively. For example, correct forms are TØ.8 A3Ø.Ø and T1.Ø AØ.8. However, T.8A3Ø., T1.A.8, and T1A3Ø are also acceptable. Period and amplitude data should not be reported for phases known to be PKP. If uncertain as to whether a phase is PKP or P, report it as a P, and include period and amplitude if legible.

ASSOCIATED SECONDARY PHASES

FORMAT

I5253Ø
I58452
ISKPØØØ14Ø1
IAPØØ552
EXPØ1Ø42
IPB19252
IPG19272
etc.

Secondary phase codes, together with their onset codes, if any, must not consist of more than 5 characters.

These arrival times need include the hour only when the hour differs from that of the preceeding phase of the EVENT group, as in the case of the SKP time shown. Thus if they are reported to the nearest whole second, their arrival times will consist of either 4 or 6 figures. If reported to the nearest tenth of a second, without including the decimal point, they will consist of 5 or 7 figures.

Likewise, a secondary arrival time need include the minute only when the minute differs from that of the preceeding phase of the EVENT group. However, such a degree of fragmentation of the data is not recommended, as experience has shown that such data are more difficult to correct if there is an error or garbling in transmission.

Arrival times may be reported to hundreths of a second, in which case a decimal point must be used.

Secondary arrivals must arrive within 66 min of the primary phase: otherwise, they will be considered to be new primary phases. One additional requirement is that PG, PB, and P*, when they are not primary phases, must not include the first motion identifiers C, D, R, or U. For example, EPNØ1Ø2Ø3.4 IPGCØ1Ø2Ø9.5 would be considered to be two different events.

As many as 23 secondary phases may be included with each EVENT group.

Since an asterisk (*) generally cannot be sent by telegram, phases P* and S* should be sent as PB and SB.

No first motion identification should be used for secondary phases.

RELATIVE IMPORTANCE

The most important secondary phases for hypocenter estimation are those which give an indication of the depth of focus. These include pP encoded as AP, sP encoded as XP, pPKP encoded as APKP, Pg encoded as PG, Lg encoded as LG. Also of great value are S phases for local and regional shocks when their onset can be read accurately enough to yield a check on the computed origin time. They are especially valuable for local and regional shocks with deeper than normal foci. Any strong phase following teleseismic P by less than 2 min 3Ø sec, which might be a pP but for which the interpreter does not wish to definitely identify as pP, should be encoded as an E or I. A pPcP and/or sPcP (encoded as APCP and XPCP respectively) together with PcP will yield depth information from stations which may be too close to the focus to record pP or sP. The same consideration applies to ScP, PcS, and ScS.

Phases which are generally prominent on short-period vertical instruments which are of some value in hypocenter estimation include PcP, ScP, PKKP and SKP. Identification of these phases by some stations may aid in the identification of these same phases from other stations which have reported them as P. Such phases as PP, PPP, SS, SSS, SP, PgPg, etc., are generally of lesser value in routine hypocenter work.

Phases closely following P which have much larger amplitudes than P and may indicate a multiple or complex event may be encoded as an E or I (these may also include breakout and stopping phases), or they may be encoded as separate shocks if the interpreter has such evidence, or desires to include their amplitudes.

LZ, LN, LE are the surface wave component identifiers

Identify data following as surface-wave period and amplitude group. Z, N, and E indicate the component. These data must relate to the same earthquake described by the preceding initial phase identification. Either the vertical component alone (Rayleigh Wave) and/or the two horizontal components may be reported. Average surface wave magnitudes are computed using only the vertical component, although individual station magnitudes computed from horizontal components are reported on the EDR.

T21A1ØØ are the surface-wave period and amplitude

The surface-wave period and amplitude (see also 3ØØØM above) must follow the letters T and A respectively. Decimal points are necessary to report decimal fractions of the amplitudes. Amplitudes should generally be reported to at least 2 significant figures. Seldom will their precision be greater than 3 significant figures. Surface-wave period and amplitude group must follow the component they apply to (e.g., LZ, LN, or LE). If nearly zero, please assign an allowable period with the zero amplitude. If a horizontal component is not scalable because it is missing, off scale, etc., do not report either horizontal component. If the horizontal periods differ, we assign them the value 2Ø sec arbitrarily.

SLO 6.84 AZ 357 are array data

Arrays now report Slowness in sec/deg (SLO) or Velocity in km/sec (VEL), and station to epicenter Azimuth in deg (AZ). These should follow the associated primary phase, secondary phases, or period-amplitude group. The order is not important. The group above could also have been reported as VEL 16.3 AZ 357.

((——)) Additional Information and Comments

All additional information must be enclosed within double parentheses, and must come between the words SEISMO and STOP. Any messages in double parentheses after the word STOP will not be machine processed and will probably be lost. If it pertains to an event for which data are included in this message, the information, enclosed in double parentheses, must follow the data of that event. Usually this type of information includes macroseismic data, e.g. ((FELT IV AT RAB)), and magnitude information. If a magnitude is sent based on a distance and/or a depth which are not well known, the applied distance (in geocentric degrees) and/or depth (in km) should be included, together with the magnitude value and scale, e.g. ((ML 5.8 D 2.1)), ((MB 6.2 D 85 DEPTH 65Ø)). Other useful information includes rockburst, coal bump, and blast information; hypocenters supplied by your network; and any other comment relative to the hypocenter, magnitude, or depth determination, such as: ((probable double-shock, SPZ amplitude refers to second shock)).

If the additional information does not pertain to any particular data, it must be appended to the end of any convenient event. Such information may include: confirmation of a change in magnification ((SPZ changed from 1ØØK to 5ØK for winter, effective OCT16, 15ØØZ)); corrections; supplementary information for events reported on earlier messages; and information on new stations. Please do not include comments such as SEP28 ((NIL)) or SEP28 ((NO SIGNAL)). The correct method to send such information is...SEP29 IPØ522195 ((SEP28 NIL))... however it is not/necessary to send such information at all if the MSGNO group is used.

STOP The stop instruction turns off automatic equipment. It must come before a signature or confirmation. No matter how long a telegram may be, confirmations should never come before the STOP. Usually, commas (,), dashes (-), and other symbols not shown in the sample message are ignored, except in comments which are enclosed in double parentheses. However, do not use a . or , at the end of a message, because this can be confused with the decimal point. Example:

```
EPØ1Ø2Ø3.4  STOP  - Correct
EPØ1Ø2Ø34   STOP
EPØ1Ø2Ø3.4. STOP  - Incorrect
EPØ1Ø2Ø34.  STOP
```

Please stress to the people preparing these telegrams and those transmitting the telegrams that they must follow the format exactly. The letter O and the number zero (Ø) must be used correctly by the telegraphic operator, and not interchanged. The same applies to the letter I and the number 1, especially following the letter T, for period. Symbols which do not appear on all teletype machines are transmitted by various upper case letters:

Symbol	Transmitted by
(	figures (upper case) K
)	" " L
,	" " N
?	" " B
/	" " X
.	" " M
((	" " KK
))	" " LL

If your teletype key board does not contain the symbols contained in the left column above, please transmit the data in the right column.

Some stations or nets routinely send data telegraphically, and then send their preliminary interpretations by mail. They are requested to indicate on their preliminary bulletins or letters, which data have previously been supplied by telegraph, and which, if any, are revisions of such data or new data. When this is known, only the events which are new or revised need be processed.

Some stations are now sending telegrams with only first arrivals, or first arrivals and their period and amplitude, within a few days of recording, and are then sending by mail reinterpretations within a few weeks. they are urged to send their important secondary phases and comments with their initial telegrams, if these more complete preliminary interpretations can be sent with only a short additional delay.

All first-motions with data received by airmail will be considered short-period first-motions unless identified as long-period first-motions on each message.

APPENDIX B

This appendix illustrates a SEISMO message which contains data from more than one station in which the sender chose to group the data by date (i.e. the station varies more rapidly than the date). This is frequently the most convenient grouping method when the signals are telemetered to one recording site from several seismometers.

In both versions frequent use of carriage-returns and line-feeds were made not simply to separate the data by seismic event, but, in so doing, to make the original copy more legible for the teletypist and others, in preparing the message for transmission.

As long as the format rules are adhered to ridgidly, the computer receiving the message does not "care" what it looks like to the eye. Each seismological agency should, together with those transmitting their messages, adopt a delimiter technique best suited to their individual situation.

Version I

```
SEISMO

MAR23
GIL IPC1919534 T1.4 A463.0  ANV IPC1918485  SIT EP1920528  KDC EP1920528
PMR EP1919478 T1.0 A65.0 LZ T20A90.0 LN T20A30.0 LE T20A95.0
NRA EP1919058  GMA EP1919063

ANV EP1927248

GIL EP1953558 T1.5 A107.0  ANV EP1952488  KDC EP1953356
NRA EP1953059

GIL EP2157109 T1.0 A25.0  ANV EPC2156570  KDC EP2156368  PMR EP2156557
T1.0 A75.0  NRA EP2156566  GMA EP2157029

GIL EP2226548 T0.9 A4.2

MAR24
GIL IPC0052368 T1.0 A65.0 I53255  NKI IPC0054070  GMA IPC0053149
NRA IPC0053162  KDC IPC0053018  ADK IPC0054325  PMR IPC0052459 T1.0 A102.5
E53305 I54582 LZ T18A14.0 LN T18A6.0 LE T18A12.0  ANV IPC0053275
SIT IPC0051589  MID IPC0052394  PMA IPC0053328

GIL EP0122119 T1.3 A25.0  NRA EP0122002  PMR EP0122070 T1.2 A16.3
ANV EP0121517
STOP
```

VERSION II

SEISMO

MAR23
GIL IPC1919534 T1.4 A463.0
ANV IPC1918485
SIT EP1920528
KDC EP1920528
PMR EP1919478 T1.0 A65.0 LZ T20A90.0 LN T20A30.0 LE T20A95.0
NRA EP1919058
GMA EP1919063

ANV EP1927248

GIL EP1953558 T1.5 A107.0
ANV EP1952488
KDC EP1953356
NRA EP1953059

GIL EP2157109 T1.0 A25.0
ANV EPC2156570
KDC EP2156368
PMR EP2156557 T1.0 A75.0
NRA EP2156566
GMA EP2157029

GIL EP2226548 T0.9 A4.2

MAR24
GIL IPC0052368 T1.0 A65.0 I53255
NKI IPC0054070
GMA IPC0053149
NRA IPC0053162
KDC IPC0053018
ADK IPC0054325
PMR IPC0052459 T1.0 A102.5 E53305 I54582 LZ T18A14.0 LN T18A6.0
    LE T18A12.0
ANV IPC0053275
SIT IPC0051589
MID IPC0052394
PMA IPC0053328

GIL EP0122119 T1.3 A25.0
NRA EP0122002
PMR EP0122070 T1.2 A16.3
ANV EP0121517
STOP

APPENDIX C

1. A. List of acceptable combinations of first arrival codes, onset codes, and first motion codes.

P	PDIF	PKP	PN	PG	PB
EP	EPDIF	EPKP	EPN	EPG	EPB
IP	IPDIF	IPKP	IPN	IPG	IPB
(P)	PDIFC	(PKP)	(PN)	(PG)	(PB)
PC	PDIFD	PKPC	PNC	PGC	PBC
PD	PDIFU	PKPD	PND	PGD	PBD
EPC	PDIFR	EPKPC	EPNC	EPGC	EPBC
IPC	DIF	IPKPC	IPNC	IPGC	IPBC
EPD	EDIF	EPKPD	EPND	EPGD	EPBD
IPD	IDIF	IPKPD	IPND	IPGD	IPBD
PU	(DIF)	PKPU	PNU	PGU	PBU
PR	DIFC	PKPR	PNR	PGR	PBR
EPU	DIFD	EPKPU	EPNU	EPGU	EPBU
IPU	EDIFC	IPKPU	IPNU	IPGU	IPBU
EPR	IDIFC	EPKPR	EPNR	EPGR	EPBR
IPR	EDIFD	IPKPR	IPNR	IPGR	IPBR
PCU	IDIFD	PKPCU	PNCU	PGCU	PBCU
EPCU	DIFU	PKPCR	EPNCU	EPGCU	EPBCU
IPCU	EDIFU	PKPDU	IPNCU	IPGCU	IPBCU
PCR	IDIFU	PKPDR	PNCR	PGCR	PBCR
EPCR	DIFR		EPNCR	EPGCR	EPBCR
IPCR	EDIFR		IPNCR	IPGCR	IPBCR
PDU	IDIFR		PNDU	PGDU	PBDU
EPDU	DIFCU		EPNDU	EPGDU	EPBDU
IPDU	DIFCR		IPNDU	IPGDU	IPBDU
PDR	DIFDU		PNDR	PGDR	PBDR
EPDR	DIFDR		EPNDR	EPGDR	EPBDR
IPDR			IPNDR	IPGDR	IPBDR

B. Since the onset codes E, I, and ( ) refer to the accuracy of the timing of the onset of the phase and not to the quality of the first motion, the following are also valid combinations:

(P)C	(PN)C	(PG)C	(PB)C
(P)D	(PN)D	(PG)D	(PB)D
(P)U	(PN)U	(PG)U	(PB)U
(P)R	(PN)R	(PG)R	(PB)R
(P)CU			
(P)CR			
(P)DU			
(P)DR			

These combinations could arise if one had poor chronometer accuracy, but a clear first motion; or. a noisy short-period instrument from which times were scaled, and first motions taken from long-period instruments.

2. List of acceptable combinations of phase codes and onset codes that may be either first arrivals or secondary phases.

PN	EPN	IPN	(PN)
PB	EPB	IPB	(PB)
PG	EPG	IPG	(PG)

First motions can only be appended to these phases when they are a first arrival.

3. List of acceptable combinations of secondary phases and their onset codes.

APN	EAPN	IAPN	(APN)
XPN	EXPN	IXPN	(XPN)
SN	ESN	ISN	(SN)
SB	ESB	ISB	(SB)
SG	ESG	ISG	(SG)
PGPG	EPGPG	IPGPG	
SGSG	ESGSG	ISGSG	
LG	ELG	ILG	(LG)
AP	EAP	IAP	(AP)
XP	EXP	IXP	(XP)
S	ES	IS	(S)
XS	EXS	IXS	(XS)
PP	EPP	IPP	(PP)
APP	EAPP	IAPP	(APP)
XPP	EXPP	IXPP	(XPP)
SS	ESS	ISS	(SS)
PPP	EPPP	IPPP	(PPP)
APPP	EAPPP	IAPPP	
XPPP	EXPPP	IXPPP	
SSS	ESSS	ISSS	(SSS)
PS	EPS	IPS	(PS)
SP	ESP	ISP	(SP)
SPP	ESPP	ISPP	(SPP)
APS	EAPS	IAPS	(APS)
PPS	EPPS	IPPS	(PPS)
XSP	EXSP	IXSP	(XSP)
PCP	EPCP	IPCP	(PCP)
APCP	EAPCP	IAPCP	
XPCP	EXPCP	IXPCP	
PCS	EPCS	IPCS	(PCS)
SCP	ESCP	ISCP	(SCP)
ASCP	EASCP	IASCP	
XSCP	EXSCP	IXSCP	
SCS	ESCS	ISCS	(SCS)
RPCP	ERPCP	IRPCP	(RPCP signifies PcPPcP)
RSCS	ERSCS	IRSCS	(RSCS signifies ScSScS)

APKP	EAPKP	IAPKP	
XPKP	EXPKP	IXPKP	
SKS	ESKS	ISKS	(SKS)
PKS	EPKS	IPKS	(PKS)
APKS	EAPKS	IAPKS	
XPKS	EXPKS	IXPKS	
SKP	ESKP	ISKP	(SKP)
PKKP			
PKKP	EPKKP	IPKKP	
SKKS	ESKKS	ISKKS	
P3KP	EP3KP	IP3KP	
P4KP	EP4KP	IP4KP	
P5KP	EP5KP	IP5KP	
P6KP	EP6KP	IP6KP	
P7KP	EP7KP	IP7KP	
RPKP	ERPKP	IRPKP	(RPKP signifies PKPPKP)
RRPKP			(signifies PKPPKPPKP)
SKSP	ESKSP	ISKSP	
G	EG	IG	(G)
T	ET	IT	(T)
TT	ETT	ITT	(TT)

Phase codes without the onset prefix are accepted. However, use of the onset prefix as an accuracy indicator is encouraged, except where such use would lead to a field of more than 5 characters.

P′ and P* are alternate phase code designators for PKP and PB respectively. They are acceptable to computers processing seismic data, and may thus be exchanged by computer links or by air mail. However, "′" and "*" are generally not available to teletype cicuits, so PKP and PB are the preferred codes for teletype data even if the originator is capable of sending "′" or "*".

Annex A8-III

Extensions to the International Seismic Code

1. Introduction

The International Seismic Code, as described in Annex A8-II, is not adequate for all the requirements of the proposed International Seismic Data Exchange, due to the definition of new parameters by the Ad Hoc Group. This appendix describes the necessary additions to the code. These have been previously specified in some detail on pp 22-30 of CD/43/Add 1, but some problems with those specifications have come to light in the wake of the WMO experiments of October, 1980 and November/December, 1981. Three types of difficulties were experienced.

a) improper handling of essential information (e.g., reporting interval and downtime information) when it is enclosed in double parentheses (i e., when it looks like commentary) (It should be noted that CD/43/Add 1, on page 23, mentions the undesirability of treating reporting interval and downtime as comments)
b) the fact that some phase identifiers (e.g., MLR) duplicate station names
c) the lack of definitive event delimiters

It has been necessary to modify the specification given in CD/43/Add.1 very slightly to overcome these problems. The modifications occur as changes to items 6 and 7 in the description of the format, a new item 8 (event delimiter), and a new name (MLRZ) for parameter group 37-38-39 (maximum amplitude of LRZ)

2. Description of the Format

The proposed format, which is described in detail in Tables A8-III(1) through A8-III(4), is in most respects identical to the International Seismic Code, However, the following deviations should be noted.

(1) Numbering

The messages originating from each national facility will be consecutively numbered starting at the beginning of each calendar year. The general form of the number is Nyn where N is a prefix, y is the last digit of the calendar year and n is a number of 1 to 5 digits.

(2) Additional phase identifiers

As described in detail in Tables A8-III(1) and A8-III(2), several new phase identifiers will be needed compared to the International Seismic Code. Each of these is to be followed by the corresponding arrival time, period and amplitude in accordance with standard practice Note that all the amplitudes of these new phases will be quoted in nanometers (nm).

(3) Identifiers for parameters

Again referring to the Tables A8-III(1) and A8-III(2), a number of new identifiers corresponding to specific computed parameters will be needed.

(4) Later phase information

For each later phase, the maximum amplitude (quoted in nm) and corresponding period that is associated to the phase will be reported. For horizontal instruments the component on which the measurements were made might be specified as a suffix (E or N) immediately following the phase identifier However, care must be taken not to exceed the maximum length (5 characters) of a phase identifier.

Additional comments

(5) Grouping of readings

Readings from short and long period instruments for the same phase should be grouped together. When the time of arrival is determined more accurately on the SP instrument, the arrival time on the LP instruments need not be given, but the long period maximum amplitude identifier should be followed as usual by its associated arrival time, period and amplitude.

(6) Reporting interval

The time interval covered by the transmitted message should be specified using the identifiers BEG (beginning) and END; for example:

((BEG APR01 120000 END APR02 120000))

Note: In case of a station transmitting a group of messages, e.g., once per day, the first message may contain the reporting interval for the entire group. If so, the number of messages (NM) in the group should be appended as, e.g.,

((BEG APR01 120000 END APR02 120000 NM7))

(7) Down-time information

If a station has been out of operation, this time interval should be reported as OUT (date, time) followed by TO (date, time). This reporting should be made as soon as possible after the station is back in operation.

((OUT SEP02 191530 TO SEP02 223515))

Partial outages are reported with a component identifier following the downtime identifier OUT.

((OUT LPZ MAY02 1330 TO MAY02 1600))

Additional explanation may be included in brackets as found necessary

(8) Event delimiter

In ISC (International Seismic Code), the start of a new event is signalled by the occurrence of one of eight accepted first arrival phase names. In effect, these phase names are used as event delimiters.

The protocol for parameter reporting defined in CD/43 allows other phases to be reported as initial arrivals, for example, initial S phases, body waves on long-period instruments with phase identifiers identical to those reported from short-period instruments, and Rayleigh and Love waves not associated to any short-period arrivals. These initial phases conflict with the ISC convention.

A repetition of the station identifier should be used between events as an event delimiter when reporting non-ISC-standard initial phases. (The ISC-standard initial phases are P, PDIF (or DIF), PKP, PN, PG, and PB.)

(9) Large Local Sequences

During a large local earthquake sequence a comment (enclosed in double parentheses) such as "a local sequence took place between (time A) and (time B)" may be used to report aftershocks which are smaller by two magnitude units or more than the main shock of the sequence, i.e., $M < M_{max} - 2$, or in the case of a swarm if $M < M_{max} - 1$.

Table A8-III(1)

Proposed identifiers for Level 1 short period parameters

Type of Wave	Component	Parameter	Proposed Identifier
P	Vertical	(a) Standard parameters - stations of types I, II and III.	
		1. Arrival time	*
		2. First-motion sign and clarity (if readable)	*
		3. Amplitudes A_i ($i=1,\ldots,4$)	
		4. Arrival times corre sponding to each A_i	M1X,M2X,M3X,M4X**
		5. Periods corresponding to each A_i	
		6. Noise amplitude, A_N .	NA
		7. Period corresponding to A_N	NT
		8. Secondary phase description:	
		Amplitude	*
		Period	*
		Arrival time	*
		9. Complexity	CMPX
		10. Spectral moment, ratio or vector	SPMM, SPRT, SPVT

S	Horizontal	11. Arrival time	*
		12. First-motion clarity	*
		13. Maximum amplitude, A_M on each horizontal component	
		14. Arrival times corresponding to each A_M	MSE, MSN**
		15. Periods corresponding to each A_M	
		16 Secondary phase description:	
		Amplitude	*
		Period	*
		Arrival time	*
T	Vertical	53. T-phase description	
		Amplitude	*
		Period	*
		Arrival time	*
P	Vertical	(b) Additional standard parameters (type III stations only)	
		17. Apparent slowness	*
		18. Epicenter azimuth and distance	*, DIS
		19. Epicenter latitude and longitude	LAT, LON
		20. Origin time	OT
		21. Magnitude m_b	MB

* Form employed in the International Seismic Code should be used.

** Each phase identifier is followed by arrival time, period (T) and amplitude (A) according to standard conventions.

Table A8-III(2)

Proposed identifiers for Level 1 long period parameters

Type of Wave	Component	Parameter	Proposed Identifier
P	Vertical	(a) Standard parameters - stations of types I, II and III.	
		22. Arrival time	•
		23. First-motion sign and clarity	•
		24. Maximum Amplitude, A_M	
		25. Arrival time corresponding to A_M	**MLP****
		26. Period corresponding to A_M	
		27. Noise amplitude, A_N	**NLPA**
		28. Period corresponding to A_N	**NLPT**
		29. Secondary phase description:	
		Amplitude	•
		Period	•
		Arrival time	•

S	Horizontal	30 Arrival time	*
		31. First-motion clarity	*
		32 Maximum amplitude, A_M on each horizontal component	
		33. Arrival times corresponding to each A_M	MSLPE, MSLPN**
		34. Periods corresponding to each A_M	
		35. Secondary phase description:	
		Amplitude	*
		Period	*
		Arrival time	*
LR	Vertical	36. Arrival time	LRZ
		37. Maximum amplitude, A_M	
		38. Arrival time corresponding to A_M	MLRZ**
		39. Period corresponding to A_M	
		40. Maximum amplitude for periods near 10, 20, 30 and 40 s	
		41. Arrival time corresponding to amplitudes for the above periods	M1L,M2L,M3L,M4L**
		42. Actual observed periods (item 40)	
		43. Noise amplitude, A_N	NLPA
		44. Period corresponding to A_N	NLPT

LQ	Horizontal	45. Arrival time	LQ
		46. Maximum amplitude, A_H on each horizontal component	
		47. Arrival times corresponding to each A_H	MLQE, MLQN**
		48. Periods corresponding to each A_H	
		(b) Standard parameters - type III stations only.	
P	Vertical	49. Apparent slowness	SLOLP
		50. Epicenter azimuth	AZLP
LR	Vertical	51. Magnitude M_S	MS
S	Horizontal	52. Magnitude m_{SH}	MSH

* Form employed in the International Seismic Code should be used.

** Each phase identifier is followed by arrival time, period (T) and amplitude (A) according to standard conventions.

Table A8-III(3)

Sample telegraphic text for the transmission of Level 1 data

```
SEISMO N82351((BEG SEP22 180000 END SEP23 240000 NM8))
ARR SEP22
IPCU1919020
M1X19035 T3 A60 M2X19112 T3.2 A53 1
M3X19160 T3 5 A29.8 M4X19233 T3.5 A27 2
MLP19060 T6A144
NT1.0 NA5.1 NLPT8 NLPA15
EPP2247 T3.6 A18.2 T8A108
ES30025 MSE30080 T4 A75 2 MSN30080 T4 A61.0
MSLPE30090 T9A216 MSLPN30090 T9A135
ESS3711 T4 7 A61.7 T12A192
LRZ4841 MLRZ5407
M1L5637 T10A135 M2L5311 T20A200
M3L5203 T30A105 M4L5012 T40A98
NLPT20 NLPA12
LQ4251 MLQE4302 T21A220 MLQN4302 T21A172
CMPX 23 02 SPMM 2 45
SLO 4 8 AZ 226 DIS94 LAT-35 LON-120 OT190541 MB6.5
SLOLP 4.8 AZLP 221 MS6.4 MSH6.6
ARR
P2353147
S58100 MSN58162 T2 7 A53.2 MSE58162 T2.8 A46.7
STOP
```

Table A8-III(4)

Explanation of the text in Table A8-III(3)

SEISMO - identification of type of data (seismic)

N82351 - message no 2351 during 1978 for the station(s) BEG SEP22 180000 END SEP23 240000 NM8 - This is the first message in a group of 8 covering the time interval indicated (UTC).

ARR - station name

SEP22 - date of recorded event (22 September)

IPCU1919020 - first-motion clarity (I), type of wave (P), direction of first motion (C - compression on short-period seismograph; U - compression on long-period seismograph), arrival time (19h19m02.0s) in component Z

M1X19035 - time of arrival (19m03.5s) for P-wave first amplitude, A_1, in component Z

T3 A60 - period (3 seconds) and amplitude (60 nm) for amplitude A_1 in component Z

M2X19112 T3.2 A53.1 - time of arrival, period and amplitude for amplitude A_2 in component Z

M3X19160 T3.5 A29.8 - time of arrival, period and amplitude for amplitude A_3 in component Z

M4X19233 T3.5 A27 2 - time of arrival, period and amplitude for amplitude A_4 in component Z

MLP19060 T6A144 - time of arrival, period and amplitude on LP seismograph, component Z. Note that for LP measurements, the amplitude and period (A and T) are not separated by a space, as they are for SP.

NT1.0 NA5.1 - period and amplitude of noise on short-period seismograph, component Z

NLPT8 NLPA15 - period and amplitude of noise on long-period seismograph, component Z

EPP2247 T3.6 A18 2 T8A108 - time of arrival, periods and amplitudes of secondary longitudinal PP wave in component Z (on short and long period instruments, respectively)

ES30025 - first-motion clarity (E), wave type (S), arrival time, (component not indicated)

MSE30080 T4 A75.2 - time of arrival, period and amplitude for maximum amplitude of short period S wave in component E

MSN30080 T4 A81.0 - time of arrival, period and amplitude for maximum amplitude of short period S wave in component N

MSLPE30090 T9A216 - time of arrival, period and amplitude for maximum amplitude of long period S-wave (component E)

MSLPN30090 T9A135 - time of arrival, period and amplitude for maximum amplitude of long period S-wave (component N)

ESS3711 T4 7 A61.7 T12A192 - clarity and time of arrival, periods and amplitudes for secondary shear phase (SS) (component not indicated)

LRZ4841 - time of arrival of Rayleigh wave in component Z

MLRZ5407 T22A271 – time of arrival, period and amplitude of maximum phase in Rayleigh wave in component Z

M1L5637 T10A135 - time of arrival and amplitude in Rayleigh wave for 10 second period in component Z

M2L5311 T20A200) - arrival times and amplitudes in Rayleigh wave

M3L5203 T30A105) for, respectively, 20, 30 and 40 second

M4L5012 T40A98) periods in component Z

NT20 NA12 - amplitude of noise for 20-second period on long-period vertical seismograph

LQ4251 - time of arrival of Love wave in component E

MLQE4302 T21A220 - time of arrival, period and amplitude of maximum phase in LQ wave in component E

MLQN4302 T21A172 - time of arrival, period and amplitude of maximum phase in LQ wave in component N

CMPX 23.02 - 'complexity' parameter in P wave recording

SPMM 2.45 - 'spectral moment' parameter for P waves

SLO 4.8 - apparent slowness (s/degree)

AZ 226 - azimuth from station to epicenter (degrees)

DIS94 - epicentral distance (degrees)

LAT-35 - latitude (degrees) of epicenter (- = south)

LON-120 - longitude (degrees) of epicenter (- = west)

OT190541 - origin time (19h 05m 41s)

MB6.5 - magnitude, determined for short-period P wave

SLOLP 4 8 - apparent slowness of long period P (s/degree)

AZLP 221 - azimuth to epicenter from LP recordings (degrees)

MS6 4 - Rayleigh wave magnitude on LPZ seismograph

MSH6 6 - S-wave magnitude on long-period horizontal seismograph

ARR - station code, repeated to serve as event delimiter

IPC2353147 - initial P phase arrival time, with clarity (I) and first motion (C) indicators.

S58100 - phase (S) and arrival time (23h 58m 10.0s) (component not indicated)

MSE58162 T2.8 A46.7 - time of arrival, period and amplitude for maximum amplitude of short period S in component E

MSN58162 T2.7 A53.2 - time of arrival, period and amplitude for maximum amplitude of short period S in component N

ANNEX A8-IV

Example of a Retransmission Request

```
SEISMO N3167 NM1
((RETRANSMISSION REQUEST))
((FOLLOWING MESSAGES NOT RECEIVED AS OF 0000UT, FEB27))
((SEAU1 AMMC N3089))
((SEAU1 AMMC N3090))
((SEBX1 EBBR N3062))
((SECZ1 OKPR N3051))
((SEFI1 EFKL N3071))
((SEID1 WIII N3026))
((SENZ1 NZKL N3067))
((SEXX1  KWBC N3103))
STOP
```

The above WMO/GTS message requests retransmission of messages numbered 89 and 90 from Australia, numbered 62 from Belgium, 51 from Czechoslovakia, 71 from Finland, 26 from Indonesia, 67 from New Zealand, and 103 from the U.S.A.

ANNEX A8-V
TAPE FORMAT FOR EXCHANGE AND STORAGE OF LEVEL 2 DATA

1. Introduction

Tape exchange and storage of level 2 data requires a magnetic tape format which allows efficient use of the medium. As well as allowing reasonably easy retrieval of waveform data at the International Data Centres (IDCs), it should also be as close to an accepted standard as the nature of seismic data permits, in order to make the writing and reading of such tapes at National Data Centres as easy as possible. To this end, a set of design goals has been developed and, in turn, these have lead to the specification of a standard tape format in which it is desirable that all waveform data be exchanged and stored. It should be noted that two features of this design may need to be modified - namely the use of 6250 BPI tapes and that of binary representations of the data.

2. Design Goals

The design features which have guided the choice of a tape format are enumerated below:

1. The format should make efficient use of 6250 BPI tape and thus have large blocks. These should contain an integral number of words and while not of fixed length, most will be large.

2. The format should contain data headers sufficient to recover and identify the data without the help of database information. These headers should be large enough to contain all necessary information but not so large as to encourage inclusion of unnecessary information. The headers should not span physical block boundaries and they should be an integral number of words long.

3. The format should be simple enough to allow reading and decoding with a straight forward user program.

4. The format should be structured so that resynchronization after a read error (bad block) is easy with the loss of minimum data.

5. The format should conform to the ANSI standards for multi-file tapes.

3. ANSI Standard Labels

The tapes should be written to conform to ANSI standard X3.27-1978 as specified in the document *American National Standard Magnetic Tape Labels and File Structure for Information Interchange*. This 1978 release is version 3 of standard X3.27 which supports fixed, variable and spanned records. Each record format has a blocked and an unblocked form. The layout of records in data files will be discussed later in this document.

The layout of required labels (80 character blocks of ASCII characters), tape marks and data files is shown below. Label blocks are denoted by their four letter identifiers and tape marks by asterisks (*).

VOL1 HDR1 HDR2*-file A-*EOF1 EOF2*HDR1 HDR2*-file B-*EOF1 EOF2**

Note the addition of the HDR2 and EOF2 labels These describe certain features of the record format used within the data files and are required when other than fixed record format is used

While multi-volume multi-file tapes with tape files which span volumes are not presently envisioned, this can be done under the standard by ending file sections with an EOV1 - EOV2 label group. Should the IDCs decide to implement an automatic volume switching capability, the layout for two volumes with sections of the same file is as follows.

VOL1 HDR1 HDR2* - - data file - section 1 - - *EOV1 EOV2**
VOL1 HDR1 HDR2* - - data file - section 2 - - *EOF1 EOF2**

The formats for the various label blocks as outlined by the standard are shown in tables below The data in these label blocks are all in ASCII. When the column labeled "standard description" says "a" chars it means any reasonable printing ASCII character (upper case only) and "n" means the subset 0-9. The column labeled IDC use attempts to indicate what the use of the field will be by the IDCs If it simply states "std" then the content is apparent from the standard definition. In other cases the default value which will appear is supplied.

3.1 VOLUME HEADER LABEL (VOL1)

character position	field	name	length (bytes)	standard description	IDC use
1-3	1	label id	3	must be VOL	std
4	2	label num	1	must be 1	std
5-10	3	vol serial num	6	any 6 "a" chars	reel name
11	4	accessibility	1	space=unlimited	space
12-31	5	reserved	20	must be spaces	std
32-37	6	reserved	6	must be spaces	std
38-51	7	owner id	14	any "a" chars	dba
52-79	8	reserved	28	must be spaces	std
80	9	std version	1	version 3	3

3.2 FILE HEADER LABEL (HDR1)

character position	field	name	length (bytes)	standard description	IDC use
1-3	1	label id	3	must be HDR	std
4	2	label num	1	must be 1	std
5-21	3	file ident	17	any "a" chars	sta or sta-ch
22-27	4	file set id	6	any "a" chars	spaces
28-31	5	file sect num	4	0001 single vol	0001
32-35	6	file seq num	4	0001..0002	std
36-39	7	generation num	4	0001 1st gen	0001
40-41	8	gen ver num	2	00 1st ver	std
42-47	9	create date	6	space yyddd	std
48-53	10	expire date	6	same as above	expired
54	11	accessibility	1	space or "a"	unlimited
55-60	12	block count	6	must be "zeros"	std
61-73	13	system code	13	(optional)	CSS
74-80	14	reserved	7	must be spaces	std

3.3 FILE HEADER LABEL (HDR2)

character position	field	name	length (bytes)	standard description	IDC use
1-3	1	label id	3	must be HDR	std
4	2	label num	1	must be 2	std
5	3	rec format	1	F = fixed D = variable S = spanned	std
6-10	4	blk length	5	max chars/blk	ie. 10240
11-15	5	rec length	5	max rec length if < 99999 else 00000	std
16-50	6	reserved	35	any "a" chars	
16-20	6a	tape density	5	NON-STANDARD	tape
21-25	6b	tape length	5	NON-STANDARD	use
26-30	6c	feet used	5	NON-STANDARD	stats
31-35	6d	marks written	5	NON-STANDARD	
36-40	6e	ibgs written	5	NON-STANDARD	
41-50	6f	bytes written	10	NON-STANDARD	
51-52	7	buf offset	2	additional chars inserted before record in each blk	00
53-80	8	reserved	28	reserved	reserved

3.4 END OF FILE LABEL (EOF1)

character position	field	name	length (bytes)	standard description	IDC use
1-3	1	label id	3	must be EOF	std
4	2	label num	1	must be 1	std
5-54	3-11	same as HDR1	50		
55-60	12	block count	6	6 "n" chars	std
61-80	13,14	same as HDR1	20		

3.5 END OF FILE LABEL (EOF2)

character position	field	name	length (bytes)	standard description	IDC use
1-3	1	label id	3	must be EOF	std
4	2	label num	1	must be 2	std
5-80	3-8	same as in HDR2	76	same as in HDR2	std

3.6 END OF VOLUME LABEL (EOV1)

character position	field	name	length (bytes)	standard description	IDC use
1- 3	1	label id	3	must be EOV	std
4	2	label num	1	must be 1	std
5-54	3-11	same as HDR1	50		
55-60	12	block count	6	6 "n" chars	std
61-80	13,14	same as HDR1	20		

3.7 END OF VOLUME LABEL (EOV2)

character position	field	name	length (bytes)	standard description	IDC use
1- 3	1	label id	3	must be EOV	std
4	2	label num	1	must be 2	std
5-80	3-8	same as in HDR2	76	same as in HDR2	std

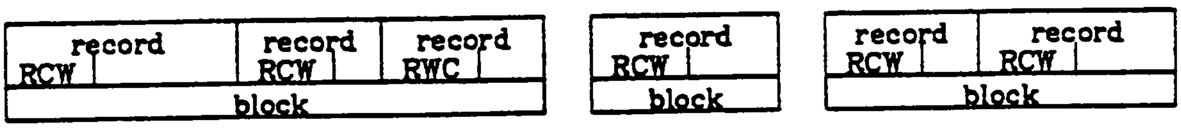
Note that the first reserved field in the HDR2, EOF2 and EOV2 labels has been used to record tape usage statistics. This is allowed under the standard as long as the system code is supplied. Systems which do not recognize the entry in system code should ignore this reserved field.

4. DATA FILE FORMAT

For simplicity the choice is, for the present, to use the simpler record formats provided by the standard. While spanned format appears tantalizing, especially for long waveform records, it is not fully supported by many systems yet, and has some implementation problems which need to be addressed before it will serve well in an exchange environment. The old fixed length record format is certainly the simplest scheme although it requires that waveforms be represented as several records rather than a single entity. For parameter data it could be somewhat wasteful since parameter records would all have to be padded to the fixed length. Even when large blocks are written a significant amount of tape is given up to record gaps and tape marks. At 6250 bpi an 8192 byte block takes only a little more room than two inter-block gaps, and only half the space required for a tape mark.

It is important to note that records of only one format are allowed in any single tape file. If we were to choose variable length record format for parameter data, then tape files containing mixed waveform and parameter data would also have the waveforms formatted as variable length complete with the record control words The question of whether or not to block records is clear no matter whether fixed or variable records are used. To treat parameter records and waveform headers as individual records suggests a relatively small record size, say 256 bytes. This means that to make any reasonable use of high density tape we must place many such records in a tape block. Examples of blocked records appear in the diagrams below.

Blocked Fixed Length Records



Blocked Variable Length Records

Variable length records use a record control word (RCW) to indicate how many characters are in the record. The RCW consists of four ASCII characters forming a decimal number which is the count of characters, inclusive of the RCW itself, in the record. For both fixed and variable there are an integral number of records in a block. The blocks can be filled with as many records as will fit in the maximum block length, but blocks shorter than the maximum length are allowed for either format. It is assumed that the actual number of characters in a block can be recovered from the operating system when the block is read. No explicit indication of the boundaries between records is provided for fixed format

4.1 WAVEFORM DATA

On waveform only tapes a fixed record format is perfectly adequate The first record for a segment will be an ASCII header as described below, with the characters "WFH1" prepended Four character designators like "WFH1" are henceforth referred to as record tags The content of the header fields after the tag is summarised in the table below where blanks appear in the unspecified byte positions such as 9,25,32 etc. Note that the table assumes a 256 character record length. If a different record length is chosen the pad field at the end would be adjusted accordingly.

bytes	name	description	format
1 - 8	date	date (ie. 1982254)	i8
10 - 24	time	epochal time (double precision)	f15 3
26 - 31	sta	station code (ie. ANMO)	a6
33 - 34	chan	channel (ie. sz)	a2
36 - 43	nsamp	number of samples	i8
45 - 55	smprat	sample rate (in samples/second)	f11.7
57 - 65	calib	calibration constant	f9.6
67 - 73	calper	calibration period	f7.4
75 - 80	instyp	instrument type	a6
82 - 82	segtyp	segment type	a1
84 - 85	dattyp	data type (ie. I4 or F4)	a2
87 - 87	clip	clipped flag	a1
89 - 96	inid	instrument id	i8
98 -105	wfid	waveform id	i8
107-136	dir	directory data came from	a30
138-157	file	file data came from	a20
159-164	volnam	volume name of tape	a6
166-170	tpfile	tape file number	i5
172-176	tpblck	block number within file	i5
178-207	remark	comment	a30
209-252	reserved	blanks	

Following the header record comes the data records which each occupy the same number of bytes as the header record. The four character record tag is occupied by a decimal number which is a record counter within the waveform. This can be used for resynchronization in case of tape read failures. Record tags for parameter data have been chosen to always contain at least one letter so they can never be confused with the record counter found in waveforms.

Since a fair amount of densification is obtained by using binary storage format, tapes written for internal use at the IDCs will probably use this means of storing waveforms. Binary waveform data samples are written as 32-bit integers or 32 bit floating point numbers (the type can be determined by inspection of the *dattyp* field in the header). Details on the order or content of the four bytes in a sample can be found in the hardware manual of the system supplying the tape. If tapes are exported in binary it will most likely be to other sites with the same computer operating system as the source of the tape. If binary data is desired for other installations it will be wise to keep to integer format , but some byte swapping may still be required due to the different orders that various computers use to map the bytes in memory.

ASCII format will be used for most export data tapes ASCII waveform data will consist of strings of decimal numbers where again the type (field width) of the data samples is derived from *dattyp* as above. Floating point data will be written using fixed point notation and a decimal point will always be present for systems or languages which use it for alignment. Integer data will be right justified in the field and an integral number of samples will be written in a record An optimized record length (like 8 character fields in 280 character records) may be chosen for such data so no padding is needed to fill out records

Most of the information in the table on the previous page is self- explanatory, but a few items require clarification:

date - the date is given as yyyyddd where yyyy=year (e.g. 1983) and ddd is the day number within that year (e.g. February 1 = 032)

time - epochal time is the number of seconds since 00:00 00.000 on January 1, 1970.

chan - the channel is given as bo where b = the frequency band (s=short, l=long, etc) and o is the orientation (z=vertical, n=North-South, etc)

calib - this is the number of nanometers of ground displacement per digital count, at the calibration period (calper) (The response curve of the instrument must be fully specified elsewhere)

instyp - An alphanumeric description of the instrument - e.g. SRO, Kirnos

segtyp - denotes whether the data is continuous (c) or segmented (s)

dattyp - data representation. I4 and F4 denote binary 4-byte (32 bit) integer and floating point. Codes will need to be devised for various binary and ASCII (formatted) representations.

clip - indicates whether (c) or not (n) the data is clipped.

inid - instrument identification number. instyp (above) may not be adequate to fully describe the instrument, and this number can be used as an index to a fuller desription of the instrument and its response.

wfid - waveform identification number (assigned by the IDC)

dir - On computer systems using a directory and file structure, denotes the directory from which the data came (or is to go to) for on-line (disc) storage

ANNEX A8-VI

Regular users of the WMO/GTS for Seismic Bulletins
(at 1 Dec 1983)

Country of origin	GTS centres	CLLLL in the starting line	TTAAii CCCC in the abbreviated heading
Argentina	Buenos Aires	14250	SEAG1 SABM
Australia	Melbourne	16550	SEAU1 AMMC
Austria	Vienna	19850	SEOS1 LOWM
Belgium	Brussels	19057	SEBX1 EBBR
Bulgaria	Sofia	19250	SEBU1 LZSO
Canada	Toronto	14751	SECN1 CWTO
Colombia	Bogota	14650	SECO1 MCBO
Czechoslovakia	Prague	18650	SECZ1 OKPR
Denmark	Copenhagen	19752	SEDN1 EKMI
Fiji	Nandi	16952	SEFJ1 NFFN
Finland	Helsinki	19551	SEFI1 EFKL
France	Paris	19050	SEFR1 LFPW
German Democratic Republic	Potsdam	18750	SEDD1 ETPD
Germany, Federal Republic of	Offenbach	18150	SEDL1 EDZW
Guatemala	Guatemala	16250	SEGU1 MGGT
Hong Kong	Hong Kong	13053	SEHK1 VHHH
Hungary	Budapest	18655	SEHU1 HAPB
India	New Delhi	12350	SEIN1 DEMS
Indonesia	Jakarta	16755	SEID1 WIII
Italy	Rome	18850	SEIY1 LIIB
Japan	Tokyo	12850	SEJP1 RJTD
Korea, Republic of	Seoul	13050	SEKO1 RKSL
Malaysia	Kuala Lumpur	16655	SEMS1 WMKK
Mauritius	Vacoas	11552	SEMA1 FIMP
Mexico	Mexico City	14950	SEMX1 MMMX
Netherlands	De Bilt	17856	SENL1 EHDB
New Zealand	Wellington	16851	SENZ1 NZKL
Nicaragua	Managua	16254	SENK1 MNMG
Norway	Oslo	19650	SENO11 ENMI
Peru	Lima	14350	SEPR1 SPIM
Poland	Warsaw	18755	SEPL1 SOWR
Sudan	Khartoum	10456	SESU1 HSSS
Sweden	Norrköping	19450	SESN1 ESWI
Tanzania, Republic of	Dar es Salaam	11350	SETN1 HTDA
Thailand	Bangkok	12150	SETH1 VTBB
Tunisia	Tunis	10257	SETS1 DTTA
United Kingdom	Bracknell	17550	SEUK1 EGRR
USA	Washington	15050	SEXX1 KWBC
		15051	SEXX2 KWBC
		15052	SEXX3 KWBC
USSR	Moscow	17250	SERS1 RUMS
Yugoslavia	Belgrade	19855	SEYG1 LYBM
Zimbabwe	Harare	11952	SEZW1 FRSB