CD/43/Add.1
25 July 1979
Original: ENGLISH

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

Appendices

GE.79-63155

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APPENDICES TO CHAPTER 3

APPENDIX 3.1

Technical instructions for extracting Level 1 parameters at seismic stations

In this appendix a detailed description is given of how Level 1 data should be extracted from SP and LP instrument recordings at stations of the global network. Reference is made throughout to parameters specified in Tables 3.1 and 3.2. By necessity, this appendix is written in a rather technical language, and the reader is referred to Chapter 3 of CCD/558 for a non-technical description of the basic principles involved.

A3.1.1 General specifications

(i) Time

Most modern seismograph stations maintain a timing accuracy of 0.1 seconds; however, it may become temporarily more uncertain. In that case the timing uncertainty should be reported. Because of the high accuracy of time measurements the problem of instrumental time delays must be noted. For WWSSN-SP instruments at 1 Hz: phase delay time is about 0.3 s, group delay time is about 0.4 s.

(ii) Seismographs are roughly divided into two classes:

1. Short period (SP) instruments having peak response at periods of the order of 1 second or less;
2. Long period (LP) systems with peak response at longer periods, up to 30 s or more; long-period instruments are here taken to include also those generally termed medium-period or broad band.

Note, however, that modern digital broad band stations have the capability of extracting signals in both the SP and LP bands.

(iii) Seismic noise is measured in the different period ranges corresponding approximately to the frequencies of main seismic signals, i.e., on records of SP seismographs (T = 0.2 - 1.0 s) and on records of LP seismographs (T = 2 - 8 s and T = 10 - 30 s, respectively). All measurements are made in the section of the recording preceding the first arrival.

A3.1.2 Standard parameters reported by participating staitions from short-period vertical seismographs

1. First arrival

On a visual record first arrivals are defined by a certain change in amplitude or phase. The time reading, after being corrected, is given in hour, minute, second and tenth of a second in Universal Coordinated Time (UTC). Some stations may be able to report one-hundredth of a second. If the applied time correction is uncertain (clock problems) by more than ±0.1 s it must be reported in qualitative remarks. The first arrival should always be identified, if possible, by one of the standard symbols. The symbols (phase codes) used by the Interantioanl Seismological Centre are recommended.

2. First motion sign and clarity

The clarity of the phase should be denoted by i if it is readable to an accuracy of at least ±0.2 s, and by e if it is more uncertain, between ±(0.2 and 1.0) s. Note that e and i denote the accuracy of the timing rather than the character of the recording which may depend on the paper or film speed. If the uncertainty in the onset of the first arrival is greater than ±1.0 s, (e) should be used.

Direction (or sign) of the first motion on the vertical SP and LP components (C or D, U or R) should be reported (see also subitem 23 below). In cases of complicated wave patterns (small onsets followed by large onsets) the first visible motion is read. Do not report the direction if in doubt. If possible the first motion on the LP horizontal components should also be reported. First motion notations:

- C short-period compression
- D short-period dilation
- U long-period compression
- R long-period dilation
- V long-period movement on the NS component, direction to the North (the code N cannot be used because PN would then be ambiguous)
- Y *ibid.*, direction to the south
- E E-W component, direction to the east
- W *ibid.*, direction to the west.

The clarity index precedes the phase identification, the first motion index follows it. The first motions from SP and LP instruments do not need to agree.

3. P-wave amplitudes

Ground amplitudes A_i of the first phase are to be determined from maximum trace amplitudes using the instrument's response curve. Trace amplitude is measured as the center-to-peak deflection from the median line or may be obtained by halving peak-to-trough deflection of symmetrical waves.

The ground amplitudes are reported to a precision of 0.1 nanometers (i.e., 10^{-10} meters). Since the upper limit for an absolute calibration of seismographs is 5-10%, it is understood that the amplitude cannot be measured with a better accuracy. The amplitudes for the first phase should be measured to the maximum deflection within the intervals, 0-6 s, 6-12 s, 12-18 s and 18-300 s, according to the duration of the wave group.

4. Associated times

The time associated with each reading of amplitude and period is reported; it should be measured as illustrated in Figure A3.1.1.

5. Associated periods

Periods corresponding to each A_i are measured at zero crossings or between two neighboring peaks or troughs. Periods should be read to one-tenth of a second.

6. Seismic noise amplitude

The maximum noise amplitude at a frequency close to that of the signal should be measured and converted to ground amplitude in nm. This amplitude is measured within 30 seconds before the first onset and reported for each event. The signal-to-noise ratios can then be determined using A_i (sub-item 3) at data centers.

7. Noise period

The period corresponding to the maximum noise amplitude is measured in a way similar to that described under 5.

8. Secondary phases

A standard notation for all phases is that used by the International Seismological Centre. Arrival times of identified but also clear unidentified secondary phases should be reported. Hour is reported only if it is not the same as the hour of the preceding phase. Identification of phases is more confidently carried out at data centers; however, advantage should be taken of experienced interpreters at individual stations. For the clarity i or e are used. Measurements of arrival time, maximum recorded amplitude and corresponding period of secondary phases follow the same rules as mentioned under 1, 3, 5; however, only one maximum amplitude is measured. It is important that among secondary phases pP and sP are reported.

9. Complexity

10. Spectral moment, ratio or vector

There are no standards for calculating the parameters under 9 and 10. Before a universal agreement is reached, it is recommended that stations computing these parameters should describe the procedure they use. Note that the complexity and spectral ratio parameters will be reported only by certain stations of specialized capabilities within the global system.

A3.1.3 Standard parameters to be reported from short period horizontal seismographs

11. Phase identification and arrival time of the S wave

The time is reported to 0.1 s.

12. Clarity of the S phase

Reported as i if readable to an accuracy of 1.0 s or better, as e otherwise. Note that the S phase onset is seldom, if ever, legible to within the + 0.2 s required for using clarity index i for P-waves.

13. Maximum amplitude of short period S

Measured within the first 10 seconds of the S wave for both the NS and EW components. The respective arrival times should not differ by more than one half signal period, so that the amplitudes can be combined vectorially.

14. Corresponding arrival time

Reported for both components in hours, min, s.

15. Corresponding period

Reported to 0.1 s precision.

16. Secondary phase descriptions

Reported as under item 8.

A3.1.4 Additional standard parameters from arrays of short period vertical seismographs

This category of parameters concerns arrays of vertical short period seismographs, including arrays of digital broad ban seismographs with short period filtering capability.

Each array station reporting the following parameters (17, 18, 19, 20, 21), should publish a description of its procedures of determining these quantities before standardized guidelines are elaborated. The parameters nos. 17 and 18 will be used for locating events at the data centers, using an agreed travel-time derivative table for this purpose, it is therefore not essential for each array station to produce and report the parameters under 19 and 20.

17. Apparent slowness

Determined with the precision 0.1 s/deg. At medium aperture arrays the slowness and direction of an arriving P wave could be obtained as a least squares fit of arrival times, or time differences, to a wave front. It can also be obtained with lower accuracy by fixed search programs.

18. Epicenter azimuth and distance

Reported to 0.1° or to the accuracy that is judged to be realistic in each case. Note that the asimuth corresponds to the station to epicenter direction.

19. Epicenter latitude and longitude

The epicenter coordinates should be reported to 0.1° or to the accuracy that is judged to be realistic in each case.

20. Origin time

Estimated and reported as hours, minutes, seconds.

21. Magnitude

Whenever epicenter distance is known, magnitudes will be determined using the vertical component short period P waves and the procedure recommended by the IASPEI Commission on Practice (Appendix 5.2).

A3.1.5 Standard parameters to be reported from long-period seismographs

Reporting should preferably be grouped by event, rather than by instrument and readings of a particular phase from different instruments should be grouped together.

Long-period P - vertical component

22. Phase identification and arrival time

Phase identification, arrival time and clarity (i or e) should be given even if a short-period initial arrival is reported. In order to avoid separate reporting of long-period arrival times being treated as a new event if different from short-period arrival time, one must indicate that the same arrival is referred to. (Grouping of the reportings for the same event would usually take care of this.)

23. First-motion sign and clarity

The comments under 2 apply here. Note that first-motion readings are desirable also on the LP horizontal components.

24. Maximum amplitude A_M

For long-period P, only one amplitude measurement (the maximum one) is required. Reporting precision is 1 nm.

25. Arrival time corresponding to A_M

Reported to a precision of 0.1 seconds.

26. Period corresponding to A_M

Reported to a precision of 0.1 seconds.

27. Noise amplitude A_N

The maximum noise amplitude is measured within 1 minute before the first onset on the vertical component, converted to ground amplitude in nm and reported for each P-wave reading. Period range 2-8 seconds.

28. Period corresponding to A_N

The period in seconds corresponding to the maximum noise amplitude is reported.

29. Secondary phase description

See subitem 8.

Long-period S - horizontal components

30. Arrival time

Phase identification and arrival time (to a precision of 1 second) are reported for one component.

31. First-motion clarity

See subitem 12.

32. Maximum amplitudes A_{II}

Measured separately on each horizontal component, within the first 40-60 seconds of the S wave. The measurements should be carried out at times differing by no more than one half signal period.

33. Arrival times corresponding to each A_{II}

Reported for both components in hour, min, s.

34. Period corresponding to each A_{II}

Reported to 0.1 s precision.

35. Secondary phase description

Reported as under item 8.

Rayleigh waves - vertical components

36. Arrival time of LR

The onset time of LR is hard to read and the clarity is strongly dependent on signal-to-noise ratio. The onset time is specified to the nearest second, but must usually be considered very uncertain.

37. Maximum amplitude A_M

Amplitude of the maximum deflection is measured on the vertical component and reported in nm.

38. Arrival time corresponding to A_M

Indicated in hour, min, second.

39. Period corresponding to A_M

Reported to a precision of 1 second.

40. Other maxima A_{max}(LR)

Maximum amplitudes A_{max}(LR) with periods of 10, 20, 30 and 40 seconds (within $\pm$ 10%) on the vertical component; reported in nm.

41. Times of the maxima A_{max}(LR)

Times are given corresponding to the four different maxima, with a precision of 1 second.

42. Corresponding periods

The actually observed periods of the other maxima of LR waves are reported in seconds.

43. Seismic noise amplitude, A_N

Largest amplitude of seismic noise with period between 10-30 seconds is measured on the vertical component within 5 minutes of the section of the record preceding the event. The ground amplitudes in nm are reported.

44. Noise period corresponding to A_N

The period is reported to a precision of 1 second. Note, however, that the long-period noise may be irregular and it is often difficult to determine the period accurately.

Love waves - horizontal components

45. Arrival time of LQ

Reported to a precision of 1 second on one of the horizontal components. Note that in the same way as for LR (item 36), LQ onsets are hard to determine accurately.

46. Maximum amplitudes A_M

Maximum ground amplitudes of LQ on the NS and EW components are reported in nm. The respective time of measurements should not differ by more than one half signal period.

47. Arrival times of A_M

The respective times of A_M on the two components are reported to a precision of 1 second.

48. Periods corresponding to A_M

Reported for each horizontal component; precision 1 second.

A3.1.6 Additional standard parameters from arrays of long-period seismographs

49. Apparent slowness

Reported for the vertical component of the P-wave only. Precision 0.1 s/deg, see also no. 17.

50. Azimuth

Azimuth can be determined not only for large arrays with digital recordings, but also for small arrays by measuring the time difference on and analog recording between the arrivals of the same wave peak in a wave train at all stations (this applies also to No. 49). The parameter helps to associate LP with SP data.

51. Surface wave magnitude M_S

Magnitude based on vertical LR waves determined using the procedure recommended by the IASPEI Commission on Practice, precision 0.1 unit. Measurements should be made directly from amplitude and period without application of station corrections.

52. Magnitude M_{SH}

Magnitude M_{SH} based on short or long period horizontal component S measurements is determined.

A3.1.7 Qualitative remarks

It is very important that the report is accompanied by remarks of the experienced analyst qualifying, if possible, the character of the event as seen from the visual inspection of the record or by a more sophisticated analysis. The following remarks are suggested:

Local: event judged to be within approximately 150 km of the station.

Regional: event judged to be within approximately 800 km (excepting local events)

Quarry blast: event announced by responsible authorities as a quarry blast, total charge in tons and coordinates should be indicated if known; events having a record typical for blasts according to the analyst's experience should be also indicated by 'possibly quarry blast' even if no official announcement is available.

Rock burst: event announced by authorities or qualified to this category by a typical wave pattern.

Mixed events: two events overlapping and causing some confusion in reading an interpretation; if possible, they should be identified (local, distant, etc.).

Multiple (double) event: complex wave pattern particularly in the P-wave group justifying such statement according to the analyst's experience.

Deeper than normal, intermediate: qualification made by the analyst if the wave pattern and amplitude ratios of main phases warrant it.

Uncertain time: if the time correction is uncertain by more than $\pm$ 0.1 because of clock problems.

The above parameters are transmitted within double parentheses according to the International Telegraphic Seismic Code (see Chapter 4).

A3.1.8 Signal duration DUR and local magnitude M_L

In case of local and regional events, these parameters, as measured on short period recordings, may be reported as well as amplitude and period.

A3.1.9 Down-time information

It is very important to keep records of the time intervals when a station has been out of operation, and such information should be communicated when applicable.

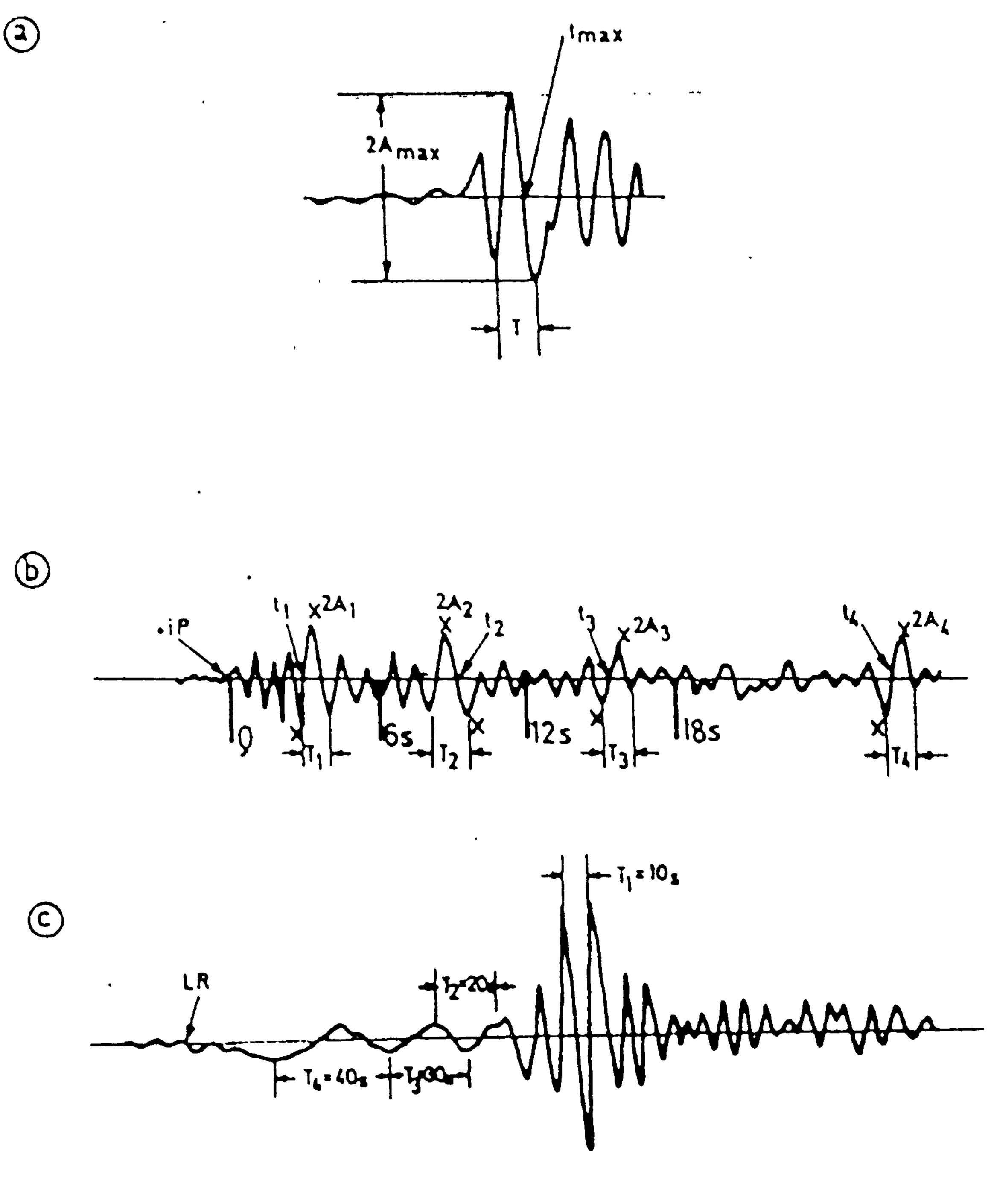


Figure A3.1.1 Illustration of rules for measuring wave amplitude, period and time of maximum oscillation (a), kinematic and dynamic parameters of SP records (b) and spectral parameters of LP records (c).

APPENDIX 3.2

Instructions for measuring amplitudes and periods for magnitude determination from observations at regional and teleseismic distances

IASPEI COMMISSION ON PRACTICE

SUBCOMMISSION ON MAGNITUDE

Revised draft, September 1978

Note: These instructions have been included only as a reference to ongoing standardization work in the seismological community, and should not be interpreted as necessarily representing the views of the *Ad Hoc* group

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 each of the phases P, S, and L waves.

For many phases, and particularly 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 also be 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 the amplitude A is measured in seconds between two neighboring peaks, or two neighboring troughs, or ideally 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, 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 nanometers using the amplitude-period response curve of the instrument. When several instruments of the same type operate at the same station or 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 seismograms is performed as described above. It is recommended that if possible 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.

L-Waves

The measurement of amplitudes, periods and times of observation on records is performed as described above for the maximum deflection and for the largest amplitude in the 17-23 second period range of the surface wave train.

The measurements for horizontal components should be carried out at the same time of arrival allowing for a difference of less than one period.

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

The observations of A and T for all phases mentioned above should be included in station reports. Itg 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.

Instructions for measuring amplitudes and signal durations for magnitude determination of local earthquakes

Amplitude measurements

For local earthquakes, i.e., those where the S-P interval is less than 2 minutes recorded on short-period instruments, it is not always possible to measure the period of seismic waves so the maximum trace deflection (converted to ground motion) and time of observation should be reported.

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 the data with which to derive relations for duration magnitudes that are based on signal amplitude magnitudes, both types of observations should be made on as many of the same earthquakes as possible.

As with regional and teleseismic data, the type of instrument and where possible the period of the peak of the response curve used should be clearly stated.

APPENDIX 3.3

Example of a bulletin from a seismic station

Table A3.3.1 shows a possible format of a seismic bulletin and at the same time gives an example of how it should be completed when processing a recording of a strong seismic event. The format of a special bulletin used at seismic stations in the USSR has been used as the basis. In the proposed global system, the time period covered by each bulletin would normally be one day. The table should be considered only as an example, and further work is required for the development of a final bulletin format.

Each sheet of the bulletin carries the name of the station, the month and year, the number of the bulletin (bulletins are numbered in sequence for each year) and the page number. In addition, the time interval of the reporting period, the geographical co-ordinates of the station and its altitude above sea level are entered on the first sheet of each bulletin.

In column 1, the numbers of all the seismograms are given (a single numbering system is used for all types of instruments installed at the station). If no earthquakes are identified in the seismogram, the words 'No earthquakes noted' are entered under the seismogram number.

In column 2, the serial numbers of the recorded seismic signals in the seismograms are listed. Signals are numbered in sequence during each year.

In column 3, the date of each signal is shown.

In column 4, the type of wave recorded and the first-motion sign and clarity are given. If the type of wave is not precisely determined, the designation of the wave is placed in brackets. Clear first motion is designated by the letter 'i' and an unclear first motion by the letter 'e'. In the event of first arrival of the signal, the first arrival sign is indicated. A '+' sign corresponds to upward motion (compression phase) on the vertical component and to N and E on the horizontal components; a '-' sign corresponds to downward motion (dilatation phase) on the vertical component and to S and W on the horizontal components.

In column 5, the abbreviated designation of the instrument and of the component for which the wave arrival time is determined are given.

In column 6, the wave arrival time (hour, minute and second) is given. The precision of measurement of the arrival time is to 0.1 s with an SP instrument and to 1 s with an LP instrument.

In column 7, the single (0-P) amplitude of the recorded oscillation in the wave in question is shown in millimeters. The mesurement precision with an SP instrument is to 0.1 mm and with an LP instrument to 1 mm.

In column 8, the displacement amplitude for the wave whose recorded amplitude is shown in column 7 is given in nanometers. The precision of measurement is to 0.1 nm.

In column 9, the period for the wave amplitude indicated in column 7 is shown in seconds. The precision of measurement for body-wave periods by both SP and LP instruments is to 0.1 s and for surface waves with LP instruments to 1 s.

In column 10, the noise amplitude for the instrument and component in question is shown in nanometers. The precision of measurement is to 0.1 nm.

In column 11, the noise period is shown in seconds, with precision to 0.1 s for an SP instrument and to 1 s for an LP instrument.

In column 12, the apparent velocity determined for P and LR waves is given in km/s, with precision to 0.1 km/s.

In column 13, the azimuth from the station to the epicenter of the event is shown in degrees, with precision to 0.1 degrees.

In column 14, the epicentral distance is shown in degrees, with precision to 0.1 degrees.

In column 15, the value for the magnitude m_b is shown in the line where the value of the maximum P-wave amplitude recorded with an SP instrument (vertical component) is entered; the value of magnitude M_{SH} in the line where the value of the S-wave A_M recorded with an SP instrument (horizontal component) is entered, and the value of magnitude M_L in the line where the value of the L-wave A_M recorded with an LP instrument (vertical component) is entered. The magnitude values are determined with precision to 0.1 units.

In columns 16 and 17 the values of the co-ordinates of the epicenter - latitude (ϕ) and longitude (λ) - are given in degrees, with precision to 0.1 degrees.

In column 18, the time at the focus when the event originated (hour, minute, second) is given with precision to 1 s.

Column 19 is provided for analyst remarks. If possible, the type of the event recorded ('local earthquake', 'quarry explosion', 'mixed with another event', etc.) should be indicated under this heading.

Columns 1 to 11 contain data compulsory for all types of stations, and columns 12 to 18 data which can be obtained only at type-III stations.

BULLETIN No. Table A3.3.1

From 22 September 00 hrs to 23 September 00 hrs 1978

Seismic station "____________________"

φ : λ : H :

Subsoil ____________________

No. of seis-mogram	No. of seismic signal	Date	Type of wave, first-motion clarity	Type of instrument, component	Arrival time (h, min, s)	Amplitude, Arrival time (mm)	(nm)	Period (s)	A_N (nm)	T (s)	Apparent velocity, km/s	Azimuth (degrees)	Epicentral distance (degrees)	Magnitude (m_b, M_s, M_{SH})	Epicentre co-ordinates φ (degrees)	λ (degrees)	Origin time (h, min, s)	OBSERVATIONS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1231	13528	22.09	+ iP	SP-Z	19.19.02.0	+ iP			5.1	1	23.1	226.4	94.2	$m_b = 6.5$	35.2 S	120.3 W	19.05.41	
			A_1	SP-Z	19.03.5	3.6	60	3										
			A_2	SP-Z	19.11.2	3.2	55.1	3.2										
			A_3	SP-Z	19.16.0	1.5	29.8	3.5										
			A_4	SP-Z	19.23.3	1.4	27.2	3.5										
			e(PP)	SP-Z	22.47.0	0.9	18.2	3.6										
			e S	SP-E	30.02.6													
			S max	SP-E	30.08.0	3.0	75.2	4										
			-"-	SP-N	-"-	2.4	61.0	4						$M_{SH} = 6.3$				
			e(SS)	SP-E	37.11.0	1.8	61.7	4.7										
			+ iP	LP-Z	19.19.02.0				12.0	20								
			P max	LP-Z	19.06.0	0.3	144	6						$m_b = 6.7$				
			e(PP)	LP-Z	22.49.0	0.3	102	8										
			iS	LP-E	30.04.3													
			S max	LP-E	30.09.0	0.6	216	9										
			-"-	LP-Z	-"-	0.4	135	9						$M_{SH} = 6.4$				
			E(SS)	LP-E	37.12.0	0.7	192	12										
			LQ	LP-E	42.51													
			LQ max	LP-E	43.02	1.1	220	21										
			-"-	LP-N	-"-	0.9	172	21										
			LR	LP-Z	48.41						3.12	221.1		$M_s = 6.6$				
			LR max	LP-Z	54.07	1.4	271	22										
			L_1	LP-Z	56.37	0.5	135	10										
			L_2	LP-Z	53.11	1.0	200	20										
			L_3	LP-Z	52.03	0.5	105	30										
			L_4	LP-Z	50.12	0.5	98	40										

APPENDICES TO CHAPTER 4

APPENDIX 4.1

Proposed Coding formats for Level 1 data

This appendix gives a detailed description of the proposed transmission format for Level 1 data. It is intended to supplement the International Seismic Code published in the WMO Manual on Codes, Vol. I, as a special appendix. Since the proposed Level 1 format is an extension of that Code, only features which are new in relation to the Code are described. An example of the full text of a Level 1 report for a strong earthquake recorded at an array station is included. Note that this example represents maximum processing in the case of a major seismic event. In most cases, however, the text will be considerably shorter, and will only provide data on the P wave recorded on a vertical short-period seismograph.

Description of the format

The proposed format, which is described in detail in Tables A4.1.1 through A4.1.4, 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. (The present code allows for a maximum of 3 digits).

2. Additional phase identifiers

As described in detail in Tables A4.1.1 and A4.1.2, 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 A4.1.1 and A4.1.2, 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. (This is not currently provided for in the International Seismic Code.) 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 in a comment field as e.g.,

((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 included 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 in a comment field 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.
Example: ((OUT SEP02 191530 TO SEP02 223515)).
Additional explanation may be included in the brackets as found necessary.

Concluding remarks

In conclusion the changes needed in the International Seismic Code in order to accommodate the envisaged data exchange are:

- expansion of the numbering field (item 1)
- addition of some 30 new allowable identifiers (items 2 and 3)
- allowing for amplitude/period information to follow later phases (item 4).

In addition, a number of new phase codes would be needed to allow for horizontal component specification (item 4). Likewise, the reporting of direction of first motion of horizontal components (Appendix 3.1, item 2) would necessitate several new allowable phase codes.

Items 6 and 7 above have in this proposal been included as comments, and will thus not necessitate any change in the established format. However, it would be desirable to agree upon a format in which these items could be reported using specific identifiers, and this should be given further study.

It is emphasized that the coding formats proposed here will need to be agreed with other users of the WMO/GTS and also approved by the WMO prior to implementation in the proposed data exchange. Further revision may therefore be necessary.

Table A4.1.1.

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,...,4)	M1X, M2X, M3X, M4X**
		4. Arrival times corresponding to each A_i	
		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	MSE, MSN**
		14. Arrival times corresponding to each A_M	
		15. Periods corresponding to each A_M	
		16. Secondary phase description:	
		Amplitude	*
		Period	*
		Arrival time	*

Table A4.1.1. (cont.)

Type of Wave	Component	Parameter	Proposed Identifier
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 A4.1.2

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	MLP**
		25. Arrival time corresponding to A_M	
		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	MSLPE, MSLPN**
		33. Arrival times corresponding to each A_M	
		34. Periods corresponding to each A_M	
		35. Secondary phase description: Amplitude Period Arrival time	 * * *

Table A4.1.2 (cont.)

Type of Wave	Component	Parameter	Proposed Identifier
LR	Vertical	36. Arrival time	LRZ
		37. Maximum amplitude, A_M 38. Arrival time corresponding to A_M 39. Period corresponding to A_M	MLR**
		40. Maximum amplitudes for periods near 10, 20, 30 and 40 s 41. Arrival time corresponding to amplitudes for the above periods 42. Actual observed periods (item 40)	M1L,M2L,M3L,M4L**
		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 48. Periods corresponding to each A_M	MLQE, MLQN**
		(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 A4.1.3

Example of a telegraphic text transmitted from an array station for a large earthquake

```
SEISMO N82351 ((BEG SEP22 180000 END SEP23 180000 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  MLR5407 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
STOP
```

Table A4.1.4

Explanation of the text in Table A4.1.3

SEISMO identification of type of data (seismic)

N82351 -- message no. 2351 during 1978 for the station(s)

((BEG SEP22 180000 END SEP23 180000 NM8)) -- This is the first message in a group of 8 covering the time interval indicated (UTC).

ARB - 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

M1Z19035 - 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

M2Z19112 T3.2A53.1 - time of arrival, period and amplitude for amplitude A_2 in component Z

M3Z19160 T3.5A29.8 - time of arrival, period and amplitude for amplitude A_3 in component Z

M4Z19233 T3.5A27.2 - time of arrival, period and amplitude for amplitude A_4 in component Z

MLP19060 T6 A144 -- 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 T3.5A18.2)
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

MSLE 30090 T9 A216 -- time of arrival, period and amplitude for maximum amplitude of long period S-wave (component E)

MSLPN 30090 T9 A135 - time of arrival, period and amplitude for maximum amplitude of long period S-wave (component N)

Table A4.1.4 (cont.)

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

MLR5407 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)
M3L5203 T30A105)
M4L5012 T40A98) - arrival times and amplitudes in Rayleigh wave for, respectively, 20, 30 and 40 second 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)

MS 6.4 - Rayleigh wave magnitude on LPZ seismograph

MSH 6.6 - S-wave magnitude on long-period horizontal seismograph

STOP - end of communication

APPENDIX 4.2

A study by the WMO on the routing and transmission of seismic data (level 1) over the World Meteorological Organization Global Telecommunication System (WMO/GTS)

Background for the WMO study

Before presenting the study by the WMO, we give below a brief introduction and a description of the input data provided for the study by the Ad Hoc group.

In the Ad Hoc group's report CCD/558, four examples of seismic networks were considered, each corresponding to a different assumption regarding the availability of stations. Each network was restricted to 50 short period (SP) and 50 long period (LP) stations.

Table 4.2.I lists the stations included in at least one of the four networks. The possible routing of Level 1 data through the GTS circuits is indicated for each station.

For the present study, it was considered desirable to get an assessment of the GTS routing of data from all of these stations but without having to make a separate study for each network. Therefore this study considers all stations taken together. The resulting 'network' of 76 SP and 76 LP stations is of course larger than any of the network examples and the conclusions of the study would be interpreted accordingly.

For example, the stations of this extended 'network' in North America and Europe are essentially those of Network I. The corresponding load on the regional GTS circuits would therefore be similar to what would happen if Network I were implemented.

On the other hand, for South America and Africa, the 'network' stations are essentially those of Network III. Therefore, the study of the line capacity in these areas would mainly be relevant for Network III and Network III (SRO).

The expected volume of data reported from each station is highly dependent on the seismic activity, which varies considerably from one day to another. The input to this study was taken to be a 'high' activity day, i.e. a volume of data that would typically occur only a few times per year. Information obtained from the experts of the Ad Hoc group indicated that a reasonable estimate of such a load would be: 50 earthquakes for each station during a 24-hour period, 20 of which would be large enough for long period parameters to be reported.

At stations which employ an automatic detector there is the possibility of false detections being generated. It is at present not possible to accurately assess the volume of data generated by such false detections, but it is assumed here that this volume will be small in comparison to that generated by real events. This question does, however, merit further study.

We assume that each event is reported as a separate telegraphic message, and that the average length of each message is as follows (station designations refer to Table 4.2.1):

SP station (A)	200 ch/message	(50 messages/day)
LP station (B)	300 ch/message	(20 messages/day)
SP & LP station (C)	300 ch/message	(50 messages/day).

The WMO study is now presented.

Routing and transmission of seismic data (Level 1) over the World Meteorological Organization Global Telecommunication System (WMO/GTS)

1. According to the information available from the *Ad Hoc* Group of Scientific Experts to Consider International Co-operative Measures to Detect and Identify Seismic Events, seismic data from stations of 50 different countries will have to be transmitted over the GTS. Each type of seismic station and the volume of data expected to be transmitted from each type of station, as well as number of each type of station, are as follows:

Station instrumentation	Volume of data	No. of stations
SP only	10.000 ch/day	19
LP only	6.000 ch/day	19
SP & LP	15.000 ch/day	57

This volume will not be constant and will on the average be much lower. However, it is assumed that the total daily volume of seismic data to be transmitted over the GTS would reach 1.159.000 characters.

2. In order to develop the routing arrangements for handling the required seismic data, the volume of data to be inserted by each GTS center and time required for transmitting data over the GTS circuits have been estimated. Table 4.2.2 shows the volume of data to be inserted by each GTS center as well as routing on the GTS, transmission speed and time in this respect. The routing arrangements have been developed taking into account the present routing of meteorological information on the GTS as prescribed in the Manual on the GTS. Each center on the Main Trunk Circuit (MTC) is responsible for collecting seismic data from the originating centers as listed in the table.

3. It should be noted that certain circuits might not be able to accommodate the required seismic data due to the heavy traffic of meteorological information which is already transmitted over the circuit concerned. Furthermore, some GTS centers which are not connected directly to a center on the MTC will transmit seismic data via other GTS centers. Therefore, the centers responsible for relaying information from other centers to the MTC center will handle a large amount of seismic data. Automated GTS centers will handle seismic data within a few minutes, but manually operated centers will take a longer time for relaying the data from other centers to the MTC centers. The relay time cannot be accurately estimated due to the various procedures employed by each particular center. Therefore, in such cases the term 'relay time' is mentioned together with the transmission time in the table.

4. For the purpose of this study, the WMCs Moscow and Washington were taken to be international seismic data centers; therefore, all available seismic data will have to be transmitted to these two WMCs. The routing plan on the MTC has been developed, taking into account the available high-speed MTC segments. In the table, the total volume of data inserted by the MTC center concerned is indicated together with the transmission time for a particular MTC center to the adjacent MTC centers. The total volume of data contains the accumulated volume which is transmitted from the upper-stream MTC center.

5. As seen from the table, difficulties are foreseen in transmitting seismic data over certain GTS circuits operating with the modulation rate 50 or 75 bauds, in particular relaying of seismic data from one center to another will cause considerable handling time at certain manually operated centers. These problem areas could be summarized as follows:

(a) Western and southern parts of Region I (Africa), e.g. Central African Empire, Ivory Coast, Ethiopia, Kenya and Southern Rhodesia;

(b) South-western part of Region II (Asia), e.g. Afghanistan and Iran;

(c) Some parts of Region III (South America);

(d) Some parts of Region V (South-west Pacific), e.g. New Zealand and Indonesia.

Table A4.2.1

Transmission of Level 1 data through the WMO/GTS

List of seismic stations, countries, possible routing through WMO/GTS and high speed center in the Main Trunk Circuit

Country	GSE Rep	Station	Designation	Possible Routing through the WMO/GTS	High Speed Centre in the Main Trunk Circuit
Afghanistan		KBL	B	Kabul - 50B - Tashkent - 1200b/s -	MOSCOW
Algeria		TAM	A	Oran - 2400 b/s -	PARIS
Argentina		LPA	B	Buenos Aires - 50B -	WASHINGTON
		MDZ	A		
Australia	*	ASP	A	Melbourne - 200B -	TOKYO
		CTA	C		
		MAW	A		
		NWAO	C		
		WRA	A		
Belgium	*	DOU	C	Brussels - 2400b/s -	PARIS
Bolivia		LPZ	B	La Paz - 50B - Buenos Aires - 50B -	WASHINGTON
		PNS	A		
Brazil		BDF	C	Brasilia - 50B -	WASHINGTON
Bulgaria	*	KDZ	C	Sofia - 1200b/s -	MOSCOW
Canada	*	ALE	C	Montreal/Toronto - 2400b/s -	WASHINGTON
		FFC	C		
		GACO	C		
		MBC	C		
		YKA	C		
Central Afr Rep		BNG	A	Bangui - 50B - Brazzaville - 50B - Dakar - 50BX2 -	PARIS
Chile		PEL	B	Santiago - 50B - Buenos Aires - 50B -	WASHINGTON
		TLL	A		
Colombia		BOCO	C	Bogota - 50B - Maracay - 50B - Brasilia - 50B -	WASHINGTON
Czechoslovakia	*	KHC	C		PRAGUE
Denmark	*	DAG	C	Copenhagen - 75B - Norrköping - 2400b/s -	OFFENBACH
		GDH	C		
		KTG	C		
Egypt	*	HLW	C	Cairo - 50B -	MOSCOW
Ethiopia		AAE	C	Addis Ababa - 50B(testing) - Nairobi - 50BX2 -	OFFENBACH
Finland	*	JYSA	A	Helsinki - 2400b/s - Norrköping - 2400b/s -	OFFENBACH
		KEV	C		
		KJF	B		

Country	GSE Rep	Station	Designation	Possible Routing through the WMO/GTS	High Speed Centre in the Main Trunk Circuit
France		LOR	C		PARIS
German Dem.Rep.	*	MOX	C	Potsdam - 50BX2 -	PRAGUE
Germany, Fed.Rep.	*	GRF	C		OFFENBACH
Hungary	*	BUD	C	Budapest - 1200b/s -	PRAGUE
India	*	GBA	C	New Delhi - 50BX4 -	MOSCOW
		HYB	C		
		KOD	B		
		NDI	C		
		SHIO	C		
Indonesia		LEM	B	Djakarta - Singapore - Kuala Lumpur - Bangkok - New Delhi -	MOSCOW
Iran		ILPA	B	Tehran - 50B -	MOSCOW
		MAIO	C		
		SHI	A		
Israel		EIL	B	Bet Dagan - 50B -	OFFENBACH
Italy	*	AQU	B	Rome - 2400b/s -	PARIS
		SAL	A		
Ivory Coast		KIC	A	Abidjan - 50B - Dakar - 50BX2 -	PARIS
Japan	*	MAT	C		TOKYO
Kenya		NIKO	C	Nairobi - 50BX2 -	OFFENBACH
Mexico	*	COM	A	Mexico City - 75B -	WASHINGTON
		UNM	B		
Morocco		IFR	A	Casablanca - 50B -	PARIS
		RBA	B		
Netherlands	*	DBN	B	De Bilt - 1200b/s -	BRACKNELL
		WTS	A		
New Zealand	*	AFI	A	Wellington - 50B - Melbourne - 200B -	TOKYO
		SBA	C		
		WEL	C		
Norway	*	NORSAR	C	Oslo - 1200b/s -	BRACKNELL
Pakistan	*	QUE	C	Karachi - 50B - Tehran - 50B -	MOSCOW
Peru		ARE	C	Lima - 50B - Buenos Aires - 50B -	WASHINGTON
Poland	*	KRA	B	Warsaw - 1200b/s -	MOSCOW
		NIE	A		

Country	GSE Rep	Station	Designation	Possible Routing through the WMO/GTS	High Speed Centre in the Main Trunk Circuit
Rhodesia		BUL	C	Salisbury - 75B - (Pretoria) - 75B - Nairobi - 50BX2 -	OFFENBACH
Romania	*	MLR	C	Bucarest - 1200b/s - Sofia - 1200b/s -	MOSCOW
South Africa		SNA	C	(Pretoria) - 75B - Nairobi - 50BX2 -	OFFENBACH
		WIN	B		
South Korea		KSRS	A	Seoul - 50B -	TOKYO
Spain		TOL	B	Madrid - 50BX4 -	PARIS
Sweden	*	HFS	C	Norrköping - 2400b/s -	OFFENBACH
Taiwan		TATO	C	(Taipei) - 75B -	TOKYO
Thailand		CMTO	C	Bangkok - 50B - New Delhi - 50BX4 -	MOSCOW
Turkey		ANTO	C	Ankara - 50B - Sofia - 1200b/s -	MOSCOW
		ISK	C		
Union Soviet SR	*	BOD	C		MOSCOW
		ELT	C		
		OBN	C		
		SVE	C		
		YAK	C		
United Kingdom	*	EKA	C		BRACKNELL
United States A	*	ALPA	B		WASHINGTON
		ANMO	C		
		COL	C		
		DUG	C		
		FVM	C		
		GUMO	C		
		KIP	B		
		LASA	C		
		OGD	B		
		SJG	C		
		SPA	C		
		WES	C		
Yugoslavia		LJU	B	Belgrade - 50B - Budapest - 1200b/s -	PRAGUE
		VAY	A		

Computerized Centers and Hubs

Washington, Bracknell, Paris, Offenbach, Norrköping, Oslo, Brussels, Copenhagen, De Bilt, Wien, Roma, Zürich, Budapest, Moscow, Tashkent, Novosibirsk, Khabarovsk, Helsinki, Tokyo, Peking, Hongkong, Melbourne, New Helhi, Montreal/Toronto, Oran.

Table A4.2.2

Estimated transmission time of seismic data from each centre of Global Telecommunication System (GTS)

MTC centre responsible for inserting data to MTC	Originating GTS centre	Volume of data (ch. per day)	Routing on the GTS	Transmission speed	Transmission time
Cairo	Cairo	15,000	Cairo-Moscow	50 bd.	37.5 min.
New Delhi	New Delhi	15,000x4+6,000 = 66,000	New Delhi-Moscow	1200 bit/s	7.3 min.
	Karachi	15,000	Karachi-New Delhi	50 bd	37.5 min.
Moscow	Kabul	6,000	Kabul-Tashkent Tashkent-Mosoow	50 bd. 1200 bit/s	15 min. +0.7 min. +relay time
	Tehran	6,000+10,000+ 15,000=31,000	Tehran-Moscow	50 bd.	77.5 min.
	Sofia	15,000	Sofia-Mosoow	1200 bit/s	1.7 min.
	Warsaw	6,000+10,000 =16,000	Warsaw-Mosoow	1200 bit/s	1.8 min.
	Ankara	15,000x2=30,000	Ankara-Sofia Sofia-Moscow	50 bd. 1200 bit/s	75 min. +3.3 min. +relay time
	Moscow	15,000x5=75,000	-	-	-

MTC centre responsible for inserting data to MTC	Originating GTS centre	Volume of data (ch. per day)	Routing on the GTS	Transmission speed	Transmission time
Moscow(cont'd)	Belgrade	6,000+10,000 =16,000	Belgrade-Sofia Sofia-Moscow	50 bd. 1200 bit/s	40 min. +1.8 min. +relay time
Volume of data inserted by Moscow:		189,000 +			
relayed from Cairo:		15,000 +	Moscow-Prague	1200 bit/s	31.6 min.
relayed from New Delhi:		81,000			
Total		=285,000			
Prague	Prague	15,000	-	-	-
	Potsdam	15,000	Potsdam-Prague	50 bd. x 2	37.5 min.
	Budapest	15,000	Budapest-Prague	1200 bit/s	1.7 min.
	Bucarest	15,000	Bucarest-Budapest Budapest-Prague	50 bd. 1200 bit/s	37.5 min. +1.7 min. +relay time
Volume of data inserted by Prague:		60,000 +			
realyed from Moscow :		285,000	Prague-Offenbach	2400 bit/s	19.2 min.
Total from Prague to Offenbach		=345,000			
Volume of data inserted by Prague:		60,000 +			
relayed from Offenbach :		814,000	Prague-Moscow	1200 bit/s	97.1 min.
Total from Prague to Moscow		=874,000			
Offenbach	Nairobi	15,000	Nairobi-Offenbach	50 bd. x 2	37.5 min.
	Addis Ababa	15,000	Addis Ababa-Nairobi Nairobi-Offenbach	50 bd. 50 bd.	37.5 min. +37.5 min. + relay time

MTC centre responsible for inserting data to MTC	Originating GTS centre	Volume of data (ch. per day)	Routing on the GTS	Transmission speed	Transmission time
Offenbach(cont'd)	Salisbury Pretoria	15,000 +21,000 =36,000	Salisbury-Pretoria Pretoria-Nairobi Nairobi-Offenbach	75 bd. 75 bd. 50 bd.	25 min. +60 min. +90 min. + relay time
	Copenhagen	15,000x3 =45,000	Copenhagen-Norrkoping Norrkoping-Offenbach	75 bd. 2400 bit/s	75 min. +2.5 min. +relay time
	Helsinki	6,000+15,000 +10,000=31,000	Helsinki-Norrkoping Norrkoping-Offenbach	2400 bit/s 2400 bit/s	1.8 min. +1.8 min. +relay time
	Offenbach	15,000	-	-	-
	Bet Dagan	6,000	Bet Dagan-Offenbach	50 bd.	10 min.
	Norrkoping	15,000	Norrkoping-Offenbach	2400 bit/s	0.8 min.
Volume of data inserted by Offenbach relayed from Prague **Total** from Offenbach to Paris		: 178,000 + : 345,000 :=523,000	Offenbach-Paris	2400 bit/s	29.1 min.
Volume of data inserted by Offenbach relayed from Paris **Total** from Offenbach to Prague		: 178,000 + : 636,000 :=814,000	Offenbach-Prague	2400 bit/s	45.2 min.
Paris	Algiers	10,000	Algiers-Paris	2400 bit/s	0.6 min.

MTO centre responsible for inserting data to MTC	Originating GTS centre	Volume of data (ch. per day)	Routing on the GTS	Transmission speed	Transmission time
Paris(cont'd)	Bangui	10,000	Bangui-Brazzaville Brazzaville-Dakar Dakar-Paris	50 bd. 50 bd. 50 bd. x 2	25 min. +25 min. +25 min. +relay time
	Abidjan	10,000	Abidjan-Dakar Dakar-Paris	50 bd. 50 bd.	25 min. +25 min. +relay time
	Casablanca	10,000+6,000 =16,000	Casablanoa-Paris	50 bd.	40 min.
	Rome	10,000+6,000 =16,000	Rome-Paris	2400 bit/s	0.8 min.
	Brussels	15,000	Brussels-Paris	2400 bit/s	0.8 min.
	Paris	15,000	-	-	-
	Madrid	6,000	Madrid-Paris	50 bd. x 4	15 min.
Volume of data inserted by Paris : relayed from Offenbach : Total from Paris to Bracknell :		98,000 + 523,000 =621,000	Paris-Bracknell	2400 bit/s	34.5 min.
Volume of data inserted by Paris : relayed from Bracknell : Total from Paris to Offenbach :		98,000 + 538,000 =636,000	Paris-Offenbach	2400 bit/s	35.3 min.
Bracknell	De Bilt	10,000+6,000 =16,000	De Bilt-Bracknell	1200 bit/s	1.8 min.

MTC centre responsible for inserting data to MTC	Originating GTS centre	Volume of data (ch. per day)	Routing on the GTS	Transmission speed	Transmission time
Bracknell (cont'd)	Oslo	15,000	Oslo-Bracknell	1200 bit/s	1.7 min.
	Bracknell	15,000	-	-	-
Volume of data inserted by Bracknell : 46,000 + relayed from Paris : 621,000 Total from Bracknell to Washington : =667,000			Bracknell-Washington	2400 bit/s	37.1 min.
Volume of data inserted by Bracknell : 46,000 + relayed from Washington : 492,000 Total from Bracknell to Paris : =538,000			Bracknell-Paris	2400 bit/s	29.9min.
Washington	Buenos Aires	6,000+10,000 =16,000	Buenos Aires-Washington	50 bd.	40 min.
	La Paz	6,000+10,000 =16,000	La Paz-Buenos Aires Buenos Aires-Washington	50 bd. 50 bd.	40 min. +40 min. +relay time
	Lima	15,000	Lima-Buenos Aires Buenos Aires-Washington	50 bd. 50 bd.	37.5 min. 37.5 min.
	Brasilia	15,000	Brasilia-Washington	75 bd.	26.7 min.
	Santiago	6,000+10,000 =16,000	Santiago-Buenos Aires Buenos Aires-Washingotn	50 bd. 50 bd.	40 min. +40 min. +relay time
	Bogota	15,000	Bogota-Maracay Maracay-Brasilia Brasilia-Washington	50 bd. 50 bd. 75 bd.	37.5 min. +37.5 min. +26.7 min. +relay time

MTC centre responsible for inserting data to MTC	Originating GTS centre	Volume of data (ch. per day)	Routing on the GTS	Transmission speed	Transmission time
Washington (cont'd)	Montreal/Toronto	15,000x5 =75,000	Montreal/Toronto-Washington	2400 bit/s	4.2 min.
	Mexico City	6,000+10,000 =16,000	Mexico City-Washington	75 bd.	26.7 min.
	Washington	15,000x9+6,000x2 =147,000	-	-	-
Volume of data inserted by Washington		: 331,000 +			
Volume of data relayed from Tokyo		: 161,000			
Total from Washington to Bracknell		:= 492,000	Washington-Bracknell	2400 bit/s	27.3 min.
Tokyo	Seoul	10,000	Seoul-Tokyo	50 bd.	25 min.
	Peking	15,000	Peking-Tokyo	75 bd. x 5	25 min.
	Bangkok	15,000	Bangkok-Hong Kong	75 bd.	25 min.
			Hong Kong-Tokyo	75 bd.	+25 min. +relay time
	Jakarta	6,000	Jakarta-Singapore	50 bd.	15 min.
			Singapore-Kuala Lumpur	75 bd.	+10 min.
			Kuala Lumpur-Bangkok	75 bd.	+10 min.
			Bangkok-Hong Kong	75 bd.	+10 min.
			Hong Kong-Tokyo	75 bd.	+10 min. +relay time

MTC centre responsible for inserting data to MTC	Originating GTS centre	Volume of data (ch. per day)	Routing on the GTS	Transmission speed	Transmission time
Tokyo(cont'd)	Tokyo	15,000	-	-	-
Volume of data inserted by Tokyo :		61,000 +			
relayed from Melbourne :		100,000			
Total from Tokyo to Washington		:=161,000	Tokyo-Washington	2400 bit/s	8.9 min.
Melbourne	Wellington	10,000+15,000x2 =40,000	Wellington-Melbourne	50 bd.	100 min.
	Melbourne	10,000x3+15,000x2 =60,000	-	-	-
Volume of data inserted by Melbourne :		100,000	Melbourne-Tokyo	200 bit/s	83.3 min.

APPENDIX 4.3

Present state of the Global Telecommunication System (GTS) of the World Meteorological Organization (WMO)

The current state of the main trunk circuits of the GTS is shown in Figure A4.3.1.

The number of characters that can be transmitted on different speed circuits is shown in Table A4.3.1.

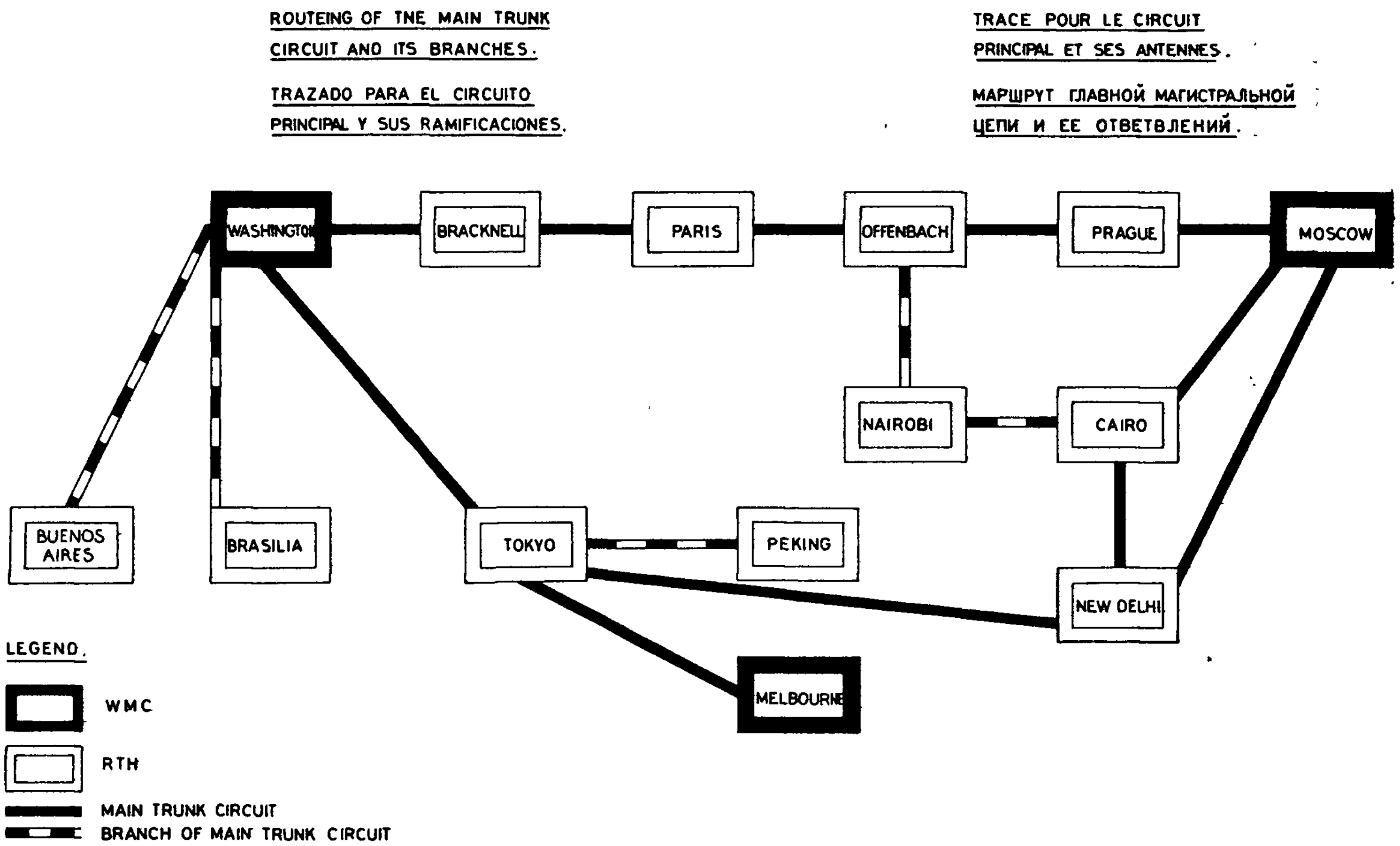


Figure A4.3.1 Schematic diagram of the Main Trunk Circuit of the WMO Global Telecommunication System

TABLE A4.3.1

Number of characters transmitted on different speed circuits

Modulation rate	Alphabet	b/ch	ch/sec.	ch/min.	ch/hr.	ch/day
50 bauds	No. 2	7.5	6.67	400	24,000	576,000
75 bauds	No. 2	7.5	10	600	36,000	864,000

Data signalling rate	Alphabet	b/ch	ch/sec.	ch/min.	ch/hr.	ch/day
200 bit/s	No. 5	10	20	1,200	72,000	1,728 x 10^3
1200 bit/s	No. 5	8	150	9,000	540,000	12,960 x 10^3
2400 bit/s	No. 5	8	300	18,000	1,080,000	25,920 x 10^3
4800 bit/s	No. 5	8	600	36,000	2,160,000	51,840 x 10^3
9600 bit/s	No.5	8	1200	72,000	4,320,000	103,680 x 10^3

APPENDICES TO CHAPTER 5

APPENDIX 5.1

International Data Post

List of co-operating countries (February 1979)

Country	Type of service	Internal Linking Service	
*ARGENTINA	S,D	PUERTA A PUERTA	Service of the Argentine Postal Administration
*AUSTRALIA	S,D	PRIORITY PAID	Service of the Australian Post Office
*BELGIUM	S	DATAPOST	Service of the Belgian Postal Administration
*BRAZIL	S	SERCA	Service of the Brazilian Postal Administration
*FRANCE	S	POSTADEX	Service of the French Postal Administration
*GERMANY (Federal Republic)	S	DATAPOST	Service of the German Postal Administration
HONG KONG	S,D	SPEEDPOST	Service of the Hong Kong Post Office
*JAPAN+	S,D	BUSINESS MAIL	Service of the Japanese Post Office
KUWAIT	S,D	MUMTAZPOST	Service of the Kuwait Postal Administration
*NETHERLANDS	S,D	EXPRESS MAIL	Service of the Netherlands Postal Administration
SINGAPORE	S,D	SPEEDPOST	Service of the Singapore Postal Administration
*SOUTH AFRICA	S	PRIORITY MAIL	Service of the South African Postal Administration
SWITZERLAND	S	SERVICE POSTALE RAPIDE	Service of the Swiss Postal Administration
*TAIWAN	S,D	SPEEDPOST	Service of the Taiwan Postal Administration
*UNITED KINGDOM	S,D	DATAPOST	Service of the British Post Office
*UNITED STATES	S,D	EXPRESS MAIL	Service of the United States Post Office
(*CANADA	-	-	Shortly to be linked)

* Listed in Table 4.1 of seismograph stations, CCD/558. +Tokyo and Osaka only.

Notes:

1. Type of service : International Datapost offers two kinds of service for business mail (which covers magnetic data tape): these are 'Scheduled' (S) or 'On-Demand' (D).

   The Scheduled service operates for regular, repetitive requirements on given dates and days and usually includes door-to-door collection and delivery in the collaborating countries. The On-Demand service caters for non-regular requirements; collection and delivery services are not usually provided and users hand in or collect items from nominated postal centers in each country.

2. Transit time : 1-3 days, depending on distances, etc., but next-day delivery is normal between major centers. As an example of a longer distance route over which seismological data is routinely sent, magnetic tapes posted in Brasilia on Monday evenings are delivered in Edinburgh, Scotland, on Thursday morning.

APPENDIX 5.2

Calibration data to be included with exchanged waveforms

All exchanged waveforms should in general be supplemented with sufficient information so that no misunderstanding can arise with respect to station identity, type of data, sampling rate, time and amplitude scale and time interval covered. The following calibration information should be transmitted with the waveform data.

1. For seismographs with analog galvanometric recording

(a) Dimensionless magnification (displacement sensitivy) defined as the ratio of the peak trace amplitude to the peak amplitude of displacement of sinusoidal ground motion at a specified frequency. The frequency will typically be 1 Hz for short period instruments and 0.05 Hz for long period instruments.

(b) Phase difference in seconds between peak trace amplitude and the corresponding peak ground displacement for the steady-state motion.

(c) Time corrections relative to UTC at the beginning and end of the seismogram.

(d) Direction of the trace deflection corresponding to ground movement in the direction up (on the vertical component) and to the north or east (on the corresponding horizontal component) should be marked directly on the seismogram.

2. For digital waveform records

(a) Quantization factor (nanometers/digital unit), i.e. the ground displacement (at a specified frequency) corresponding to 1 digital unit.

(b) Phase difference (in seconds) as under 1.

(c) Time correction (relative to UTC) for the beginning of the record.

(d) Polarity of the data (positive polarity means that the ground movement directions up, north and east correspond to positive numbers on the digital records).

Note:

Additional calibration information will be retained at each station and at the International Data Centers, including complete phase and amplitude response characteristics for all instruments. These files are updated regularly, as new calibration are performed, and the International Centers may request additional calibration measurements to be made as desired. It is therefore not considered necessary to transmit this complete calibration information with every requested waveform.

APPENDIX 5.3

Specification of waveform recording media at some seismological stations that may be included in a global network

Table 5.3.1 contains detailed specification of waveform recording media at most of the stations listed in Table 4.1 of CCD/558, as well as for some additional stations that may be included in a global network. Note that both the operational status and the type of equipment at these stations are subject to change.

Table 5.3.1

Station	Code	Type (see Chapter 3)	Specifications and formats of recording media
Albuquerque Ankara Bangui Bogota Chiang Mai Guam Mashad Narrogin Shillong Taipei	ANMO ANTO BCAO BOCO CMTO GUMO MAIO NWAO SHIO TATO	Seismic Research Observatory (SRO) (Type II)	Digital: Long period data, 3 components, sampled continuously at 1 sample per second. Short period data, vertical component, sampled at 20 samples per second for detected events only. Recording is on 0.5 in magnetic tape, 9 track, 800 bits per inch. A 16-bit word is used, 1 sign bit, 11 bits resolution (66 db) and 4 bits of gain ranging (60 db). Format is 2's complement with odd parity, record length 1000 words with 10 words of data. Analog: Continuous recording of 3 long period and vertical short period data by pen on 30 x 90 cm sheets.
Addis Ababa Afiamalu l'Aquila Arequipa Bulawayo College Danmarkshavn Dugway French Village Godhavn Helwan Kabul Kevo Kajaani Kodaikanel Kap Tobin Lembang Lormes La Plata New Delhi Peldehue Quetta Scott Base Shiraz Shillong San Juan Sanae South Pole Toledo Tepoztlan Wellington Weston Windhoek	AAE AFI AQU ARE BUL COL DAG DUG FVM GDH HLW KBL KEV KJF KOD KTG LEM LOR LPA NDI PEL QUE SBA SHI SHL SJG SNA SPA TOL TPM WEL WES WIN	World-wide Standard Seismograph Network (WWSSN) (Type I)	Analog: Recording by galvanometric deflection of a light spot on photographically sensitive paper, 30 x 90 cm sheets. Three components long and short period, one sheet per component with 24 hours recording on each sheet. Recording drum rates: long period - 1 revolution per hour, short period - 1 revolution per 15 min.

Table 5.3.1 (continued)

Station	Code	Type (see Chapter 3)	Specifications and formats of recording media
Alaskan Long period array	ALPA	Long period array (Type III)	Long period data only. Digital: 0.5 in magnetic tape, 9-track binary, 1600 bits per inch (556 or 800 bits per inch with 7 tracks available). Data and identification information are in 65-word records, 32 bits per word. An identification record precedes, 21 (7 x 3) data records. Data is written in IBM floating point format.
Eilat Kipapa Ogdensburg Toledo	EIL KIP OGD TLO	High gain Long period (HGLP) (Type II)	Long period data only. Digital: Continuous sampling, 3 components, velocity (one sample per 5 records) and displacement (one sample per 5 records). Recording is on 0.5 in magnetic tape, 7 track binary, 556 bits per inch, 3 characters (18 bits) per sample, 15 bit resolution, 2000 samples per record. Analog: Recording is similar to WWSSN station, but the magnification is considerably higher.
Hagfors	HFS	Short period array with associated long period instruments (Type III)	Digital: Long period data, sampled continuously at one sample per second. Short period data are sampled at 20 samples per second for automatically detected events only. Recording is on 9 track, 800 bits per inch industry compatible tape.
Norwegian Seismic Array	NORSAR	Short period array with associated long period instruments (Type III)	Digital: Data continuously recorded on 9 track, 1600 bits per inch magnetic tape. Short period data are sampled at 20 Hz, long period data at 1 Hz. All data are retained for 1 year. Facilities exist for conversion to other formats.

Table 5.3.1 (continued)

Station	Code	Type (see Chapter 3)	Specifications and formats of recording media
Graefenberg	GRF	Broad-band array (Type III)	Digital: 9 track, 800 bits per inch (1600 bpi optional) magnetic tape. Format: each block contains 10 seconds of data. Sampling rate 20 samples per second.
Eskdalemuir	EKA	Short period array with associated long period instrument (Type III)	Digital: 0.5 in magnetic tape, 9 tracks, 800 bits per inch, IBM file structure. Short period data. Two partial array sums, for detected events only, sampled at 20 samples per second, or continuously recorded raw data from 20 array channels, digitized at 20 samples per second. Long period data. Continuously recorded, vertical component, digitized at 1 sample per second.
Finnish Seismic Array	JYSA	Short period array with associated long period instrument (Type III)	Digital: Short period data are continuously recorded on instrumental tape in serial form, one track, 2400 bits per inch, sampling rate 20 samples per second. Long period data digitized at 1 sample per second. Facilities exist for conversion to other formats, e.g. 9 track, 1600 bpi magnetic tape.
Alice Springs	ASP	Standard short period (similar to WWSSN) (Type I)	Analog: 3 components visible recording on heat sensitive paper 300 x 900 mm sheets at 60 mm/min.
Charter Towers Kabul Matsushiro	CTAO KBAO MATO	Abbreviated Seismic Research Observatory (ASRO) (Type II)	Digital: Converted HGLP - long period data, 3 components, sampled once per second. Recording is on 0.5 in magnetic tape, 800 bpi NRZI. Short period vertical component recording as for SRO. Analog: 3 LP components, visible recording on heat sensitive paper 300 x 900 mm sheets at 60 mm/min (SP) and 15 mm/min (LP).
Warramunga	WRA	Short period array with associated long period instrument (Type III)	Digital, Analog: See EKA

Table 5.3.1 (continued)

Station	Code	Type (see Chapter 3)	Specifications and formats of recording media
Alert Flin Flon Mould Bay	ALE FFC MBC	Canadian Standard Station (Type I)	Analog: Recording by galvanometric deflection of a light spot on photographically sensitive paper, 30 x 90 cm sheets. Three components long and short period, one sheet per component with 24-hour recording on each sheet. Recording drum rates: long period - 1 revolution per hour. short period - 1 revolution per 15 min.
Yellowknife	YKA	Short period array (Type III)	Digital: Data are sampled at 20 samples per second for automatically detected events only; recording on 9 track, 800 bpi industry compatible tape. Analog: Continuous short period data recorded on FM magnetic tape.
		Long period array (Type III)	Analog: Data are recorded continuously on FM magnetic tape. Digital: Digitized time segments would be available on request.
Glen Almond	GACO	SRO bore-hole components; Canadian recording formats (Type II)	Digital: Long period data, 3 components sampled continuously at 1 sample per second. (Short period 3-component digital data formats for automatically detected events under development).
de Bilt	DBN	Long period (ZNE) (Type I)	Analog: Recorded on 30 x 90 cm photographic paper.
		Broad band (Z) (Type II)	Analog: Recorded continuously on FM magnetic tape. Digital: (Projected for 1981) continuous recording on magnetic tape.
Winterswÿk	WTS	Short period (Type I)	Analog: Recording by pen on 30 x 180 cm paper. Digital: (Projected for 1981) continuous recording on magnetic tape.

Table 5.3.1 (continued)

Station	Code	Type (see Chapter 3)	Specifications and formats of recording media
Gauribidanur	GBA	L-shapped array of SPZ instruments and a triangular array of LPZ instruments (Type III)	Analog: Recording on 1 in, 24-track magnetic tape with 20 channels of seismic record plus 1 channel for time. Similarly long period data are also recorded separately on analog tape. Facilities for hard copy of seismograms are available. Usually resolution of 0.1 sec is used for SP records and 1 sec for LP records. Digital: short period recording of frequency modulated signals at 20 HZ on 9-track 800 bpi magnetic tape.
Pavlikeni	PVL	Short and long period instruments (Type I)	Analog: 3 component photographic recording similar to WWSSN
Kasperské Hory	KHC	Broad band and short period (Type II)	Analog: Continuous recording of 2 vertical short period seismographs on photographic paper, 30 x 90 cm sheets per comp. per day, recording speed 60 mm/min. 3 broad band components recorded continuously on ПМ magnetic tape and on photographic paper, 30 x 90 cm sheet, recording speed 15 mm/min.
Cheia	MLR	Short and long period instruments (Type I)	Analog: continuous recording of 3-component short period seismographs on photographic paper. 3-component continous SP seismograph pen-recordings on paper (magnification 200k, recording speed 120 mm/min). 3-component SP seismograph recording on analog tape (detected events only), 3-component WWSSN LP seismograph continuously recording on photographic paper. Digital (planned for 1980) continuous recording of 3-component SP seismograph.

APPENDIX 5.4

Some Digital Tape Recording 'Standards'

The description 'Industry compatible tape' is commonly used. It means that data may be interchanged between computer systems of different manufacture as long as the tape used is to the same compatible standard. The standards for magnetic tape laid down by bodies such as European Computer Manufacturers Association (ECMA) and American National Standards Institute (ANSI) define the physical properties of tape such as spool dimensions, tape width and thickness, recording mode and density and positioning of reflective strips. They do not define tape codes or label and block formats. Two versions of digital tape in common use are:

9-track, 0.5 in width, 800 bits per inch (bpi) with non-return-to-zero inverted recording mode (NRZI), and

9-track, 0.5 in width, 1600 bpi with phase encoding recording mode (PE).

Standards for 7-track tapes also exist (for example, the high gain long period stations at Kipapa and Ogdensburg) but it is superseded by the 9-track standard and is not recommended.

Not all systems use the same tape code, but the most common ways of recording characters on digital tape are the IBM extended binary coded decimal interchange code (EBCDIC) or the American National Standard Code for Information Interchange (ASCII). Conversion routines convert one tape code to another.

The digital labelling of tapes is dependent on the file structure arrangements of the systems which handle them. Tapes may therefore be labelled according to some convention (e.g. IBM standard) or in some non-standard way, depending upon the requirements of a particular system.

Tapes which are used in applications not requiring a file-structured system (e.g. field data tapes) can be unlabelled.

The block format of the data recorded on digital tape is governed by the software of the recording system; reading the tape therefore requires appropriate software in the replaying system. Inter-block gaps on 800/1600 bpi nine-track tapes are nominally 0.6 in, block lengths are dependent on recording software parameters.

APPENDICES TO CHAPTER 6

APPENDICES TO CHAPTER 6

Introduction

These appendices should be considered as guidelines for the further detailed specification that has to be made of the procedures to be used at international data centers.

These detailed specifications necessary for the establishment of the international data centers should be worked out on the basis of the guidelines given in this report, past experience at existing data centers and ideas and results that might be obtained from studies performed in connection with the possible further work of the Ad Hoc group.

The specifications should include all necessary mathematical formulas and data handling routines and listings of the computer programs to be used. Travel time curves should be specified in detail, showing for example to which region and which signal frequency they apply. Also the various amplitude distance corrections to be used in magnitude calculations should be explicity given.

One of the appendices, Appendix 6.5, has been drafted to a high degree of detail to show, as an example, what such specifications might finally look like.

APPENDIX 6.1

Procedure for the association of short period Level 1 data for event definition and procedure for 3-dimensional event location

The automatic association of arrival times is the first important step in the event definition and location procedure. The association procedure involves a preliminary selection of those arrival times that appear to be associated with the same event. The sorting procedure is based primarily on teleseismic P-wave arrival times and preliminary locations obtained from array station data. The P-wave arrival times are associated either using a preliminary array location or using other P-wave arrival times occurring within a given time window. This time window is estimated from the Jeffreys-Bullen travel time model and depends on the geographical distribution of the reporting stations. Reported quantitative remarks such as "local" or "regional" are useful in this process. Also P and S readings reported from stations at local distances may be used provided local travel time curves are available.

The time association should be carried out according to a procedure which will need to be described explicitly and in detail. Certain time requirements should be specified for the acceptance of a group of associated phases as an event. Requirements should also be specified for the acceptance of the association of an individual station with an event.

A minimum number of stations are required to define an event as follows:

- Four single stations, not more than two of which are local stations
- One array station at teleseismic distance and two single stations (with no distance restriction)
- Two array stations at teleseismic distances

To further reduce the probability of making a wrong time association and thus create an artificial event from arrival times which happened to fit together, a special control procedure should be employed. This procedure should check that the stations which have defined an event also have a defined -- reasonable -- probability of detecting an event with the actual magnitude at the actual distances, based on *a priori* information on the detection capability of the stations. It should also be checked that the stations which have not reported an event do not have a high probability of detecting an event with the actual magnitude in the actual region. A possible event should e.g. be declared as artificial and excluded if a certain number of stations with high detection probabilities did in fact not detect the event. A detailed description of this association control procedure will need to be worked out.

The final locations of the events should be carried out using a 3-dimensional location procedure similar to those used at existing seismological data centers. A detailed description of the location procedure including an estimate of the uncertainties in the estimated source parameters should be elaborated. The location procedure should allow for the use of data from local stations when appropriate local travel time curves are available.

APPENDIX 6.2

Local travel time curves and the regions and distance intervals in which they are applicable

To use stations at local distances from an event for the definition and location of the event, local travel time curves are needed. These curves should be tied to individual stations or group of stations and be defined in a certain distance interval. The travel times should be given as tables or as explicit expressions.

Examples of such local travel times are given below.

Region: Scandinavia lat. 55° - 70°N, long. 10° - 30°E.

Station: Hagfors (HFS)

Phase	Travel time (s)	Distance interval (km)
P_g	-0.8 + 0.167 d	115 - 490
P_n	8.5 + 0.121 d	235 - 1250
S_g	-1.2 + 0.283 d	115 - 1400
S_n	13.0 + 0.213 d	350 - 1360

d denotes distance (km) between source and receiver. The travel times refer to surface foci events.

APPENDIX 6.3

Amplitude distance correction for the estimation of body wave magnitude m_b

Body wave magnitude (m_b) should be computed using the formula

$$m_b = \log A/T + f(\Delta)$$

where A is zero-to-peak amplitude in nanometers, T is period in second and $f(\Delta)$ is a distance correction function. The Gutenberg and Richter (1956) amplitude-distance correction function should be used for distances (Δ) greater than 20 degrees. This function is shown for the PV wave in the particular case of shallow foci in Figure A6.3.1.

At distances below 20 degrees, further studies need to be carried out, and existing regional magnitude scales (e.g. see references below) should be studied as part of this effort.

References

Gutenberg, B., and C.F. Richter, 1956: Magnitude and energy of earthquakes. Ann. Geofisica, 9, 1-15.

A survey of practice in determining magnitude of near earthquakes: Summary report for networks in North, Central and South America compiled by W.H.K. Lee and R.J. Wetmiller, United States Geological Survey, Open-File Report 76-677, 1976.

Part 2: Europa, Asia, Africa, Australasia, the Pacific, compiled by R.D. Adams, World Data Center A for Solid Earth Geophysics, Report SE-8, 1977.

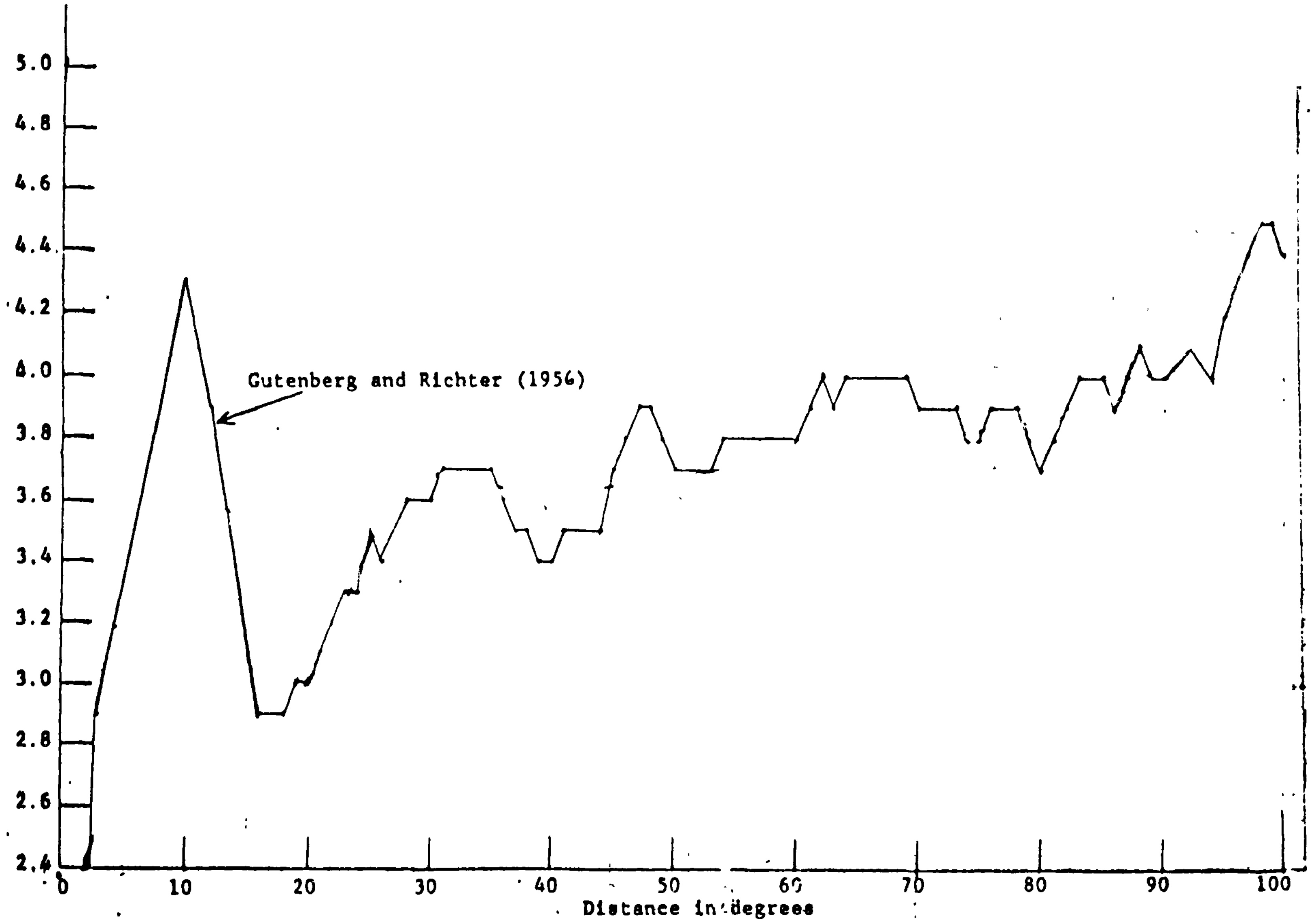


Figure A6.3.1 Magnitude (m_b) correction function f (Δ) for the PV wave in the case of shallow foci, after Gutenberg and Richter (1956)

APPENDIX 6.4

Calculation of magnitude

The discussion below is limited to the estimation of surface wave magnitude M_s, but the formulas and procedures are equally applicable to body wave magnitudes, m_b.

The most common way of calculating the magnitude of a seismic event is based on straight forward averaging. From the reported zero-to-peak amplitude (A) in nanometers and period (T) in seconds individual station magnitudes, M_{si}, are calculated according to the formula:

$$M_{si} = \log (A/T)_i + 1.66 \log (\Delta)_i + 0.3$$

where i denotes station index running from 1 to the total number of stations (N) having reported (A/T) values. A straight average value is then formed of the M_{si}. The standard deviation is also calculated as a measure of the data scatter. Values significantly deviating from the mean, e.g. by more than three times the standard deviation are sometimes discarded.

From a statistical point of view mean values formed in this way can be strongly biased. This could occur in particular for weak events with only a small number of observations of (A/T). In such cases this type of mean values become too large. Maximum likelihood methods, which reduce the bias, have been suggested by Ringdal (1976), Elvers (1978), von Seggern and Rivers (1978) and Ringdal (1978). These methods, which assume that observed station magnitudes are subject to normal distributions, combine reported amplitude period ratios with noise values at stations where no signals have been detected. It can be noted that noise amplitudes are included in the list of Level 1 data to be reported (Cf Chapter 3). An appropriate maximum likelihood method to be used for magnitude estimation at international data centers can therefore be specified. Methods have also to be developed that give estimates of upperbound surface wave magnitudes for events, for which body waves but not surface waves have been detected (Elvers, 1974). Specifications for making such upperbound estimates should also be given further study.

<u>References</u>

Ringdal, F, 1976
Maximum likelihood estimations of a seismic magnitude. Bull. Seism. Soc. Am., 66:789-802.

Elvers, E, 1978
Seismic magnitude estimates, with a minimum number of detections, FOA report April C 20234-T1. National Defense Research Institute, Stockholm.

Elvers, E, 1974
Seismic event identification by negative evidence. Bull. Seism. Soc. Am., 64:1671-1684.

Von Seggern, D and Rivers, D.W, 1978
Comments on the use of truncated distribution theory for improved magnitude estimation. Bull. Seism. Soc. Am., 68:1543-1546.

Ringdal, F, 1978
A reply to "Comments on the use of truncated distribution theory for improved estimation" by von Seggern and Rivers. Bull. Seism. Soc. Am., 68:1547-1548.

APPENDIX 6.5

Travel times for Rayleigh- and Love-waves for continental and oceanic structures

This appendix has been drafted to a high degree of detail to show, as an example, what the specifications of the procedures at international data centers might look like.

The appendix gives initially a brief description of the mathematical formulas used.

Table A6.5.1 gives the Rayleigh-wave group velocity (after Filson, 1974) for continental and oceanic structure to be used for estimating the arrival times of Rayleigh-waves at individual stations from events located from short period data.

The map shows in 5° x 5° areas the regions to which the two structures should be applied.

A listing of a computer program for the computation of Rayleigh-wave travel times from an epicenter to a recording station is given in subappendix 5A.

Data for Love-waves are not included in this example, but similar tables should be worked out for this type of wave.

Reference

Filson, J.R., 1974
Long period results from the International Seismic Month.
Lincoln Laboratory Report 1974-15, Massachusetts, USA.

Procedure for calculating surface-wave travel times

The surface waves are assumed to follow great circle paths from source to receiver (distance D). The distance D is divided into parts belonging to regions with different group velocity curves. This is made by a step procedure.

In the figure the line PQ denotes a great circle path between source and receiver. As is shown in the figure p and a are colatitude and longitude of P and c and b colatitude and longitude of Q. N is the north pole. A point M is moved from P to Q by increasing d in small steps. For each step the colatitude (m) and the longitude (a+n) of M are calculated. The following formula is used for calculating m:

$$\cos m = \cos d \cdot \cos p + \sin d \sin p \cos az$$

This is obtained from the spherical triangle PNM, where az is the azimuth to Q viewed from P (d, p and az are known). The same formula applied again to PNM gives n:

$$\cos d = \cos p \cos m + \sin p \cos m . \cos n$$

The correct solution of n (positive or negative value) is chosen depending on if az is greater than or less than 180°.

To avoid numerical problems care is taken to cases when P, Q or M are close to one of the poles or when D is close to 180°.

The earth is divided in a grid with r (longitude) times s (latitude) number of squares. The grid spacing is several times the increment of d. A matrix corresponding to the grid indicates which region each square in the grid belongs to. By transforming the coordinates of M to matrix indices

$$\text{index } 1 = \frac{a+n}{360} \cdot r + 1; \quad \text{index } 2 = \frac{m}{180} \cdot s + 1$$

the region in which M is situated is found. By summing up the number of steps taken in each region the distance D is divided into parts belonging to the various regions. The travel time is then calculated as the sum of the travel times within the different regions as follows:

$$T_t = \frac{D}{\sum_i k_i} \sum_i \frac{k_i}{v_{i,t}}$$

k_i = number of steps in region i

$v_{i,t}$ = group velocity in region i for waves with period t

T_t = travel time from source to receiver for waves with period t

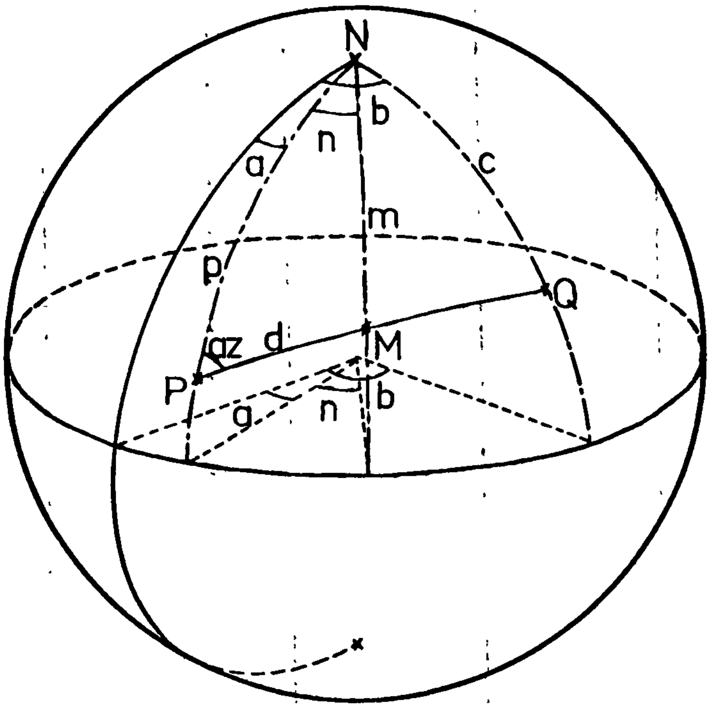
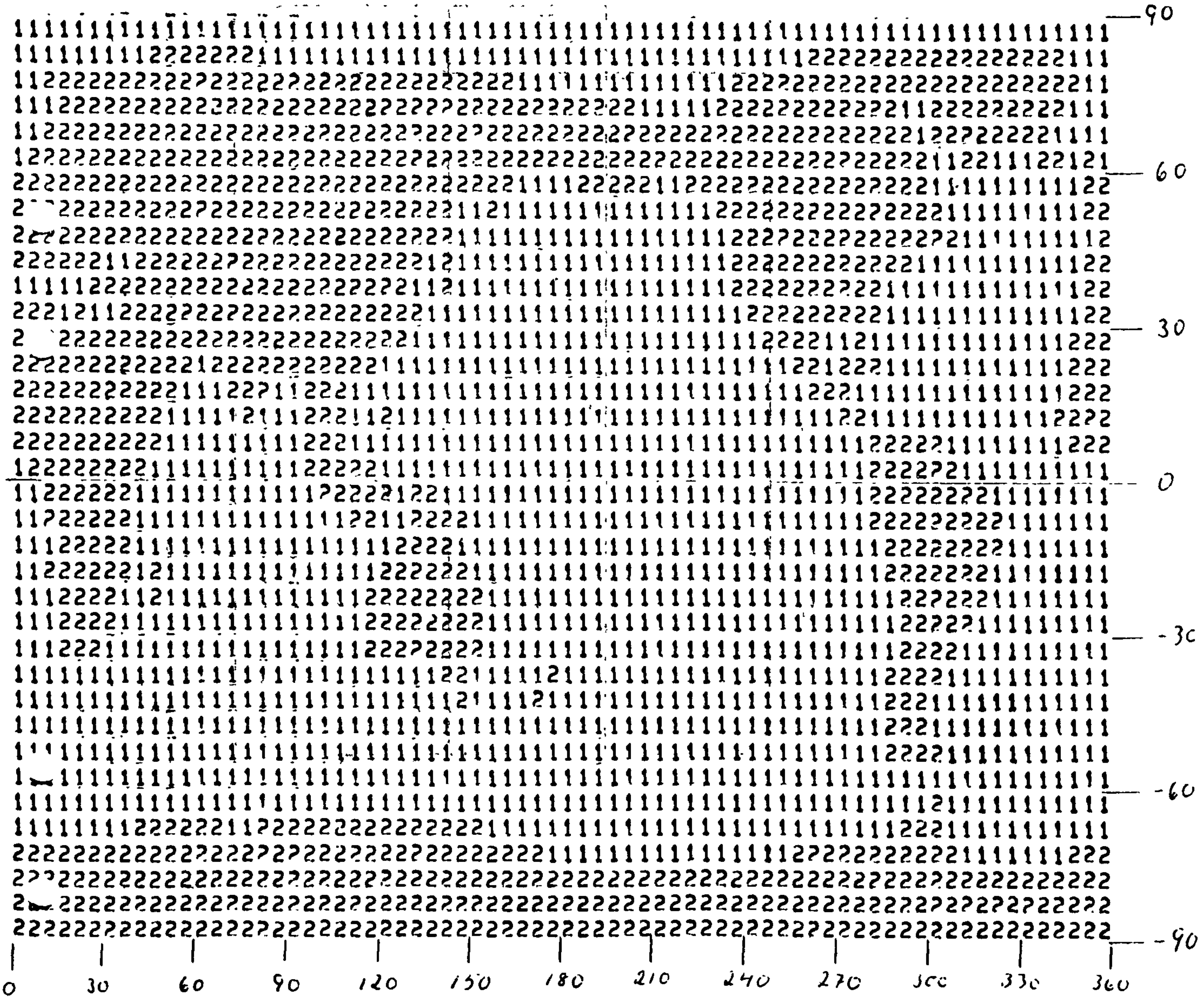


Table A6.5.1

Period (sec)	Group velocity (km/s)	
	Region 1 (Ocean)	Region 2 (Continent)
1	1.95	1.00
2	1.70	1.20
3	1.45	1.50
4	1.20	1.70
5	1.05	2.00
6	1.00	2.50
7	0.98	2.70
8	1.00	3.00
9	1.02	3.15
10	1.10	3.15
11	1.15	3.15
12	1.25	3.15
13	1.35	3.10
14	1.60	3.10
15	1.80	3.10
16	2.20	3.05
17	2.65	3.00
18	2.95	2.95
19	3.25	2.95
20	3.40	2.95
21	3.60	2.95
22	3.70	2.95
23	3.75	3.00
24	3.80	3.80
25	3.85	3.05
26	3.85	3.05
27	3.90	3.10
28	3.90	3.15
29	3.90	3.20
30	3.90	3.25
31	3.90	3.30
32	3.95	3.35

Table A6.5.1 (cont.)

Period (sec)	Group velocity (km/s)	
	Region 1 (Ocean)	Region 2 (Continent)
33	3.95	3.40
34	3.95	3.45
35	3.95	3.45
36	3.95	3.50
37	3.95	3.55
38	3.95	3.60
39	4.00	3.60
40	4.00	3.65
41	4.00	3.65
42	4.00	3.65
43	4.00	3.70
44	4.00	3.70
45	4.00	3.70
46	4.00	3.75
47	4.00	3.75
48	4.00	3.75


90
60
30
0
-30
-60
-90
0
30
60
90
120
150
180
210
240
270
300
330
360

```
      SUBROUTINE TTIME(COLAE, CLONE, AZS, DIST, TIM, PT, NL, IGV)
C
C*   INGVAR JEPPSSON, FOA 202, 790109
C
C
C*   THIS ROUTINE CALCULATES THE TRAVELTIMES FOR SURFACE WAVES FROM AN
C    EVENT TO A SEISMIC STATION.
C    TRAVELTIMES ARE CALCULATED FOR UP TO FOUR DIFFERENT SURFACE WAVE
C    PERIODS.
C
C    THE EARTH IS DIVIDED IN A NUMBER OF REGIONS, EACH REGION IS GIVEN
C    A NUMBER. TO EACH REGION BELONGS A GROUP VELOCITY CURVE WITH THE
C    SAME NUMBER AS THE REGION (THE GROUP VELOCITY GIVEN FOR PERIODS
C    BETWEEN 1 AND 48 SECONDS).
C
C    THE EARTH IS ALSO DIVIDED IN A GRID, AND TO THIS GRID CORRESPONDS
C    A MATRIX. EACH ELEMENT IN THE MATRIX CONTAINS A NUMBER EQUAL TO
C    THE NUMBER OF THE REGION THE CORRESPONDING SQUARE BELONGS TO.
C
C    THE TRAVELTIME IS CALCULATED AS THE TRAVELTIMES WITHIN
C    EACH REGION. SO, FIRST THE DISTANCE THE SURFACE WAVES TRAVEL WITHIN
C    EACH REGION IS CALCULATED, ASSUMING THE WAVE TRAIN TRAVELS ALONG A
C    GREAT CIRCLE PATH (NO REFRACTION OR MULTIPATHING). THIS IS MADE BY
C    A STEP PROCEDURE FROM EVENT TO STATION. THE NUMBER OF STEPS TAKEN IS
C    SUMMED UP FOR EACH REGION AND THE NUMBER OF STEPS IS THEN CONVERTED
C    TO DISTANCE.
C
C
C    NOTATION:
C    ALL ANGLES IS GIVEN IN RADIANS IF NOTHING ELSE IS STATED.
C
C    COLAE, CLONE = COLATITUDE AND LONGITUDE OF THE EVENT
C    COLA=COLAE. CLON=CLONE
C    AZS, DIST = AZIMUTH AND DISTANCE FROM EVENT TO STATION
C    AZ=AZS
C    TIM(J) = TRAVEL TIME FOR SURFACE WAVE WITH PERIOD PT(J)
C    PT(J) = SURFACE WAVE PERIOD (J=1 TO NL)
C    NL = NUMBER OF PERIODS FOR WHICH TRAVELTIMES SHALL BE CALCULATED
C       (NUMBER OF PERIOD MEASUREMENTS: MAX 4)
C    IGV = PARAMETER DENOTING TYPE OF WAVE PATH USED AT MAGNITUDE
C       DETERMINATION (IGV=1: MORE THAN 75% OCEANIC STRUCTURE;
C       IGV=3: MORE THAN 75% CONTINENTAL STRUCTURE: IGV=2: OTHERWISE)
C    IREG(I1, I2) = MATRIX CONTAINING REGION NUMBERS FOR ALL SQUARES
C       IN THE GRID
C    I1M, I2M = MAXIMUM VALUES OF I1 AND I2 RESP. (I1M*I2M=NUMBER OF
C       SQUARES IN THE GRID)
C    GRIDC, GRIDL = LATITUDINAL AND LONGITUDINAL SIZE OF A SQUARE IN
C       THE GRID (IF I1M=36 AND I2M=72 A SQUARE IS 5*5 DEGREES)
C    NR = TOTAL NUMBER OF REGIONS (AND GROUP VELOCITY CURVES)
C    VELR(I, T) = GROUP VELOCITY CURVES. THE MATRIX CONTAINS THE GROUP
C       VELOCITY FOR SURFACE WAVES WITH PERIOD T IN REGION NUMBER I
C       (NR=MAX VALUE OF I)
C    I = REGION NUMBER
C    T = PERIOD OF SURFACE WAVE (INTEGER)
C    D = DISTANCE FROM THE EVENT TO A POINT M (IN DIRECTION AZS)
C    CM, LM = COLATITUDE AND LONGITUDE RESP. FOR POINT M
C    DM = DIFFERENCE IN LONGITUDE BETWEEN THE POINT M AND THE EVENT
C    DD = STEP SIZE
C    DDG = STEP SIZE IN DEGREES
C    P(I) = STEP COUNTER FOR REGION I
C    PP = TOTAL NUMBER OF STEPS (SUM OF ALL P(I) WHEN STATION IS REACHED)
C    PART(I) = DISTANCE IN REGION I OF THE SURFACE WAVE PATH
C    COCE, COAZ, COD, COCM, CODM = COS-VALUES OF COLA, AZ, D AND DM RESP.
C    SICE, SIAZ, SID, SICM = SIN-VALUES OF COLA, AZ, D AND CM RESP.
C    TWOPI = 2*PI
C    DEGKM = NUMBER OF KILOMETERS PER DEGREE.
C    IT = NUMBER OF OUTPUT UNIT FOR ERROR MESSAGES AND WARNINGS
```

```
C    DEGKM = NUMBER OF KILOMETERS PER DEGREE.
C    IT = NUMBER OF OUTPUT UNIT FOR ERROR MESSAGES AND WARNINGS
C
C    ALL STATEMENTS ARE STANDARD FORTRAN EXCEPT THOSE PRECEDED BY A LINE
C    BEGINNING WITH C***
C
C
      REAL PART(2), P(2), LM, CM, TIM(4), PT(4)
      INTEGER T
      COMMON /LP1/IREG(36,72), VELR(2,48)
      DATA IT/6/, NR/2/, DDG/1./, DEGKM/111.2/
      DATA PI/3.141593/, I1M/36/, I2M/72/, TWOPI/6.283186/
C
C    CHECK IF ANY OF THE PARAMETERS IN THE SUBROUTINE CALL STATEMENT
C    IS OUT OF RANGE.
C
      IF (COLAE.LT.O..OR.COLAE.GT.PI.OR.CLONE.LT.O..OR.
     *CLONE.GT.TWOPI.OR.AZS.GT.TWOPI.OR.
     *AZS.LT.O..OR.DIST.LT.O..OR.DIST.GT.PI) GO TO 500
C
C    SET CORRECT VALUES TO SOME PARAMETERS AND SET COUNTERS TO ZERO.
C
   85 GRIDC=PI/FLOAT(I1M)
      GRIDL=TWOPI/FLOAT(I2M)
      DD=DDG*PI/180.
      D=0.
      DO 90 I=1,NR
   90 P(I)=0.
      COLA=COLAE
      CLON=CLONE
      AZ=AZS
C
C    GIVE AZ A WELL DEFINED VALUE IF DIST IS CLOSE TO 180 DEGREES.
C
      IF (DIST.GT.(PI-0.001)) AZ=0.1
C
C    CHECK IF THE EVENT IS CLOSE TO ONE OF THE POLES.
C
      IF (COLA.LT.0.001.OR.COLA.GT.(PI-0.001)) GO TO 650
C
C    CALCULATE FREQUENTLY USED SIN- AND COS-VALUES.
C
  100 COCE=COS(COLA)
      SICE=SIN(COLA)
      COAZ=COS(AZ)
      SIAZ=SIN(AZ)
      CM=COLA
      LM=CLON
      GO TO 400
C
C    INCREASE DISTANCE D FROM EVENT TO POINT M WITH STEP DD.
C
  150 D=D+DD
C
C    WAS THE STATION REACHED WITH THIS STEP?
C
      IF (D.GT.DIST) GO TO 1000
C
C
C
C    CALCULATE THE COORDINATES (CM, LM) FOR POINT M.
C
      COD=COS(D)
      SID=SIN(D)
      COCM=COCE*COD+SICE*SID*COA[illegible]
```

```
      COD=COS(D)
      SID=SIN(D)
      COCM=COCE*COD+SICE*SID*COAZ
C
C   CHECK IF ARCCOS-ARGUMENT IS OUT OF RANGE.
C
      IF (ABS(COCM).GT.1.0) GO TO 710
C **
  340 CM=ARCOS(COCM)
C
C   CHECK IF M IS CLOSE TO ONE OF THE POLES.
C
      IF (CM.LT.0.0001.OR.CM.GT.(PI-0.0001)) GO TO 720
      SICM=SIN(CM)
      CODM=(COD-COCE*COCM)/(SICE*SICM)
C
C   CHECK IF ARCCOS-ARGUMENT IS OUT OF RANGE.
C
      IF (ABS(CODM).GT.1.0) GO TO 730
C **
  350 DM=ARCOS(CODM)
C
C   CHOSE THE RIGHT SOLUTION OF DM DEPENDING ON AZIMUTH.
C
  360 IF(AZ.GT.PI) DM=-DM
C
C   CALCULATE LONGITUDE OF POINT M AND CHOSE RIGHT INTERVAL.
C
      LM=CLON+DM
      IF (LM.LT.0.) LM=LM+TWOPI
      IF (LM.GT.TWOPI) LM=LM-TWOPI
C
C
C
C   CALCULATE WHICH SQUARE THE POINT M (WITH COORDINATES CM, LM)
C   FALLS WITHIN; THAT IS DETERMINE THE VALUES OF THE INDICES
C   TO THE IREG-MATRIX AND DETERMINE WHAT REGION THE SQUARE
C   BELONGS TO (REGION NUMBER=I). START WITH M = EVENT.
C   INCREASE APPROPRIATE STEP COUNTER.
C
  400 I1=IFIX(CM/GRIDC)+1
      I2=IFIX(LM/GRIDL)+1
      IF (I1.LT.1.OR.I1.GT.I1M.OR.I2.LT.1.OR.I2.GT.I2M) GO TO 700
      I=IREG(I1, I2)
      P(I)=P(I)+1.
      GO TO 150
C
C
C
C   OUTPUT OF ERROR AND WARNING MESSAGES.
C
  500 WRITE(IT,501) COLAE, CLONE, AZS, DIST
  501 FORMAT(1X, '***WARNING: TTIME-ARGUMENT OUT OF RANGE:'/
     *1X, '    EVENT LAT, LONG  ', 2F8.5, 5X,
     *'    AZIMUTH, DISTANCE  ', 2F8.5)
C
C   NO CORRECTION OF THE ARGUMENTS IS MADE.
C
      GO TO 85
C
C
  650 WRITE(IT, 651) COLA
  651 FORMAT(1X, '***EVENT CLOSE TO ONE OF THE POLES: COLAT=', F9.5)
C
C   MAY CAUSE NUMERICAL TROUBLE. SET NEW VALUE.
C
      IF (COLA .LT.0.001) COLA=0.001
      IF(COLA.GT.(PI-0.001)) COLA=PI-0.001
      GO TO 100
```

```
      IF(COLA.GT.(PI-0.001)) COLA=PI-0.001
      GO TO 100
C
C
  700 WRITE(IT, 701) I1, I2
  701 FORMAT(1X, '***IREG-ARGUMENT OUT OF RANGE: I1=', I3, '  I2=', I3)
C
C  IF IREG-ARGUMENT IS OUT OF RANGE THIS STEP IS IGNORED (NO STEP
C  COUNTER INCREASED).
C
      GO TO 150
C
C
  710 IF (ABS(COCM).LT.1.001) GO TO 715
C
C  NO MESSAGE IF ONLY TRUNCATION ERROR.
C
      WRITE(IT, 711) COCM
  711 FORMAT(1X, '***ARCCOS-ARGUMENT OUT OF RANGE: COCM=', F12.8)
C
C  IF ARCCOS-ARGUMENT IS OUT OF RANGE, IT IS CORRECTED TO +1. OR -1.
C  RESPECTIVELY INDEPENDENT OF THE ACTUAL VALUE, AND THE EXECUTION
C  IS CONTINUED.
C
  715 COCM=SIGN(1., COCM)
      GO TO 340
C
C
  720 WRITE(IT, 721) CM
  721 FORMAT(1X, '***M NEAR ONE OF THE POLES: COLAIM=', F12.8)
C
C  GIVE DM A WELL DEFINED VALUE.
C
      DM=0.
      GO TO 360
C
C
  730 IF (ABS(COM).LT.1.001) GO TO 735
C
C  NO MESSAGE IF ONLY TRUNCATION ERROR.
C
      WRITE(IT, 731) COM
  731 FORMAT(1X, '***ARCCOS-ARGUMENT OUT OF RANGE: COM', F12.8)
C
C  IF ARCCOS-ARGUMENT IS OUT OF RANGE, IT IS CORRECTED TO +1. OR -1.
C  RESPECTIVELY INDEPENDENT OF THE ACTUAL VALUE, AND THE EXECUTION
C  IS CONTINUED.
C
  735 COM=SIGN(1., COM)
      GO TO 350
C
C
C
C  CALCULATE THE DISTANCE IN DIFFERENT REGIONS OF THE WAVE PATH.
C  FIRST, SUM UP THE TOTAL NUMBER OF STEPS.
C
 1000 PP=0.
      DO 1001 I=1,NR
 1001 PP=PP+P(I)
      DO 1005 I=1,NR
 1005 PART(I)=P(I)*DIST/PP
C
C
C
C* CALCULATE THE TRAVELTIME AS THE SUM OF THE TRAVELTIMES IN THE
C  DIFFERENT REGIONS, AND MULTIPLY BY A CONSTANT FACTOR TO GET THE
C  TIME IN SECONDS.
C
      DO ... I=1,
```

```
C     DIFFERENT REGIONS, AND MULTIPLY BY A CONSTANT FACTOR TO GET THE
C     TIME IN SECONDS.
C
         DO 1100 J=1, 4
   1100  TIM(J)=0.
         DO 1155 J=1, NL
         I=IFIX(PI(J)+0.5)
         DO 1150 I=1, NR
   1150  TIM(J)=TIM(J)+PART(I)/VELR(I, I)
         TIM(J)=TIM(J)*DEGKM*180./PI
   1155  CONTINUE
C
C
C*  CONVERT TO TENTH OF SECONDS BY MULTIPLYING BY TEN.
C
         DO 1160 J=1, NL
   1160  TIM(J)=TIM(J)*10.
C
C
C*  CALCULATE VALUE OF IGV DEPENDING ON WAVE PATH.
C          IGV=1 FOR MORE THAN 75% OCEANIC STRUCTURE
C          IGV=3 FOR MORE THAN 75% CONTINENTAL STRUCTURE
C          IGV=2 OTHERWISE
C
         SPART=PART(1)/DIST
         IGV=2
         IF (SPART.GT.0.75) IGV=1
         IF (SPART.LT.0.25) IGV=3
C
C
         RETURN
         END
```

APPENDIX 6.6

Automatic process for the association of long-period surface wave data with events located from short-period observations

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 for long-period Rayleigh and Love waves from an epicenter to the long-period stations are estimated using the travel times given in Appendix 6.5. Reported long-period surface wave data should be preliminary associated with an event if the estimated arrival times of surface waves at a certain period agree with those reported within a predetermined time interval. To reduce the probability of making a wrong association of surface waves, a procedure similar to that discussed for short-period signals in Appendix 6.1 could be applied. This procedure checks that stations to which surface waves have been associated also have a reasonable probability of detecting such signals from an event with the actual magnitude at the actual region. A detailed description of the association control procedure will need to be elaborated.

APPENDIX 6.7

Example of output bulletin and data file structures at International Data Centers

1. Example of a possible format of an output bulletin (containing basic information) from an International Data Center for one event

780120
002421.6 ± 7.3 9.6S ± 0.1 159.3E ± 0.1 28 km ± 10 BASED ON 12 STAT
SOLOMON ISLANDS
NUMBER OF ASSOC. SP-TIMES 34 NUMBER OF ASSOC. LP-TIMES 8
MB : 5.1 BASED ON 6 STAT STD : 0.30
MS : 5.0 BASED ON 7 STAT STD : 0.35
CMPX : 1.23 SPMM : 1.21 SPVT : 0 -9 -18 -13 -37 STAT : ARR.

Explanations

780120 = date of event

002421.6 ± 7.3 9.6S ± 0.1 159.3E ± 0.1 28 km ± 10 BASED ON 12 STAT

= origin time, epicenter, depth with associated error estimates and number of stations used for defining event

SOLOMON ISLANDS = region

NUMBER OF ASSOC. SP-TIMES 34 NUMBER OF ASSOC. LP-TIMES 8

= number of short period and long period arrival times that could be associated with the event

MB : 5.1 BASED ON 6 STAT STD : 0.30

= estimated bodywave magnitude based on amplitude and period measurements at 6 stations. Standard deviation among the individual station magnitudes is also given.

MS : 5.0 BASED ON 7 STAT STD : 0.35

= estimated surface wave magnitude based on amplitude and period measurement at 7 stations. Standard deviation among the individual station magnitudes is also given.

CMPX : 1.23 SPMM : 1.21 SPVT : 0 -9 -18 -13 -37 STAT : ARR.

= identification data for the event as reported from station ARR.

2. Data file formats

The data storage at the data centers could preferably be divided into several data files as follows:

- Station parameters and calibration data
- Input data reported from individual stations
- Output parameters obtained as a result of the processing at the centers
- Internal "book-keeping" files
- Level 2 data files.

These data files should be identical at the different data centers and they should be arranged so that data are easily accessible by modern computer techniques. Detailed specifications of the format used for the various data files will need to be elaborated. An example of a possible structure of data files at international data centers is given at the end of this appendix.

Station parameters and calibration data file

This file contains station parameters such as latitude, longitude, instrument and regularly updated calibration data. This file should also contain information about the time intervals during which any individual station has been out of operation.

Input data file

The file contains all the information that has been reported to the data centers via the WMO/GTS. The contents of this file depend on what actually are reported from the individual stations as discussed in chapters 3 and 4.

Output data files

These files should contain the parameters obtained as a result of the data processing at the centers. They should also contain all the individual station data that are associated with an event. The output file should furthermore contain all the unassociated data.

Internal "book-keeping" file

This file should contain a record of the processing that has been carried out at the individual centers. It is quite similar to the internal data files which are presently kept at large data centers.

Level 2 data file

This file would contain all the digital Level 2 data that have been forwarded to the data centers as results of requests. There will also be a need for archival storage of Level 2 data received on non-digital form.

3. An example of a possible structure of data files at International Data Centers

In the following, an example is given of a possible structure of data files at international data centers.

Structure and basic functions of data banks in international centres

The purpose of a data bank is:

To store all data received by the international centre from stations in the global network;

To store data processed in the centre;

To ensure the prompt supply of necessary information at the request of States parties to a treaty on the complete and general prohibition of nuclear-weapon tests.

Figure 6.7.1 gives a schematic view of a bank's structure. The data bank's information control system comprises the following main elements:

Input and output programmes;

Bank software (set of programmes);

Bank information fund;

Bank information retrieval language;

Information system hardware;

Information system service personnel.

The information fund can be divided into four large files, according to the nature of the data stored in it:

I. Focal parameters of events located by the centre;

II. Calibration data and particulars of stations;

III. Signal parameters (Level-1 data) from each individual station;

IV. Original recordings of P and L waves of events (Level-2 data) for each individual station;

The basic functions of a bank's information control system are as follows:

To record seismic data on machine carriers (files I-IV);

To store seismic data on the machine carriers for the regulation period;

To supply stored information upon request within the established time-limit and in a specially processed form.

Depending on the operational requirements of the international centre, the bank may be equipped with an automated data-control system ensuring the rapid retrieval and supply of required information.

The type of data to be stored in the bank can be seen in tables 6.7.1 - 6.7.5. Table 6.7.1 represents file I, which stores the focal parameters of seismic events located by the centre. Clearly, the format to be used for data in file I should be the same as that used for the bulletin of seismic events, which includes 22 parameters. Parameters 1 and 2 (number and date of event) should be used for information-retrieval purposes.

Figure 6.7.1 Example of Structure of the data bank of an international centre in the global network

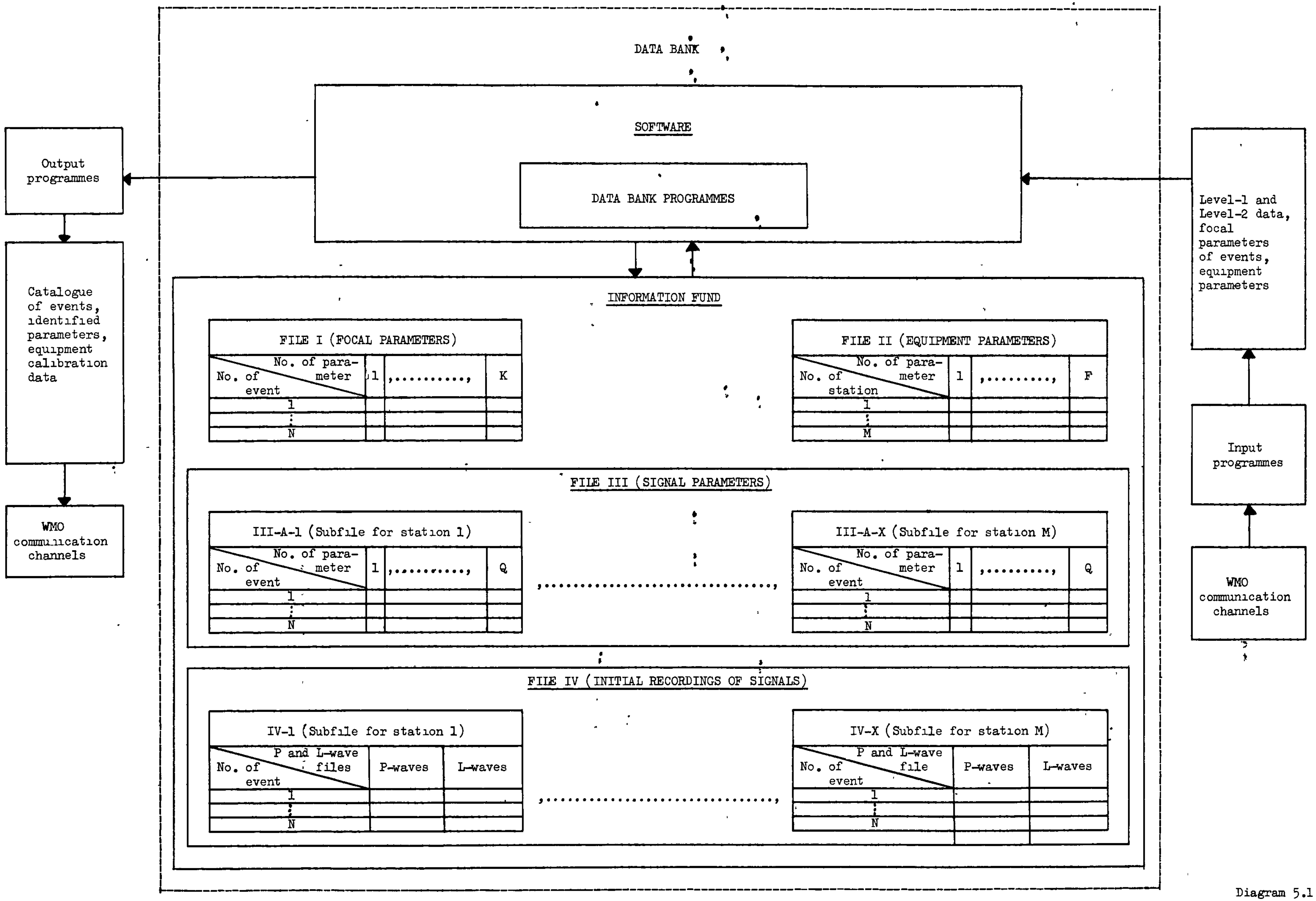


Diagram 5.1

Table 6.7.2 represents file II, which, in addition to the specifications of SP and LP instruments, gives some basic information about the stations (co-ordinates, soil conditions). File II has 11 parameters. Parameter 1 should be used for information retrieval.

Tables 6.7.3 and 6.7.4 represent file III - Level-1 data from all stations in the global network. This file is subdivided into two: file III-A and file III-B. File III-A (Table 6.7.3) is designed to store data that have been associated with located events; file III-B (Table 6.7.4) is designed to store "isolated signals", which, after appropriate processing in the centre, cannot be associated with a located focus. Each of the two files is in turn subdivided into M subfiles (M = number of stations). Each subfile in file III-A contains Level-1 information for each consecutive located event. Only the first five parameters are standard, and the remaining data can be sent from stations in telegraphic form. The volume of data sent in this manner will differ according to the nature of the signal recording. Parameters 1 and 2 can be used for information retrieval.

Each of the III-B subfiles stores Level-1 data related to "isolated" signals detected at a given station. In this case, the first three parameters are standard for all signals and may be used for information retrieval purposes. The texts of telegraphic communications from a given station could be stored with Level-I parameters.

Table 6.7.5 represents file IV in station No.1. It contains segments of signals recorded on SP and LP instruments. The bank could store, for a set period, 60-second segments of P waves, 30 seconds of noise from SP vertical instruments, 20-minute segments of L waves from three-component LP instruments and 5 minutes of noise from vertical LP instruments. File IV is subdivided into M subfiles (M = number of stations). Each subfile stores information on each consecutive event in connexion with which one or another State has requested information from a station in the global network. Each event in the subfile is defined by 6 parameters, with parameters 1 and 2 being used for information-retrieval purposes.

Input and output programmes serve to enter into the bank Level-I and Level-2 information and focal parameters obtained as a result of processing by the centre and to retrieve listed data when a request is submitted. Level-1 information and data from the catalogue of events should be transferred from the centre in the form of digital files. It is probable that, initially, at least for some of the stations, it will be in photocopy form only that Level-2 information can be transmitted to and from the centre.

Table 6.7.1

File I (focal parameters)

No. of parameter	Type of focal parameter	Unit of measurement	Accuracy of measurement	Volume of data (computer words 16-bits)
1	Number of seismic event			1
2	Date of event	year, day, month		1
3	Origin time (T_o)	hour, minute, second	0.1	1
4	Error in T_o	second	0.1	1
5	Epicentre latitude (φ)	degree	0.01	1
6	Error σ_φ	degree	0.01	1
7	Epicentre longitude (λ)	degree	0.01	1
8	Error σ_λ	degree	0.01	1
9	Magnitude M_6 (SP instrument)		0.1	1
10	Error σM_6		0.1	1
11	Magnitude M_6 (LP instrument)		0.1	1
12	Error σM_6		0.1	1
13	Magnitude M_{SH} (SP instrument)		0.1	1
14	Error σM_{SH}		0.1	1
15	Magnitude M_{SH} (LP instrument)		0.1	1
16	Error σM_{SH}		0.1	1
17	Magnitude M_S (LP instrument)		0.1	1
18	Error σM_S		0.1	1
19	Focal depth (h)	km	1	1
20	Error σ_h	km	0.1	1
21	Number of stations contributing to determination of epicentre			1
22	Comments			5

Table 6.7.2

File II (station parameters)

No. of parameter	Type of station parameter	Unit of measurement	Accuracy of measurement	Volume of data (computer words 16-bits)
1	Number of the station			1
2	Station latitude	degree	0.01	1
3	Station longitude	degree	0.01	1
4	Type of bedrock			1
5	Height above sea-level	metre		
	SP instrument frequency response:			
6	Z-component (0.25 - 10 Hz)	nm-Hz		30
7	NS-component (" ")	nm-Hz		30
8	EW-component (" ")	nm-Hz		30
	LP instrument frequency response:			
9	Z-component (1 - 100 secs)	nm-Hz		40
10	NS-component	nm-Hz		40
11	EW-component	nm-Hz		40
12	Date of last determination of instrument specifications			1

Table 6.7.3

File III-A-I (Station No. 1, identified signals from located events)

No. of parameter	Type of signal parameter (Level-1)	Unit of measurement	Accuracy of measurement	Volume of data (computer words - 16 bits)
1	Number of event (No. 1)			1
2	Date of event	year, day, month		1
3	Epicentre azimuth	degree	0.1	1
4	Epicentral distance	degree	0.1	1
5	Local station correction for travel time of P-wave	second	0.1	1
6	Focal correction for P-wave	second	0.1	1
7 ⋮ Q ⋮	Text of telegraphic message from station No.1 concerning event No.1 as detected on SP and LP instruments (Level-1 parameters) : SEISMO ..... : .... STOP :	⋮	⋮	⋮
1 ⋮	Number of event (No. X) ⋮	⋮	⋮	⋮
Q	SEISMO ...... STOP			

Table 6.7.4

File III-B-I (Station No. 1, signals not identified with located events)

No. of parameter	Type of signal parameter (Level-1)	Unit of measurement	Accuracy of measurement	Volume of data (computer words — 16 bits)
1	Number of signal (No. 1)			1
2	Date of signal	year, month, day		1
3	Arrival time of P-wave	hour, minute, second	0.1	1
4 ⋮	Text of communication from station No. 1 concerning signal No. 1 as detected on SP and LP instruments (Level-1 parameter) SEISMO..... ⋮	⋮	⋮	⋮
Q	... STOP			
⋮	⋮	⋮	⋮	⋮
1	Number of signal (No. N)			
⋮	⋮	⋮	⋮	⋮
Q	SEISMO ... STOP			

Table 6.7.5

File IV-I (Level-2 data at Station No. 1)

No. of parameter	Type of signal parameter (Level 2)	Length of signal (seconds)	Frequency of quantification	Volume of data (computer words - 16 bits)
1	Number of station (No. 1)			1
2	Number of event (No. 1)			1
3	Recording of P-waves on an SP instrument (Z-component)	90	20	1 800
4	Recording of L-waves on an LP instrument (Z-component)	1 500	1	1 500
5	Recording of L-waves on an LP instrument (NS-component)	1 200	1	1 200
6	Recording of L-waves on an LP instrument (EW-component)	1 200	1	1 200
.		.	.	.
.		.	.	.
.		.	.	.
1	Number of station (No. 1			
2	Number of event (No. N)			
.	.	.	.	.
.	.	.	.	.
6				

The bank software would consist of a set of information-fund control programmes and an information retrieval service. Data received for storage in the bank need not be subject to any additional processing or conversion. Thus, the bank software could be confined to data control and retrieval programmes.

The bank information retrieval language is the form in which seismic data are printed out. It must be based on parameters selected to suit each file in the information fund. The parameters selected for information-retrieval purposes play a particularly important role in the bank data-control process.

APPENDIX 6.8

Estimation of Level 1 and Level 2 data volumes to be handled at International Data Centers

This appendix contains an estimate of the Level I and Level II data to be received and processed at the centers. The purpose of this estimate is to form a basis for a specification of the equipment needed at the international centers. Note that the estimates of data volumes at Level I given in this appendix are not directly comparable to those specified in Appendix 4.2 for data transmission on the WMO/GTS, since the coding procedures are entirely different.

Level I data

The structure of an international center and the organization of its work are closely linked with the size of the information flow into the center, and, consequently with the volume of the information to be stored in the data bank over long periods. Rough estimates of the flow and the volume of data to be stored in the center can be made on the basis of the number of computer words (16 bits each) required to describe a single event on SP or LP equipment at Level I (see Tables 3.1 and 3.2). Such an estimate is given in Table A6.8.1, for the purposes of which it was assumed that the global network will consist of 25 type-I stations, 15 type-II stations and 10 type-III stations.

The number of events recorded by stations in the global network depends on a number of geophysical and other factors. The basic factors are:

The level of seismic activity at the time.

The level of seismic noise normally detected by the stations.

The position of a station relatively to the high-seismic-activity zones.

The sensitivity of the equipment and the manner in which it is installed in the station.

The methods used to distinguish signals from noise.

The number of signals recorded at individual stations over a 24-hour period may vary considerably from a few to 100 or more, depending on the factors listed above. The wave configuration of the signals recorded at a given station is also governed by a number of geophysical factors (magnitude, focal depth, epicentral distance, etc.). Thus, in the case of weak events at teleseismic distances, SP instruments normally register only longitudinal wave groups. Deep-focus events are normally marked by an absence of surface waves.

Since most of the events recorded at any given station are small in magnitude and have their focus in the earth's crust, most signals consist of trains of longitudinal waves recorded on vertical SP instrument.

For the sake of simplicity in calculating the data flow from stations to a center, it is assumed that over a 24-hour period each station records an average of 50 signals, 30 of which consist only of longitudinal waves detected on SP instruments and the remaining 20 of which consist of P and S waves detected on SP instruments and P, S and L waves detected on LP instruments.

Table A6.8.1

Volume of Level 1 data from stations to an international center over a 24-hour period

Type of Station	Type of Equipment	Maximum Frequency Response (Hz)	Recorded Wave Types	Volume of Data (Computer Words) for Each Event	Number of Events in each 24-hour period	Data Flow (Computer Words per 24-hour per.)
I	SP	1	P	31	30	930
Analog	SP	1	P+S	45	20	900
Recording	LP	0.05	P+S+L	56	20	1 120
II	SP	1	P	31	30	930
Digital	SP	1	P+S	45	20	900
Recording	LP	0.05	P+S+L	56	20	1 120
III	SP	1	P	47	30	1 410
Array	SP	1	P+S	61	20	1 220
Station	LP	0.05	P+S+L	60	20	1 200

Using the data provided in Table A6.8.1, it is possible to calculate approximate over-all Level I data flow to a center from all 50 stations in the global network over a 24-hour period.

Type-I stations: 25 x (930 + 900 + 1,120) = 73,750

Type-II stations: 15 x (930 + 900 + 1,120) = 44,250

Type-III stations: 10 x (1,410 + 1,220 + 1,200) = 38,300

Thus, the over-all volume of data that will be received by a center over a 24-hour period amounts to: 73,750 + 44,250 + 38,300 = 156,300 computer words.

Level II data

The approximate volume of Level II data received by a center from stations in response to requests can be estimated on the basis of the assumption (which is of course highly uncertain) that information concerning five events characterized by P and L waves will be requested each month.

Previous calculations concerning the volume of Level II data (CCD/558) showed that a 60-second recording of P waves sampled 20 times per second on a vertical SP instrument would amount to 1,200 computer words, and a 20-minute three-component recording of surface waves sampled once a second would amount to 3,600 computer words. As an extension to the earlier recommendations, however, it would seem advisable to include, in addition to the waveforms of P and L waves, small segments of the noise preceding the signals. In the case of SPZ instruments, a 30-second noise segment should be taken, and in the case of LPZ instruments, a five-minute segment. In this case, a 90-second recording on a SP instrument together with a 25-minute recording on a Z component and a 20-minute recording on each of two horizontal LP instrument will amount to 5,700 words, or slightly more if auxiliary information is taken into account. Thus, the total volume of Level II data for five events per month from 25 stations equipped with digital recording devices would be approximately 712,500 words. The remaining 25 stations in the assumed global network do not have digital recording facilities and would therefore transmit Level II information in analog form and not over digital channels.

It is also possible to estimate the approximate volume of data to be stored in a center subsequent to the processing of Level I data.

In accordance with the proposed format for catalogues of seismic events, one event requires approximately 30 computer words. If it is assumed that, over a 24-hour period, a center detects 50 events, each of which is recorded by half the stations in the global network, i.e. 25 stations, the volume of focal-parameter data over a 24-hour period will be: 50 x 30 = 1,500 words. The volume of azimuth and epicentral distance data for the 50 events detected by array stations over a 24-hour period will be 50 x 25 x 2 = 2,500. Thus, the total volume will be 4,000 words.

If it is assumed that all Level I data received by a center are transferred to the bank for long-term storage (some of the data will be associated with located events, while the rest will consist of unassociated signals), the volume of data received by the bank over a 24-hour period will be: 156,300 + 4,000 = 160,300 words.

Since Level I data and the focal parameters of events will have to be stored in the center over a long period, an estimate should be made of the volume of data that may be expected in this connection.

In the course of one month, the total volume of Level I data, processed data and data concerning instrument calibration parameters would be approximately 5 million words, so that in the course of one year, the volume of data would be about 60 million words.

APPENDIX 6.9

Specification of the equipment to be used at International Data Centers

This appendix contains a brief description of the equipment needed at the individual international data centers to carry out the tasks specified for such centers. This question is also addressed in the first report of the *Ad hoc* group (CCD/558).

International centers in the global network must be equipped to receive data through WMO channels and to process, analyze and store both reported and processed data. In this connection, the centers must be provided with sufficiently powerful modern computers and communication equipment.

The report of the *Ad hoc* group (CCD/558) suggests that centers should be equipped as follows.

Each center should have a main computer, which would process Level I data, and two mini-computers, one of which would assure communication between the center and stations in the global network and between centers, and the other of which would perform back-up functions. The data center's main computer could include the following.

A central processor with a memory that can store at least 100,000 computer words and a calculating speed of at least one million instructions per second.

Mass storage on disk for data and programs, with a capacity of at least 50 million computer words.

Four magnetic tape transports for digital recording.

Three interactive terminals.

Access to a large back-up computer (either nearby or remote) in case of a system breakdown.

The data archive function will require another computer with a large memory.