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***Keynote** on the History of the Treaty Verification Regime –* **Full Version**

The GSE Story:
Conceptual Development of the CTBT Verification System

Rodolfo Console

INGV

National Data Center

12 September 2025

SnT 2025 CTBT: SCIENCE AND TECHNOLOGY CONFERENCE
8 SEPTEMBER ONLINE DAY
9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE

The GSE Story: Conceptual Development of the CTBT Verification System

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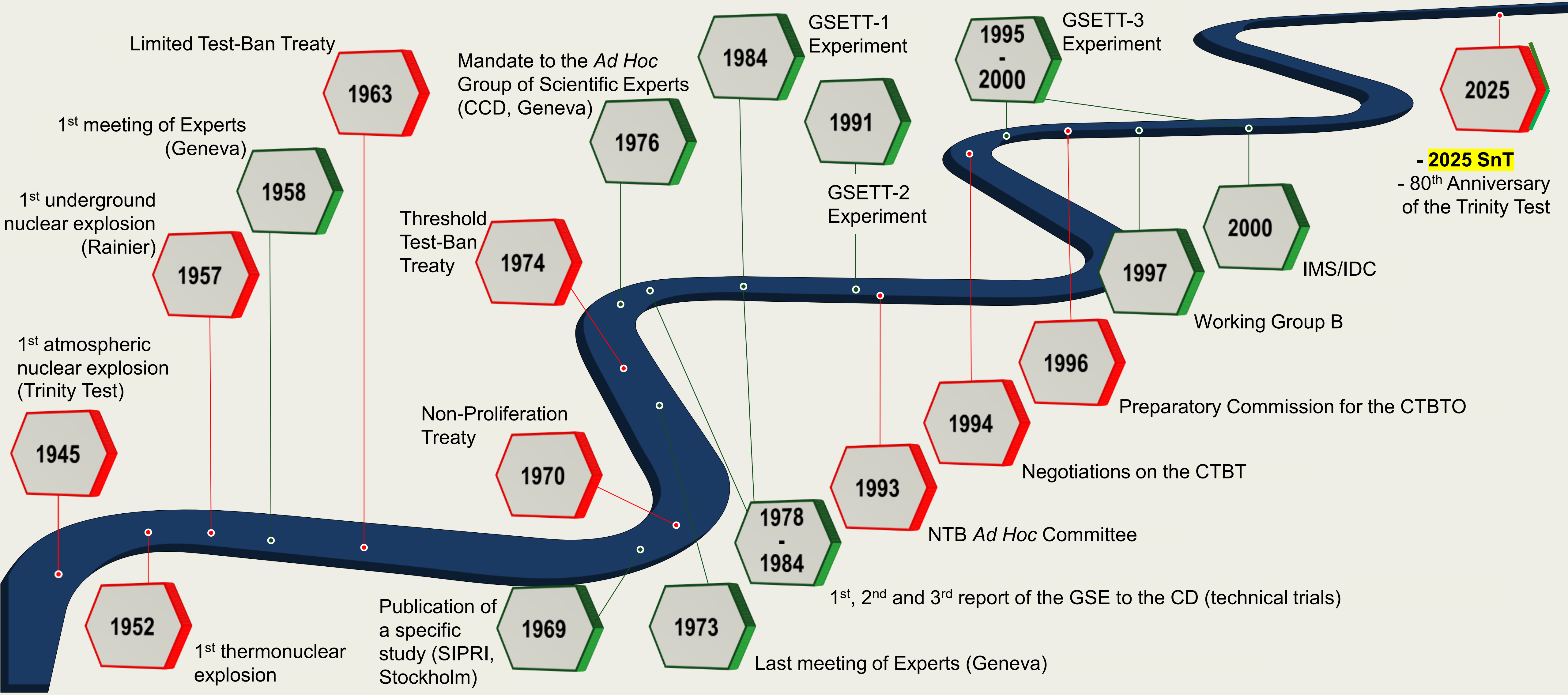
History of Relevant Events Concerning Nuclear Explosions in Political and Scientific Context



The Early Treatment of CTBT Verification

- On **September 19, 1957**, the US carried out the 1.7-kiloton RAINIER test on the Nevada Test Site, the world's first underground nuclear explosion in which the radioactive products were fully contained.

- Early in **1958** an inter-agency US committee was appointed to study the technical feasibility of monitoring a test ban. This panel reported in April that a system of 24 inspection stations in the USSR could detect underground explosions down to a yield of one or two kilotons.

- The level of technical discussion of the RAINIER data reached a low point when the AEC publicly announced that seismic signals from this shot were detected to a maximum distance of only 400 km. After an outcry from knowledgeable scientists, the detection estimate was revised to 3700 km because of an observation in Alaska. However, the seismogram in question during a 24-hour period contained numerous detections with amplitude comparable to that from the RAINIER explosion.

(from Richards & Zavales, 1996)

The Early Treatment of CTBT Verification (continued)

- After an intense series of negotiations at the top level of the US and USSR Goverments, a **Conference of Experts** (to Study the Possibility of Detecting Violations of a Possible Agreement on the Suspension of Nuclear Tests) started on **July 1, 1958, in Geneva**.

- Delegates generally agreed that tests on the surface and in the atmosphere of the Earth could be readily detected by their output of acoustic and radio waves and radioactive debris, and oceanic tests could be easily detected with hydroacoustic waves.

- It was agreed that when an underground test is conducted at a depth sufficient to prevent radioactive debris from reaching the surface, signals produced by seismic waves were the only means of detection.

(from Richards & Zavales, 1996)

The Early Treatment of CTBT Verification (continued)

- Meetings of scientific experts in the frame of the **Conference of the Committee on Disarmament** (Geneva, 1958-1973).

The United Nations Office at Geneva.

The Council Chamber.
(cc_jean-marc_ferre_1)

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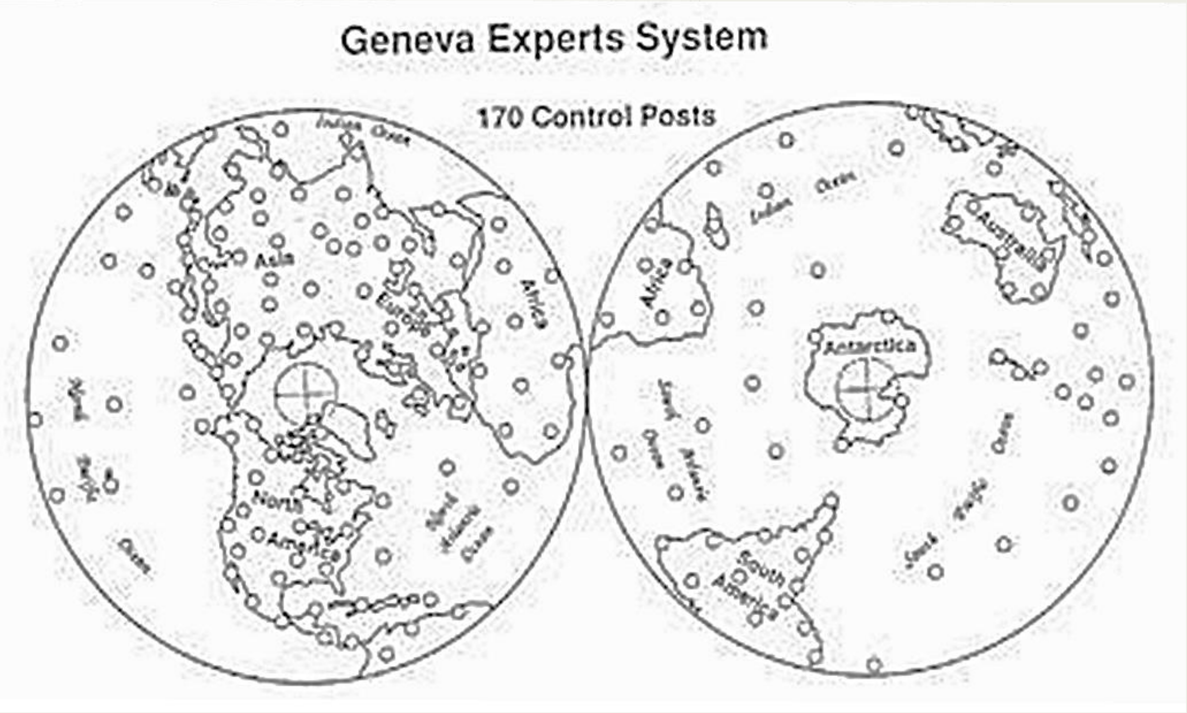
The Early Treatment of CTBT Verification (continued)

- In the **1st Geneva Conference (July 1958)**, the British delegation proposed a **system composed by 160 to 170 land-based control posts**, each operating a small array of about 10 seismic sensors: 100 to 110 based on continents, 20 on large islands, and 40 on small islands.

- Such a system would detect and identify 90% of the earthquakes equivalent to 5 kilotons or more, and a small percentage of those equivalent to one kiloton. The other 10% of 5 kt equivalent events would have to be inspected and estimates of the number of such events ranged from 20 per year (USSR estimate) to 100 per year (US estimate).

- The Geneva system of 170 control posts was never built, but on the basis of comparison with other networks, it appears that it would have enabled monitoring on a global basis of mb 3 rather than mb 4.



(from Richards & Zavales, 1996)

The 1969 SIPRI Specific Study

1969: The **Stockholm International Peace Research Institute** (SIPRI) published "Seismic Methods for Monitoring Underground Explosions“, a study by leading seismologists from ten countries, including four nuclear powers.

- This study provided a comprehensive assessment of seismic detection and identification of underground nuclear explosions, crucial for future negotiations on a comprehensive test ban.

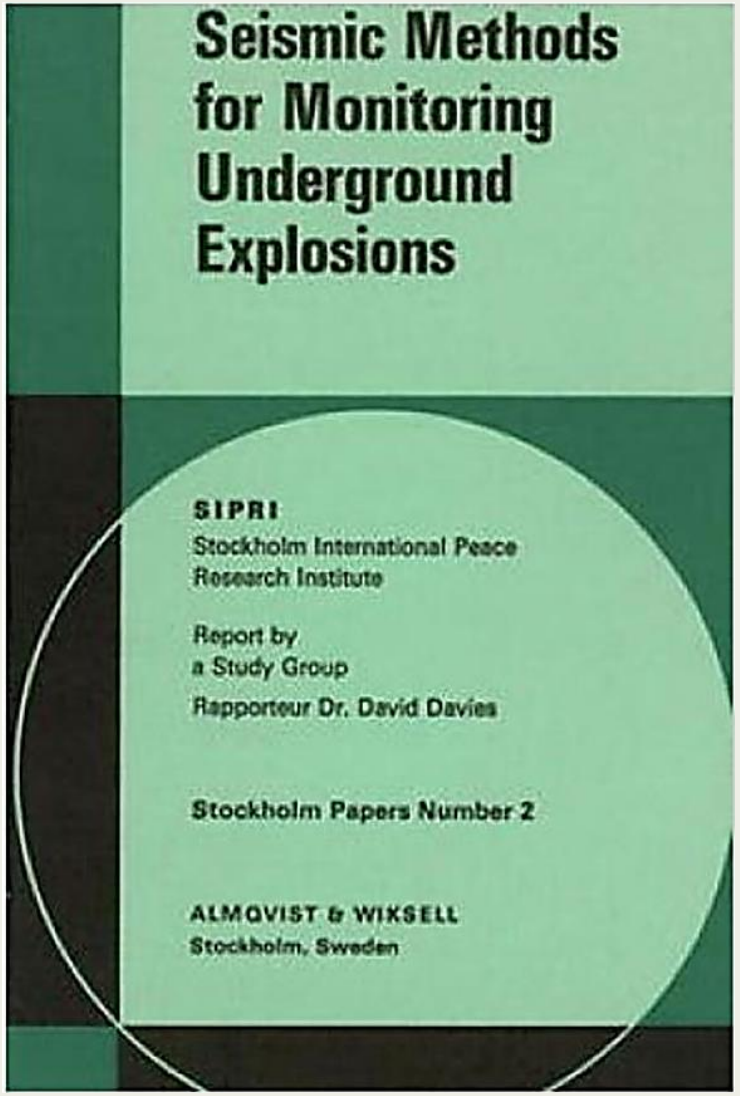
- It hypothesized a **global seismic network with approximately 50 to 100 high-quality seismic stations** to effectively monitor underground nuclear explosions.

- **Its Detection Capabilities:**

Large-yield tests (≥10 kt) → Easily detectable worldwide.

Moderate-yield tests (≈1-10 kt) → Detectable in most regions, depending on geological conditions.

Low-yield tests (<1 kt) → Detection was challenging, especially if decoupling techniques were used to muffle seismic signals.



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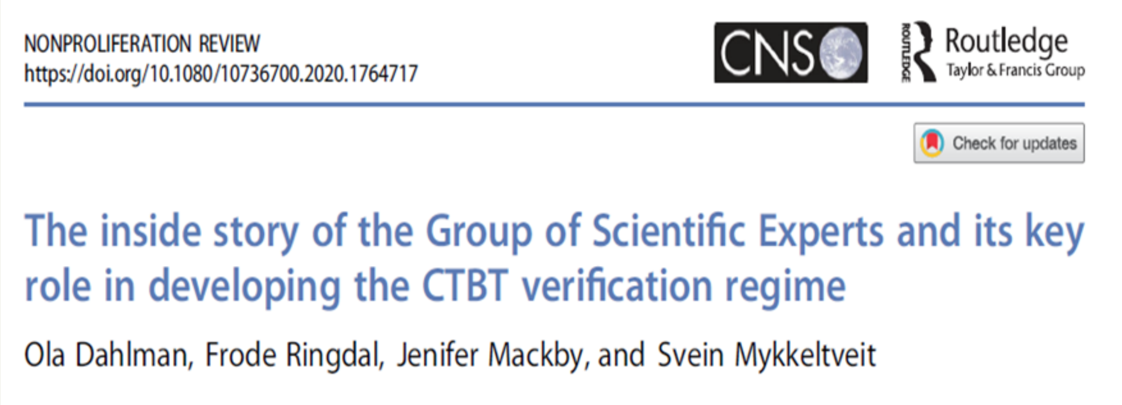
Literature on the Verification of a Comprehensive Test-Ban Treaty


NONPROLIFERATION REVIEW
https://doi.org/10.1080/10736700.2020.1764717

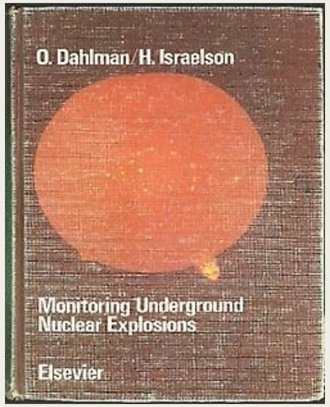
CNS

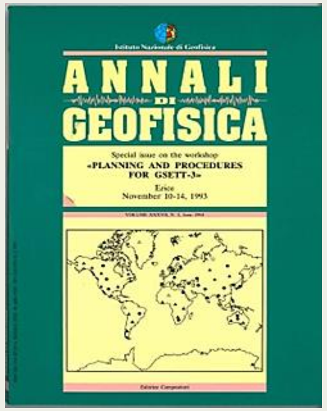
Routledge Taylor & Francis Group

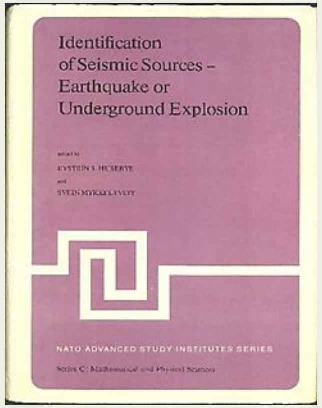
Check for updates

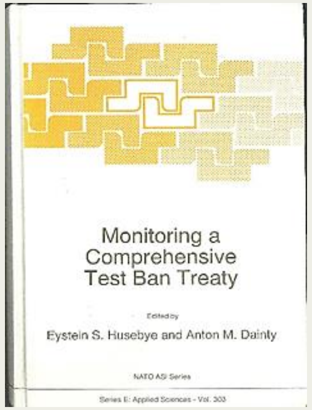
The inside story of the Group of Scientific Experts and its key role in developing the CTBT verification regime

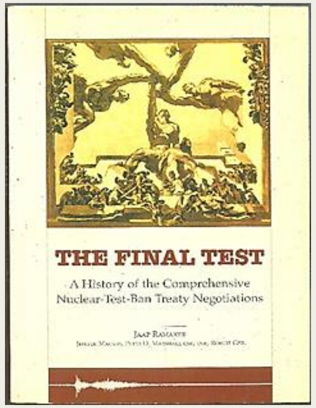
Ola Dahlman, Frode Ringdal, Jenifer Mackby, and Svein Mykkeltveit

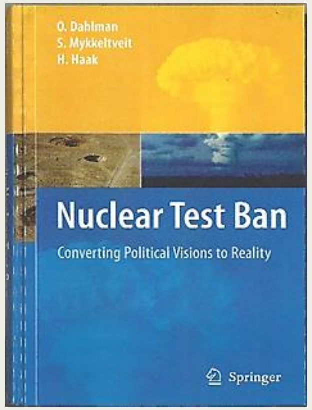


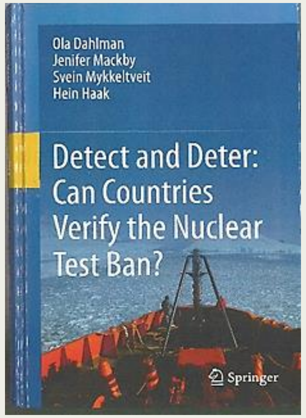


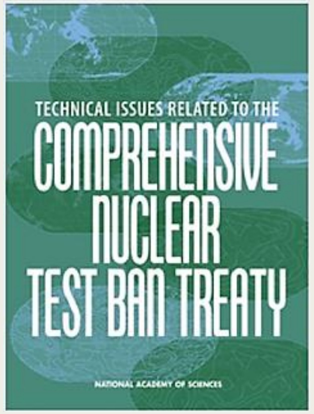


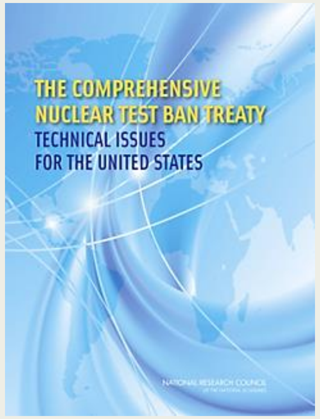


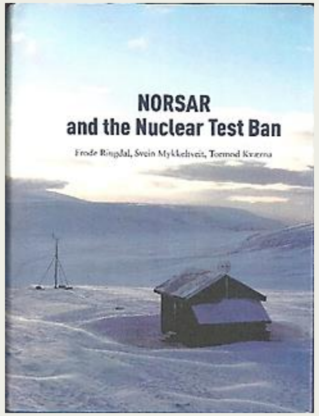












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The Last Meeting of Scientific Experts at the Conference of the Committee on Disarmament (CCD, Geneva - 10 July 1973)

- **Submitted papers:**

CCD/397 (Sweden): Working paper with points to be considered by experts on the verification of a ban on underground nuclear explosions.

CCD/404 (USA): A programme of research related to problems in seismic verification.

CCD/405 (Sweden): Working paper reviewing recent Swedish scientific work on the verification of a ban on underground, nuclear explosions.

CCD/406 (Canada): Working paper on the verification of a comprehensive test ban by seismological means.

CCD/407 (USA): Comments on document CCD/399, submitted by Japan, concerning magnitude determinations.

CCD/408 (Japan): Working paper on comparison between earthquakes and underground explosions observed at Matsushiro Seismological Observatory.

CCD/409 (Italy): Some observations on detection and identification of underground nuclear explosions - prospects of international co-operation.

- **Among other participants:**
  - P. W. Basham (Canada)
  - S. Suyehiro (Japan)
  - H. I. S. Thirlaway (UK)
  - O. Dahlman (Sweden)
  - H. Israelsson (Sweden)
  - R. Console (Italy)

Reception offered by the Japanese Delegation

Final Steps in Preparation of the Group of Scientific Experts (Geneva, Spring 1976) Ke08

- After the expert meeting of July 1973 at the CCD, two young researchers from the Swedish Defense Research Establishment, Hans Israelsson and Ola Dahlman, realized that *ad hoc* meetings wouldn't lead to concrete outcomes and concluded that a continuous process was needed.

- This process would have to involve a group of experts working together under the CCD's framework, with a clear mandate from political authorities and a consistent agenda (Dahlman *et al*., 2020).

- This idea was supported by many Delegations of the CCD, and some of them submitted national working papers on the subject of monitoring underground nuclear explosions:

Sweden - CCD/481, 26 March 1976, The Test Ban Issue.
Sweden - CCD/482, 26 March 1976, Working Paper on co-operative international measures to monitor a CTBT.

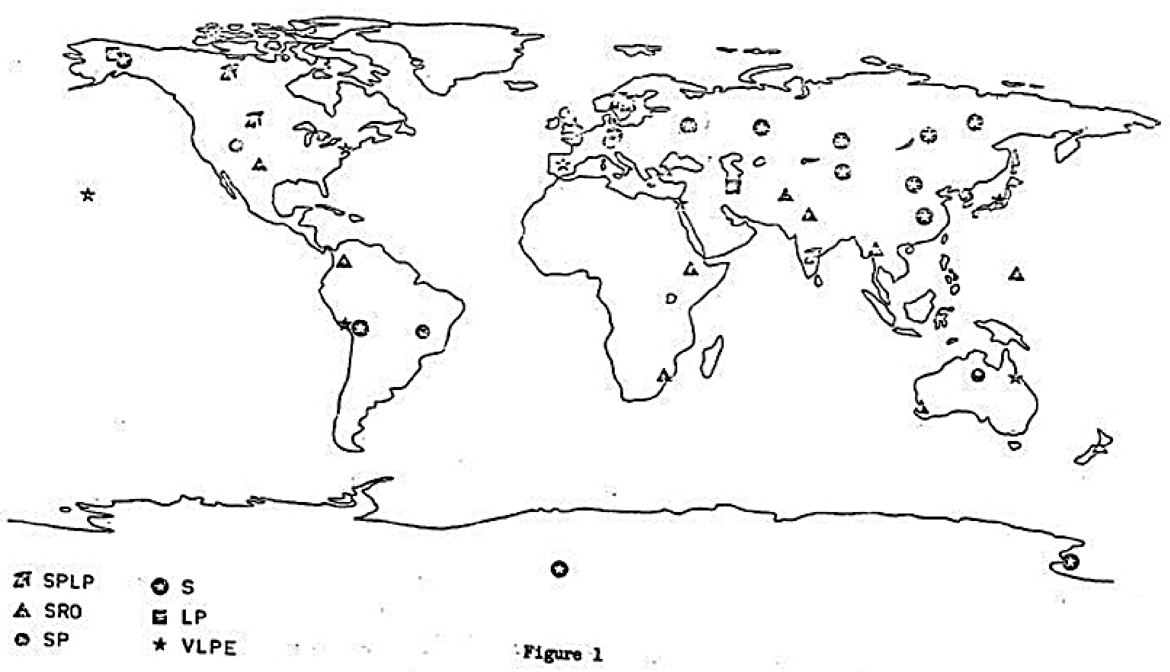


Figure 1 of CD/482 - Seismic stations selected for the monitoring network example:

SPLP = Array with short and long period systems

SRO = Seismological Research Observatory

SP = Array with short period system

S = Single station with short period system

LP = Array with long period system

VLPE = Very Long Period Experiment Station

Final Steps in Preparation of the GSE (continued)

Norway - CCD/484, 9 April 1976: Working paper on some new results in seismic discrimination.

UK – CCD/486, 12 April 1976: Working Paper on the United Kingdom's contribution to research on seismological problems relating to underground nuclear tests.

UK – CCD/487, 12 April 1976: Working Paper on the recording and processing of P waves to provide seismograms suitable to discriminate "between earthquakes and underground explosions.

UK – CCD/488, 12 April 1976: Working Paper on the United Kingdom's contribution to research on seismological problems relating to underground nuclear tests.

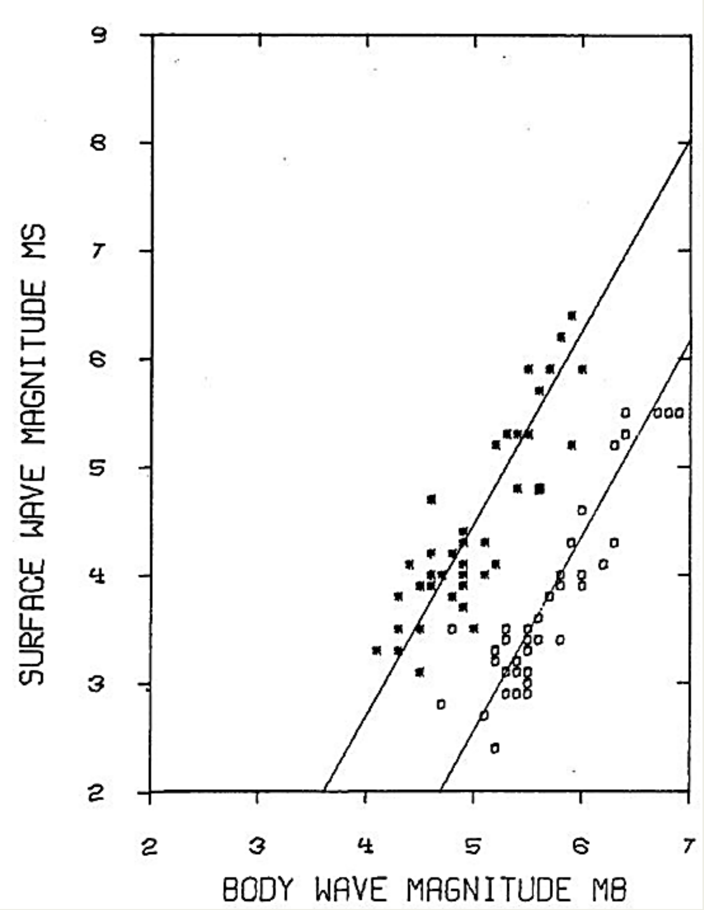
Japan – CCD/489, 13 April 1976: Working Paper on the estimation of focal depth by pP and sP phases.

Canada – CCD/490, 20 April 1976: The verification of a comprehensive test ban by seismological means.

USA – CCD/491, 20 April 1976: Current status of research in seismic verification.

UK – CCD/402 , 21 April 1976: Text of a statement on a comprehensive test ban made by Mr. Fakley at an informal meeting of the CCD on Tuesday, 20 April 1976.

Japan – CCD/403, 26 April 1976: Working Paper containing statement by Dr. Shigeji Suyehiro at the informal meetings with participation of experts on a Comprehensive Test Ban on 20 April 1976.



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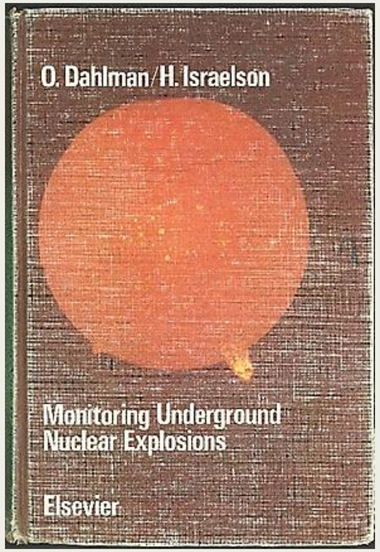
The Seismic Network Considered by Dahlman and Israelson (1977)



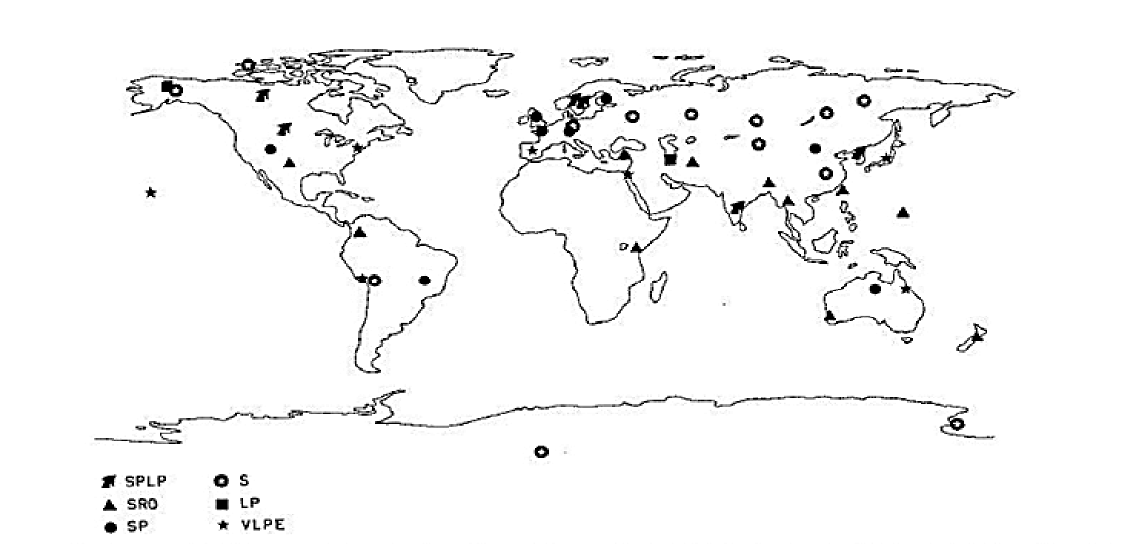


Fig. 15.1. Geographical locations of the seismic stations of the monitoring network. SPLP = Array with short-period and long-period systems. SRO = Seismological Research Observatory. SP = Array with short-period system. S = Single station with short-period system. LP = Array with long-period system. VLPE = Very-Long-Period Experimental Station.

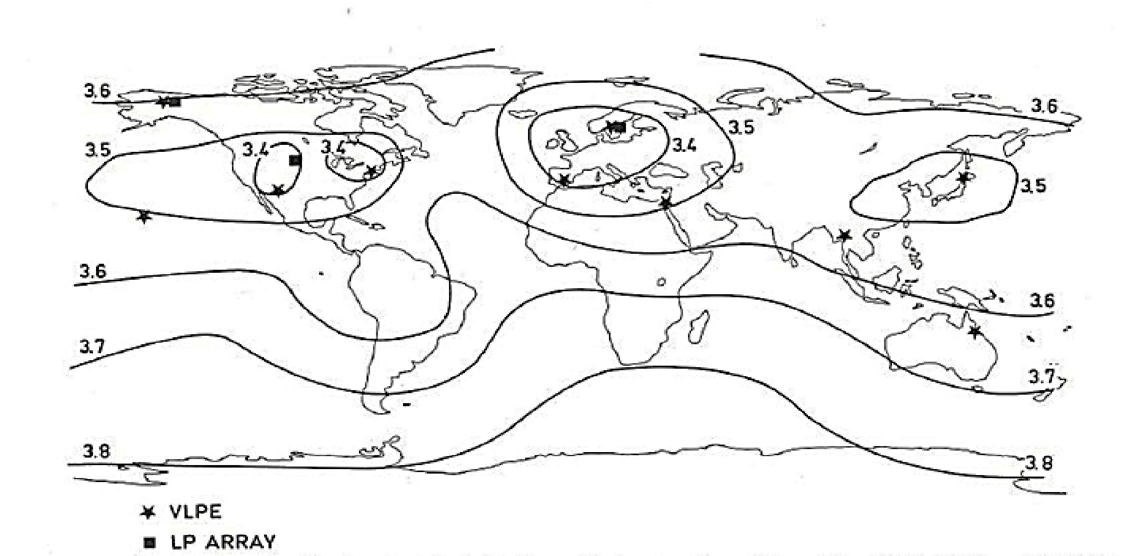


Fig. 7.21. Long-period earthquake detection thresholds for a seismic network consisting of the ALPA, LASA, and NORSAR arrays and ten VLPE stations, as defined by ARPA (1973). The thresholds are given as the surface-wave magnitude, M_s, for which long-period signals of shallow earthquakes would be detected with 90 % probability by at least four stations in the network.

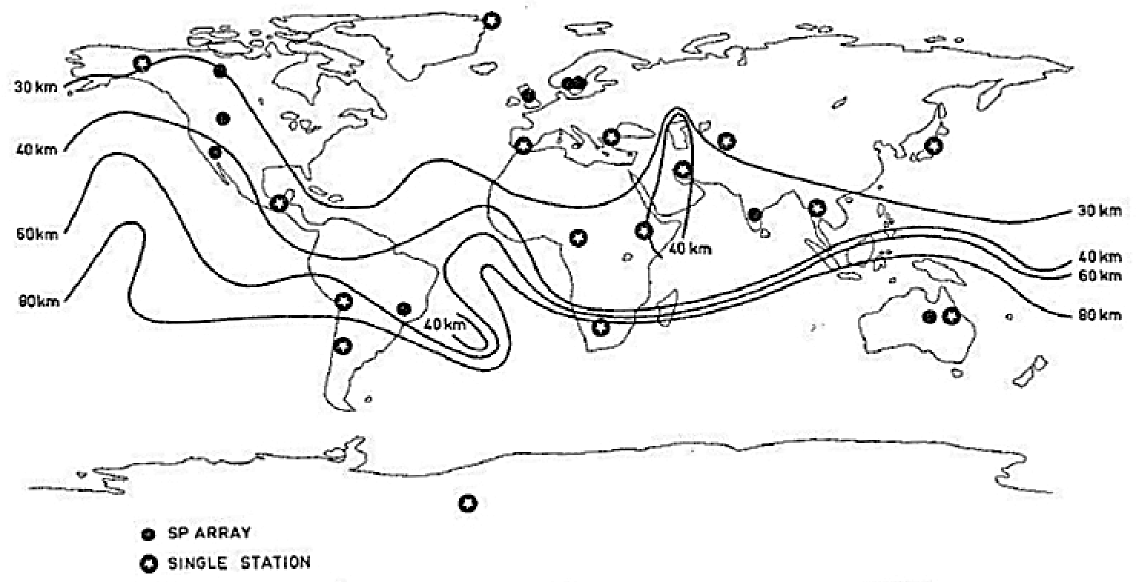


Fig. 8.8. Estimated global location accuracy for magnitude-4.5 events located by a network of 25 high-sensitive stations.

The First Mandate of the CCD to the GSE

- **CCD decision of 22 July 1976:**

Established the ***Ad Hoc* Group of Scientific Experts (GSE)** to consider international co-operative measures to detect and to identify seismic events.

- The task assigned by the CCD to the GSE was to specify the characteristics of an **international monitoring system** based on the following three main pillars:

(1) A **global network of seismological stations**, selected from existing and planned installations.

(2) **Transmission facilities for the timely exchange of data** between seismological stations and data centres.

(3) **Facilities, procedures and related financial implications** with respect to contributing and receiving centres for detecting, locating and identifying seismic events throughout the world and facilitating the collation and dissemination of relevant documentation (Dahlman *et al.*, 2020).

The First Mandate of the CCD to the GSE (continued)

- **Scientific experts and representatives from the following Member States of the CCD participated in one or more of the first four sessions:** Bulgaria, Canada(*), Czechoslovakia, Egypt(*), Federal Republic of Germany(*), German Democratic Republic, Hungary, India(*), Italy(*), Japan(*), Mongolia, Netherlands(*), Nigeria(*), Pakistan, Peru, Poland, Romania(*), Sweden(*), Union of the Soviet Socialist Republics, United Kingdom and the United States of America(*).

- **Australia(*), Belgium(*), Denmark(*), Finland(*), New Zealand and Norway(*)** were invited and participated in the work of the *Ad Hoc* Group.

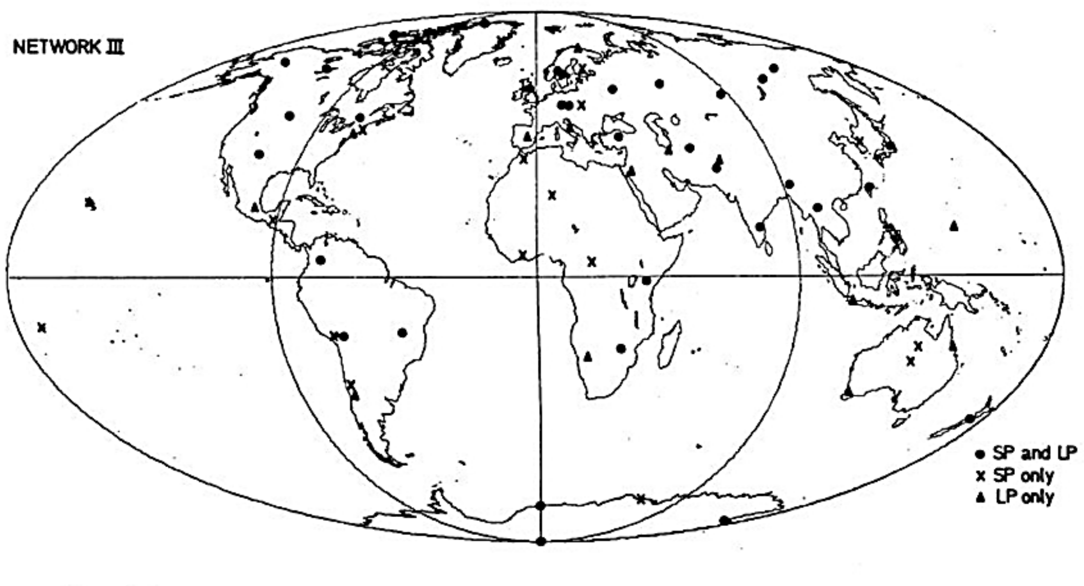
- At the first meeting **Ulf Ericsson** of **Sweden** was elected to serve as Chairman of the *Ad Hoc* Group, and **Frode Ringdal** of **Norway** as scientific secretary.

(*) participating in the first session

The First Mandate of the CCD to the GSE (continued)

- The Ad Hoc Group met in five sessions at Geneva, on the following dates:

1st session	2-6 August 1976	CCD/513 (1st progress report)
2nd session	21-25 February 1977	CCD/528 (2nd progress report)
3rd session	25-28 April 1977	CCD/534 (3rd progress report)
4th session	25 July – 5 August 1977	CCD/542 (4th progress report)
5th session	27 February-10 March 1978	CCD/558 (1st report)



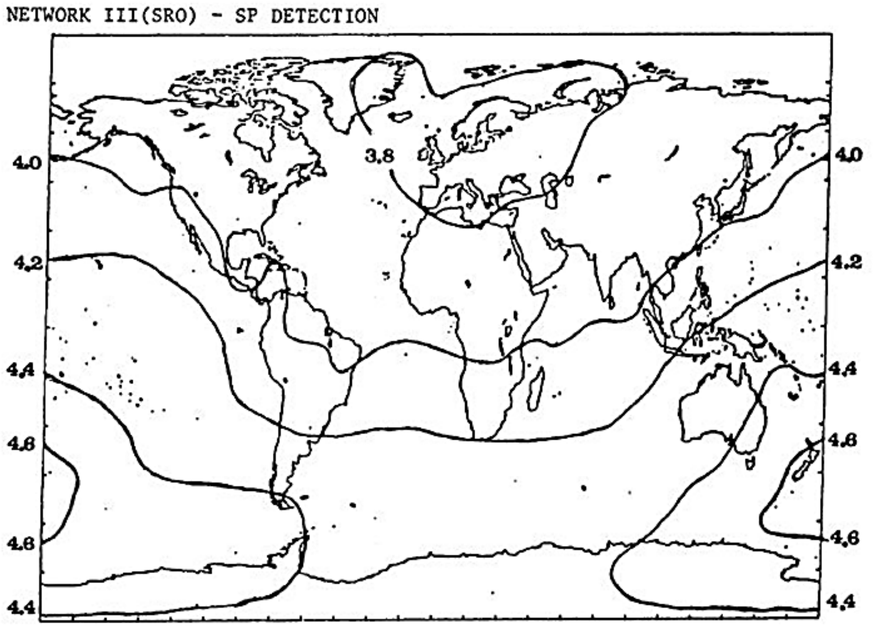


Figure 4.3 Map showing the location of stations in Network III and Network III (SRO).

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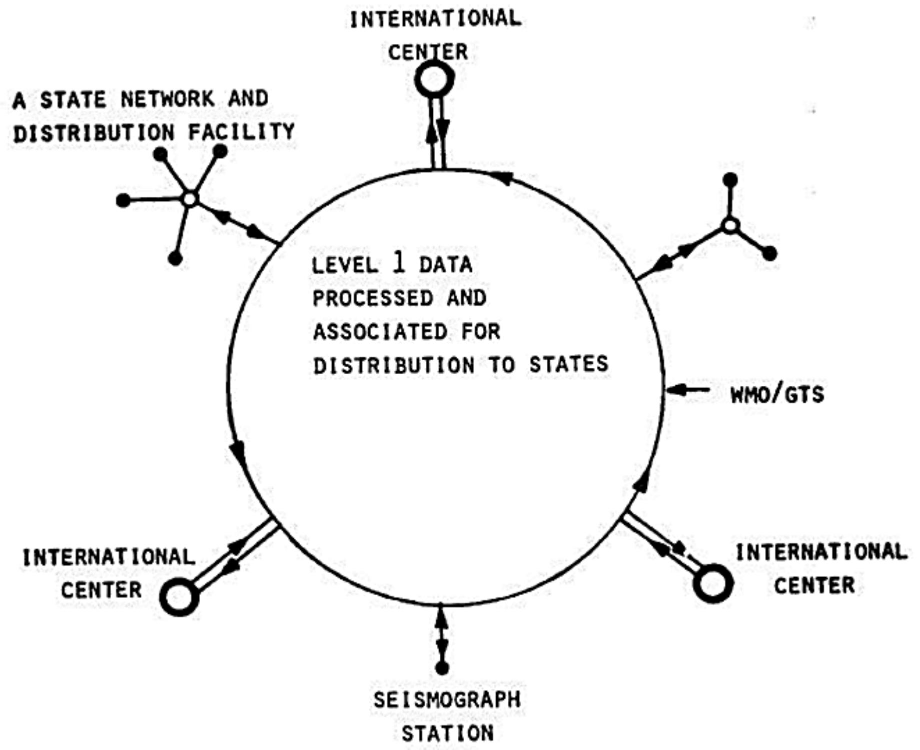
The First Mandate of the CCD to the GSE (continued)
The Concept of Data Communications



PURPOSE OF STATE FACILITY:

1) SENDS LEVEL 1 DATA
2) RECEIVES EPICENTERS AND ASSOCIATED IDENTIFICATION PARAMETERS
3) SENDS AND RECEIVES LEVEL 2 DATA ON REQUEST.

A SINGLE STATION WHEN OFFICIALLY AUTHORIZED HAS SIMILAR COMMITMENTS.

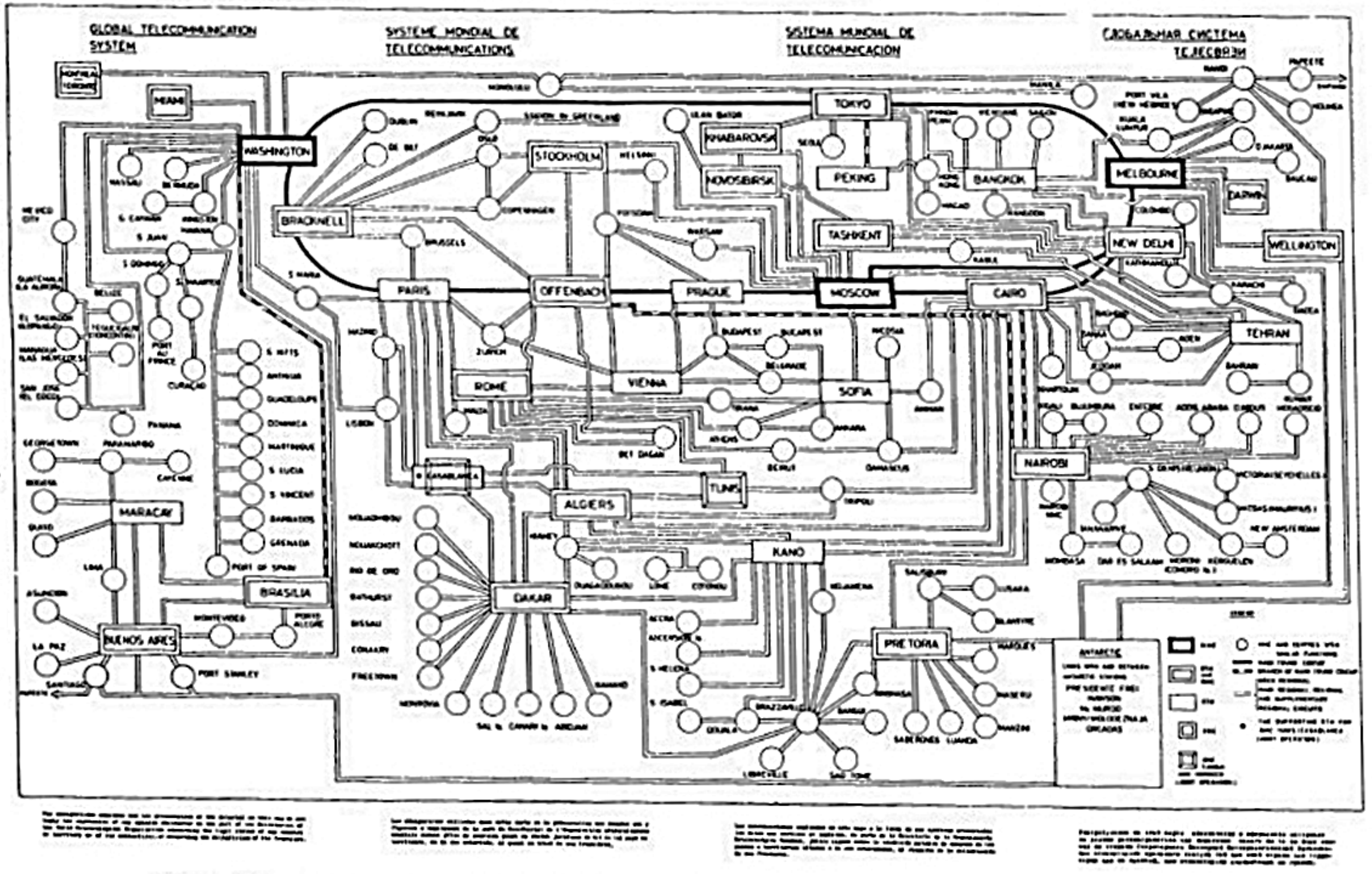


Figure 6.1 Schematic view of the WMO/GTS communications network.

The First Mandate of the CCD to the GSE (continued)

- The data from each individual observatory should be provided on two levels:
  - **Level I:** Routine reporting, with minimum delay, of parameters of detected seismic signals;
  - **Level II:** Data transmitted as response to requests for additional information, mainly waveforms for seismic events of particular interest.

- It should be noted that **Level I and Level II data are fundamentally different**, in both number and volume. **Level I data** would comprise condensed information of each detected seismic event (typically ten or more per day for each station), and would include, inter alia, the onset time of energy, the dominant signal frequency, and the signal amplitude. These measurements would then be transmitted to the IDCs for rapid processing using the WMO/GTS links. In contrast, **Level II data** for each requested event would be many orders of magnitude more voluminous than the Level I data, but would be requested only for seismic events of particular interest in a CTBT monitoring context (Dahlman *et al.*, 2020).

Initial GSE Level I Data Exchange

Early Trials (1978):

Initial concept of international data exchange adopted by the GSE, based mainly on parametric (Level I) data (seismic bulletins).

- Seismograms analyzed daily in each seismic station.
- Parameters visually extracted from seismograms by the analysts.
- Bulletins containing arrival times and amplitudes in standard format prepared in each National Data Center (NDC).
- Bulletins sent by **telex** over the **World Meteorological Organization (WMO) communication systems**, with the **concept that all the data are available to all participants**.

Each phase reported in the bulletin should include:

- Arrival time.
- Phase name (according to the IASPEI standard) if known.
- Amplitude and period of the ground motion.
- (For teleseismic P waves only) Maximum amplitude in the first 2-5 s.
- (For teleseismic P waves only) Maximum amplitude in the next 25-30 s.

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Data Proposed to be Exchanged at Level I Short Period Instruments

Short period Parameters (Body waves-Vertical Component)	Unit of Measurement	Precision of Measurement	Volume of Data (Computer Words)
a). Standard Parameters - All stations			
1. Arrival time	hour,min,s	0,1 s	3
2. First motion sign and clarity (if possible)			1
3. *Amplitudes A_i (i=1, ...,4)	nm	0,1 nm	4
4. *Arrival times corresponding to each A_i	hour,min,s	0,1 s	12
5. *Periods corresponding to each A_i	s	0,1 s	4
6. Signal-to-noise ratio			1
7. Phase description,			1)
Amplitude	nm	0,1 nm	1) 6xn
Period	s	0,1 s	1)
Arrival time	hour,min,s	0,1 s	3)
of secondary phases, e.g., S, PcP, PP,... (reported when possible)			where n is the number of phases detected
8. Complexity (digital stations only)			1
9. Spectral moment, ratio or vector (digital stations only)			1-6
b). Additional Standard Parameters - Arrays Only			
10. Apparent velocity	km/s	0,01 km/s	1
11. Epicenter azimuth and distance	degrees	0,01 degrees	2
12. Epicenter latitude and longitude	degrees	0,01 degrees	2
13. Estimated time at focus	hour,min,s	1 s	3
14. Magnitude m_b		0,1 unit	1

* The A_i, i=1,2,...,4 correspond to maximum amplitudes in the intervals 0-6 seconds, 6-12 seconds, 12-18 seconds and 18-300 seconds after P-wave arrival, respectively.

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Data Proposed to be Exchanged at Level I Long Period and Broad-Band Instruments

Long Period Parameters	Unit of Measurement	Precision of Measurement	Volume of Data (Computer Words)
a). Standard Parameters - All Stations			
(i) Body-waves (Vertical and horizontal components)			
1. Arrival time	hour,min,s	1 s	3
2. Maximum amplitude A_{max}	nm	1 nm	1
3. Arrival time of A_{max}	hour,min,s	1 s	3
4. Period corresponding to A_{max}	s	0.1 s	1
5. Noise amplitude A_N	nm	1 nm	1
6. Period corresponding to A_N	s	0.1 s	1
7. Phase identification, amplitudes, arrival times and periods for additional phases, e.g., ScS, etc. (reported when possible)			6xn where n is the number of phases
(ii) Surface waves (Rayleigh-vertical and Love-horizontal)			
8. Arrival time	hour,min,s	1 s	3
9. Maximum amplitude A_{max}	nm	1 nm	1
10. Arrival time of A_{max}	hour,min,s	1 s	3
11. Period corresponding to A_{max}	s	1 s	1
12. Maximum amplitudes for periods of 10, 20, 30 40 seconds	nm	1 nm	4
13. Arrival times of maximum amplitudes at 10, 20, 30, 40 seconds	hour,min,s	1 s	12
14. Noise amplitude A_N	nm	1 nm	1
15. Period corresponding to A_N	s	1 s	1
16. Association to short period detection (if possible)			1
b). Additional Standard Parameters - Arrays Only			
17. Apparent velocity	km/s	0.1 km/s	1
18. Epicenter azimuth	degrees	1 degree	1
19. Magnitude M_s		0.1 unit	1

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The GSE at the End of Its First Mandate: March 1978

Standing, from left to right: V. Kàrnik, I. T. Noponen, J. Hjelme, E. Bisztricsàny, M. M. Schneider, A. J. Meerburg, H.-P. Harjes, P. M. McGregor, R. D. Adams, P. W. Basham, A. R. Ritsema, J. R. Filson, P. K. Iyengar, R. Hagengruber, B. M. Tygard, H. I. S. Thirlaway, L. S. Turnbull, R. Console, I. R. Kenyon, L. Ocola, E. S. Husebye, I. Passetchnik, I. Botcharov, O. Kedrov, H. Israelson, O. Dahlman, gentleman (not identified). **Seated, from left to right:** L. V. Hristoskov, S. Suyehiro, F. Ringdal, U. Ericsson, P. Csillag, lady (not identified), R. Teisseyre.

The GSE Second and Third Mandate

- The **Conference of the Committee on Disarmament (CCD)** was renamed the **Conference on Disarmament (CD)** in **1979**.

- The **second mandate** to the GSE included its sixth (24 to 28 July 1978, CCD/576), seventh (19 February to 1 March 1979, CD/18) and eighth session (16 to 27 July 1979), when the GSE submitted its second report (CD/43).

- The **third mandate** was quite longer: from the ninth (11 to 15 February 1980, CD/61) to the 17th session (27 February to 9 March 1984), when the GSE submitted its third report (CD/448).

- Ulf Ericsson of Sweden served as Chairman of the *Ad Hoc* Group from 1976 until his death in November 1982. During these years, he guided the work of the Group with great skill and dedication.

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

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The GSE in the Early '80s

Following the country alphabetic order:

- P. M. McGregor, L. V. Hristoskov, P. W. Basham, V. Karnik, J. Hjelme, M. M. Schneider, H.-P. Harjes, E. Bisztricsany, P. K. Iyengar, R. Console, S. Suyehiro, A. R. Ritsema, R. D. Adams, L. S. Turnbull, I. R. Kenyon, 0. Kedrov, H. Israelson.

The GSE Conference Room (February 1983)

M. Yamamoto, R. Console and P. H. Grover.

L. V. Hristoskov, O. Kedrov, M. M. Schneider, H.-P. Harjes , E. Bisztricsany, R. Console and P. H. Grover.

The GSE Informal Receptions

- Besides the formal meetings, the GSE experts used to organize informal receptions.

- This photo was taken at the happy hour of the Australian delegation in August 1983: R. Console (Italy), H. Korhonen (Finland), P. M. McGregor (Australia), and P. H. Grover (UK).

The GSE in March '86

We can recognize, among others:

- R. D. Adams, E. Bisztricsany, M. M. Schneider, S. Suyehiro, O. Kedrov, I. Passetchnik, R. Alewine , F. F. Pilotte.

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New Countries and New Experts Were Joining the GSE

22 July 1986 official photo, among the others: R. Kebeasy (Egypt), X. Xian-jie (China), A.U. Kerr (USA), M. Henger (Germany, Fed. Rep.), S.J. Gibowicz (Poland), R. Alewine (USA), P. Johansson (Sweden), R.G. North (Canada), F. F. Pilotte (USA), D.L. Springer (USA), P.D. Marshall (UK), E. Johannisson (Sweden).

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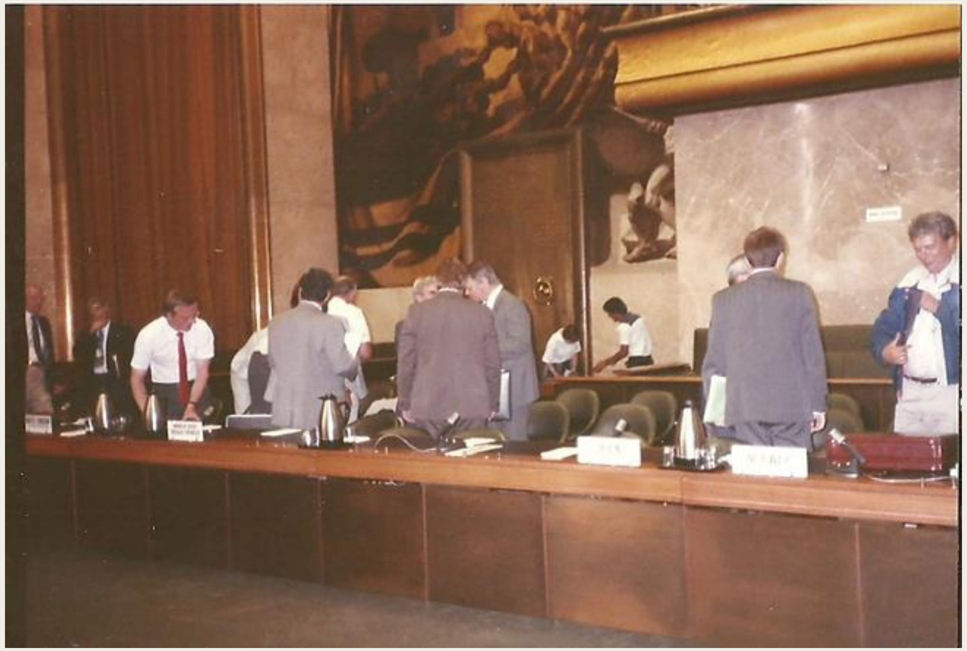
The GSE in the Council Room (August '89)

We can recognize, among others:

- S. Suyehiro, E. Johannisson, F. Ringdal, O. Kedrov, E. S. Husebye.



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The GSE Workshops

- **The first: 1978, Japan, Tokyo,** included a visit at the Matsushiro Seismological Observatory.
- **Second one: 1980, Federal Republic of Germany,** Erlangen, included a visit at the BGR Grafenberg Array.
- **Several others followed**:

Ottawa, Canada, October 1984. **Linkoping, Sweden, May 1988.** **Montebello, Canada, November 1992.**

The GSE Tests

- **GSE activities** played a crucial role in **testing and assessing components for a future monitoring system**. However, the **technological limitations of the late 1970s** significantly restricted what could be practically tested. As new advancements emerged, they were gradually incorporated. Some tests (named "technical trials") were initially conducted on a small scale and focused mainly on the capacity of data transmission, rather then on the content of data itself.

- The GSE also carried out **three large-scale global tests** focused on exchanging and analyzing data, mainly from natural earthquakes.

- The **first test** (GSETT-1, 1984) utilized Level I data from participating seismic stations, primarily transmitted through WMO/GTS channels. The **second test** (GSETT-2, 1991) expanded data exchange by including both Level I and the much larger Level II data, using high-speed transmission links. Data from both tests were analyzed at up to four experimental international data centers located in Canberra, Moscow, Stockholm, and Arlington, Virginia. The **third test** (GSETT-3, January 1995 – February 2000) was the most ambitious, aiming to **develop a prototype for a centralized international data center** capable of evolving to meet future seismic monitoring needs under a treaty.

(From Dahlman *et al*., 2020)

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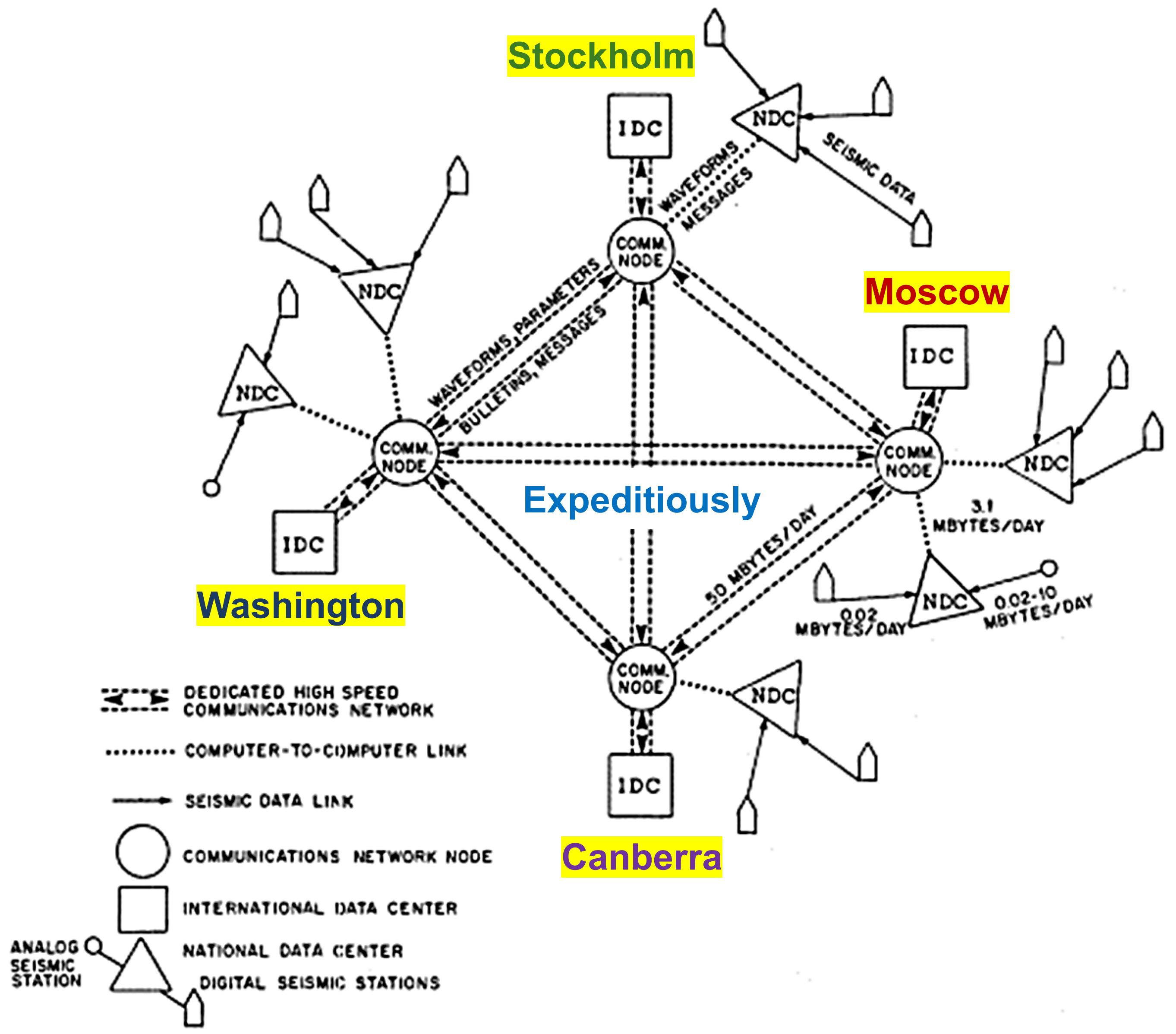
The Concept of Multiple IDCs

- GSE proposed in 1987 the concept of **multiple IDCs** in the **Global Communication System of the international exchange of seismic data**.

- It was tested during **GSETT-2, in 1991** (after an initial simpler form **in GSETT-1, in 1984).**

- From 80 baud (bits per second) by telex of the 1970's with bulletins only, to 3.1 MBytes per day of 1991 with exchange of waveforms via satellite link, to today's 36 GBytes/day.



The GSE Informal Receptions

GSE friends: D. Springer, R. Console, S. Suyehiro and G. Payo (July-August 1989).

Donald Springer used to invite all the GSE experts to a reception organized at his hotel once per session.

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The GSE during the August 1991 Session in Geneva

(From Dahlman *et al.*, 2020)

The GSE during the Workshop in Dallas, Texas in December 1991

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The GSE during a Break in the Summer Session of 1993

We can recognize, among others, in the **first photo:** B. Massinon, R. Kebeasy, S. Suyehiro, P. W. Basham, S. Mykkeltveit, N. N. Belyashova, H. Trodd; in the **second photo:** H.-P. Harjes, J. Hjelme, F. Ringdal, A. Kijko, H. Haak, R. Alewine, U. Kradolfer.

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Reception at the residence of the Japanese Ambassador, Summer 1993

N.-O. Bergkvist, C. Lopez, W. Debski, L. Toth, M. Henger.

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CTBT *Ad Hoc* Committee – Geneva, 1993

The GSE Story:
Conceptual Development of the CTBT Verification System

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GSETT-3 Workshop – Erice, Sicily – November 1993 (OSI concept – P. Marshall)

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Frode Ringdal
NFR/NORSAR, Kjeller, Norway

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Accurate determination of phase arrival times using autoregressive likelihood estimation

Tormod Kværna
NFR/NORSAR, Kjeller, Norway

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Automated detection and association of surface waves

Robert G. North and Catherine R.D. Woodgold
Geophysics Division, Geological Survey of Canada, Ottawa, Ontario, Canada

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Seismic signals detection and classification using artificial neural networks

Giovanni Romeo
Istituto Nazionale di Geofisica, Roma, Italy

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Near real time estimation of magnitudes and moments for local seismic events

Cenk Deniz Mendi (1)(2) and Eystein S. Husebye (1)
(1) University of Bergen, Institute of Solid Earth Sciences, Bergen, Norway
(2) On leave from TÜBİTAK, Marmara Research Center, Earth Sciences Department, Gebze, Kocaeli, Turkey

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On-site inspection for nuclear test ban verification

Peter David Marshall, O.B.E.
AWE Blacknest, Brimpton, U.K.

Informal Meeting at the ING Headquarters of Rome (1993)

G. Smriglio (ING), U. Kradolfer, H. Trodd, C. Lopez, D. Springer, S. Suyehiro, R. Console, R. Di Giovambattista (ING).

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The GSETT-3 Seismic Network

- As of August 1994, the GSE submitted to the CD the progress report of its 39th session (CD/1270).

- The CTBT verification system to be tested in the GSETT-3 envisaged 58 Alpha (*i.e.,* primary) stations, 93 Beta (*i.e.,* auxiliary) stations and gamma data from NDC.

Annex I: Status of GSETT3 Station and Gamma Data Committments

Country	Alpha Stations Envisaged by GSE	Beta Stations Offered	Station Committment Status	Date Available to the IDC	Gamma Data Committed
Argentina	1	-	committed	Dec. 1994	yes
Australia	5	11	committed	Aug./Sept.1994	yes
Austria	0	1	lacking	unknown	-
Belgium	0	0	not applicable	not applicable	yes
Bolivia	1	-	lacking	unknown	-
Botswana	1	-	lacking	unknown	-
Brazil	1	0	committed	unknown	-
Bulgaria	0	1	committed	July 1995	yes
Canada	6	18	committed	Now/Sept. 1994	yes
Cen. Afr. Republic	1	-	committed	unknown	-
China	3	1	lacking	unknown	-
Cook Islands	0	1	committed	now	-
Czech Republic	0	1	committed	Sept. 1994	yes
Denmark	1	0	lacking	July 1995	yes
Egypt	1	0	lacking	unknown	-
Finland	1	4	committed	now/Nov. 1994	yes
France	1	0	committed	Jan. 1995	yes
Germany	1	9	lacking	unknown	-
Hungary	0	1	committed	now	yes
India	1	0	committed	unknown	-
Indonesia	1	-	lacking	unknown	-
Iran	0	1	lacking	June 1995	yes
Israel	0	1	lacking	Nov. 1994	-
Italy	0	2	committed	now	yes
Ivory Coast	1	-	lacking	unknown	-
Japan	1	7	committed	Sept. 1994	yes
Kazakhstan	1	-	lacking	unknown	-
Kenya	1	-	lacking	unknown	-
Rep. of Korea	1	-	lacking	unknown	-
Mexico	1	2	lacking	unknown	-
Netherlands	0	1	committed	Aug. 1994	yes
N. Africa (XAF)	1	-	lacking	unknown	-
New Zealand	0	1	committed	now	yes
Norway	3	1	committed	now/Oct. 1994	yes
Pakistan	1	1	committed	expect Jan.1995	-
Papua New Guinea	1	-	lacking	unknown	-
Paraguay	1	-	lacking	unknown	-
Peru	0	1	committed	Dec. 1994	-
Poland	0	1	lacking	unknown	yes
Romania	0	1	committed	Sept. 1994	yes
Russian Federation	5	5	committed	Jan. 1995	-
S. America (XSA)	1	-	lacking	unknown	-
South Africa	1	1	committed	Aug./ Dec. 1994	yes
Spain	1	2	committed	Jan. 1995	yes
Sweden	1	0	committed	Sept. 1994	yes
Switzerland	0	1	committed	Jan. 1995	yes
Thailand	1	-	lacking	unknown	-
Turkey	1	-	lacking	unknown	-
Turkmenistan	1	-	committed	unknown	-
United Kingdom	0	2	committed	Oct. 1994	yes
United States	7	12	committed	Aug.- Nov. 1994	yes
Western Samoa	0	1	committed	now	-
Zambia	0	1	lacking	unknown	-
TOTAL (Committed)	58 (38)	93 (76)	29 Countries		24

The GSE Story:
Conceptual Development of the CTBT Verification System

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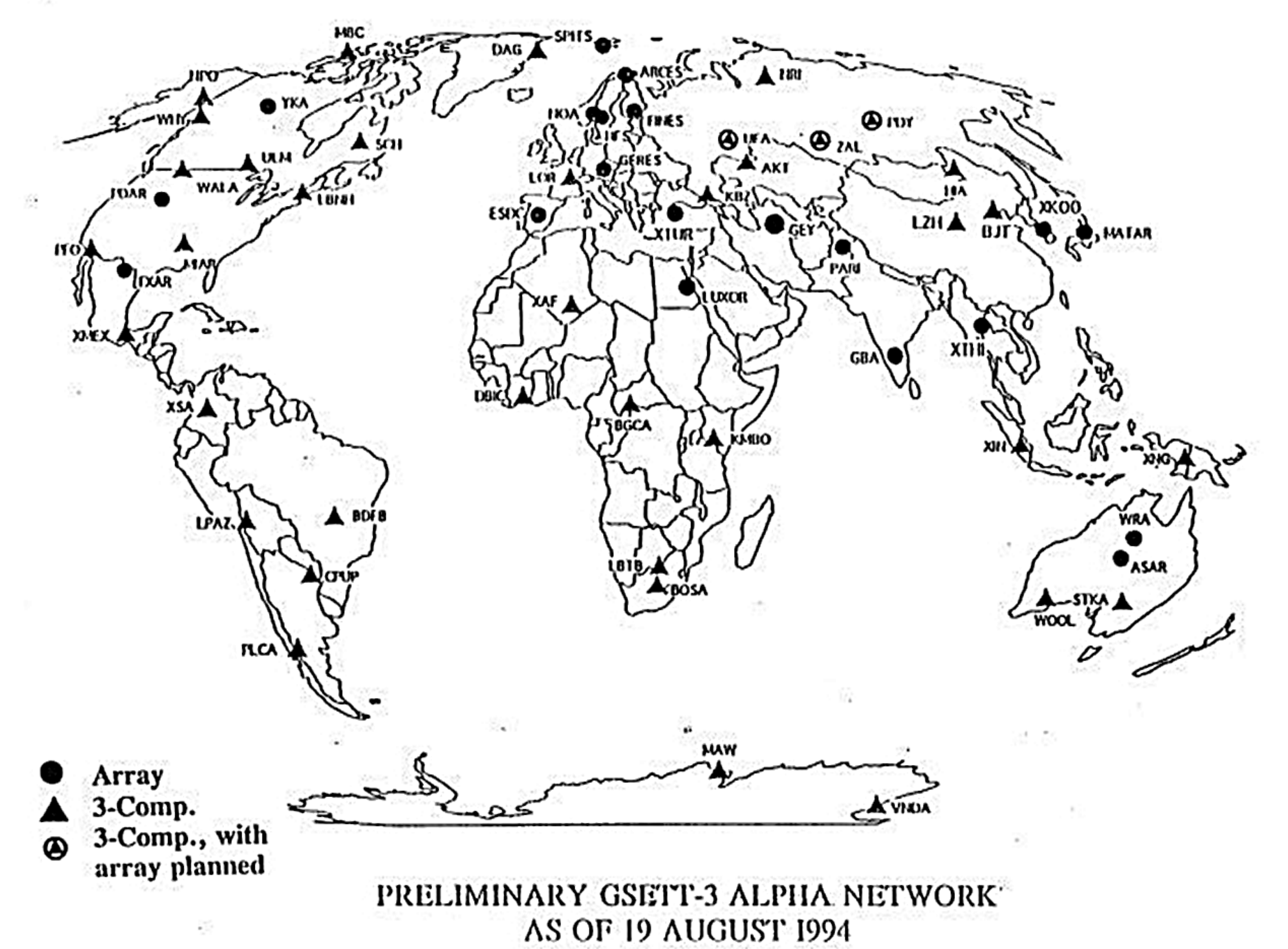
Map of the GSETT-3 Alpha Network



The GSETT-3 Prototype International Data Center (PIDC)

- The Prototype International Data Centre (PIDC) in Arlington, Virginia, USA, played a key role in the GSETT-3.

- The PIDC operated continuously between January 1995 and February 2000.

- Starting with seismic data only, the PIDC was responsible for real-time data collection, processing, analysis, and distribution of data and products.

- There was a smooth and orderly transition from GSETT-3 PIDC to CTBTO PrepCom's monitoring system (IMS and IDC).

1995: Richard Gustafson demonstrating the PIDC capability

The GSETT-3 PIDC Tasks

- Acquired data from over 200 seismic, hydroacoustic, infrasonic and radionuclide facilities worldwide.

- Performed:
  - **signal detection identification** of seismic waves generated by underground disturbances;
  - **event association**: correlating detected signals from multiple stations to determine the location, depth, and magnitude of an event;
  - **event characterization**: providing suitable parameters for event screening.

- Run automatic processing (to produce the automatic products, SELs and ARR) and performed interactive analysis to produce Reviewed Event Bulletins (REB) and Reviewed Radionuclide Reports (RRR) that were issued daily under EIF timeliness requirements:
  - the REBs produced by PIDC contained 99,212 events.

- Distributed data and products to many institutions in the world (existing or future NDCs).

The GSETT-3 PIDC

- Over 50 nations participated in GSETT-3 through the operation of stations, provision of data and bulletins, and staffing the PIDC.

- A visiting scientist program brought scientists from many countries to participate in the development, operation and evaluation of the PIDC.

The international PIDC team in 1995.

The GSETT-3 PIDC Success

- Participation steadily increased and new functionality was added to the PIDC every few months. Many new features were provided by a variety of US and foreign agencies.

- Several analysts and processing engineers were trained. Many of these scientists supported the IDC/IMS and WGB tasks in the years after 2000.

- GSETT-3 bulletins have been used by the USGS National Earthquake Information Center and the International Seismological Centre (ISC) and have markedly improved the products of these two agencies.

- The software developed for, and tested at, the PIDC was transferred to the IDC in Vienna in a series of software releases, completed early in 2002.

- The development and operation of the PIDC helped establish the technical capability to monitor the CTBT, served as platform for international technical cooperation and as the operational test and evaluation platform for transition to the Treaty IDC.

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GSE Final Meeting – Geneva, August 1996

Standing, in the back row, from left to right, among others: M. Tarvainen, E. Hjortenberg, O. Starovoit, P. W. Basham, J. R. Filson, M. D. Denny, R. Console, L. Toth, S. Mykkeltveit, M. Henger, H. Haak. **Standing, in the middle row, from left to right, among others:** J. Schulze, N.-O. Bergkvist, V. Kovalenko, B. Massinon, H.-P. Harjes, R. Alewine, H. Trodd, R. M. Kebeasy, M. De Becker, P. Johansson, S. Xu, R. Crusem, U. Kradolfer, W. Debski, I.-B. Kang, P. Harjadi. **Seated, from left to right, among others:** L. V. Hristoskov, S. Suyehiro, F. Ringdal, O. Dahlman, J. Mackby, N. N. Belyashova, C. Lopez.

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The CTBTO International Monitoring System and the Vienna International Center

Many GSE members continued activity as PTS staff or WGB delegates!

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14 years later...
(SnT 2013)

Vitaly Schchukin, Natalya Belyashova, Bernard Massinon, Rashad Kebeasy, Jon Fyen, Frode Ringdal, Pierce Corden, Ralph Alewine, Svein Mykkeltveit, Rodolfo Console.

25 years later…
(NDC Workshop, Toledo, October 2022)

Victoria Oancea, Gus Gustafson, Rodolfo Console, Carmen Lopez.

Acknowledgements

- I am grateful for the support received from several GSE colleagues in the preparation of this presentation.

- In particular, Victoria Oancea provided material concerning the PIDC, and Svein Mykkeltveit and Jenifer Mackby reviewed the whole text.

- Paul Richards contributed with relevant material concerning the early negotiates for the CTBT.

- Thanks also to the Italian NDC colleagues that contributed to the collection of pictures and documents.

THANK YOU!

I am grateful for the support received from several GSE colleagues and other scientists in the preparation of this presentation.

- Link to the **Nobel Laureate Assembly For the Prevention of Nuclear War** on occasion of the **80th Anniversary of the Trinity Test**, including the speech by CTBTO Executive Secretary Dr. Floyd, available here: https://vimeo.com/1099802892

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