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VII.6 Report on an affordable, interactive and mobile seismic array installation

The primary objectives of seismic arrays are to monitor earthquake and nuclear explosion occurrence both on local and global scales, and to provide a data base for further research. However, large arrays such as NORSAR are costly to build and have high operational and maintenance overheads. On the other hand, technically simple arrays without an integrated time basis and non-digital recording produce data which are extremely difficult to handle and analyze efficiently. This article reports on the realization of a fully automated digital miniarray that is affordable for most research groups.

The basic concept here is that of the Remote Seismic Terminal Enhanced (RSTE), a field unit whose tasks comprise analog/digital conversion of data streams, real-time event detection processing, creation of event logs/seismic bulletins as a background processing task and finally temporary storage of original event data of significance.

The data center unit is operated by an RST which may be a much simpler device, say based on a personal computer with graphics installed in a study at home. The major tasks of the RST are to retrieve data from the field, download new operational instructions for the RSTE, redefine operational parameters, etc. The RST/RSTE communication link may either be via the switched telephone network, satellites or other convenient means.

The miniarray system we are now designing may be termed a second-generation RSTE/RST system, as our first generation, tied to a small North Star minicomputer, already has been demonstrated to work satisfactorily (e.g., see Husebye and Thoresen, 1984). Design considerations here are to:

- take advantage of recent improvements in communications systems and advances in microcomputer technology
- to produce a presumably affordable seismological recording system that can retrieve, process and transfer data in automated and semi-automated modes from an array remotely located

- to produce continuous/detected data from an unattended array that is immediately available to the user, thereby severing links with slow and cumbersome centralized data centers. Adding a color graphic display option to the host computer entails that waveform displays and associated analysis results can easily be visually assessed by the user even if the RST is based on a personal computer set-up.
- to produce a mobile and interactive system that allows the user ultimate flexibility in creating his own data base.

Present hardware configuration (Fig. VII.6.1)

The RSTE is based on the OMNIBYTE minicomputer which is powerful and consequently relatively expensive. Its choice was motivated by flexibility in software development for a prototype system. Adding a multiplexer to the A/D converter, it can handle up to 32 channels (differential inputs or 64 single-ended channels), although A/D conversion and multiplexing 8 channels of 16 bits requires 4 ms. We are considering a double input from each seismometer; one unfiltered and one analog bandpass filtered channel. The S-500 seismometer is inexpensive and completely portable without the need for a mass lock. It can be operated as either a vertical or horizontal instrument in a variety of environmental conditions. Peaked at 1 Hz, the instrument response is virtually flat to 100 Hz.

The RST is configured around a personal computer (PC-type, IBM compatible) with Polyforth operating system and language. Any reasonable computer may serve as host, although use of a PC is to emphasize the personal seismometry aspect. A color graphics option is included for waveform display enabling interactive operations thereby providing an analyst with considerable flexibility in seismogram analysis.

System design principles

Array operation as seen today or in the past comprises five major tasks, which naturally are incorporated into the remotely located miniarray. These tasks are:

i) Data transmission from seismometer to RSTE. In order to save on costly transmission fees charged by local telecommunications utilities, it is essential that data processing takes place in the field. A/D conversion is at the seismometer vault to cut down on transmission line noise.

ii) Real-time event detection processing. Noise suppression is via simple bandpass filtering. Detector design is by the relatively simple STA/LTA process operating on a 'voting' detector. It has been decided to abandon beamforming detection because of its extravagant computing requirements and in this context, negligible detection abilities over the voting detection scheme.

iii) Event analysis; signal parameter extraction and event log (daily bulletin preparation. This will be performed by the RSTE without any analyst intervention. Fast frequency-wavenumber analysis combined with phase/seismicity zone recognition algorithms ensures that bulletin preparation will include all quality data.

iv) External hardware testing and operational software modifications. In this system it is possible to down-load operational parameters (such as filter parameters, A/D converter gain settings, detector threshold levels, etc.) from the RST to the RSTE, and perform simple response tests of the seismometers.

v) Communication, data storage and exchange. This can be decided upon by the user and may be via switched telephone networks, radio/microwave telemetry, dedicated data links or satellite communications. It is estimated that only 5 mbyte of data are to be transferred daily, and will not be a costly operation.

The hardware/software system is schematically shown in Fig. VII.6.2 and is planned to be operational in August 1984.

Cost breakdown

The hardware cost for the compact RSTE field unit (excluding seismometers) consisting of CPU board, A/D converter, 4 mbyte RAM and modem is estimated to roughly $6000, while an RST (personal computer, graphics monitor/software and modem) is estimated to roughly $4000.

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Reference

Husebye, E.S. and E. Thoresen (1984): Personal seismometery now! EOS, May 1984 (in press).

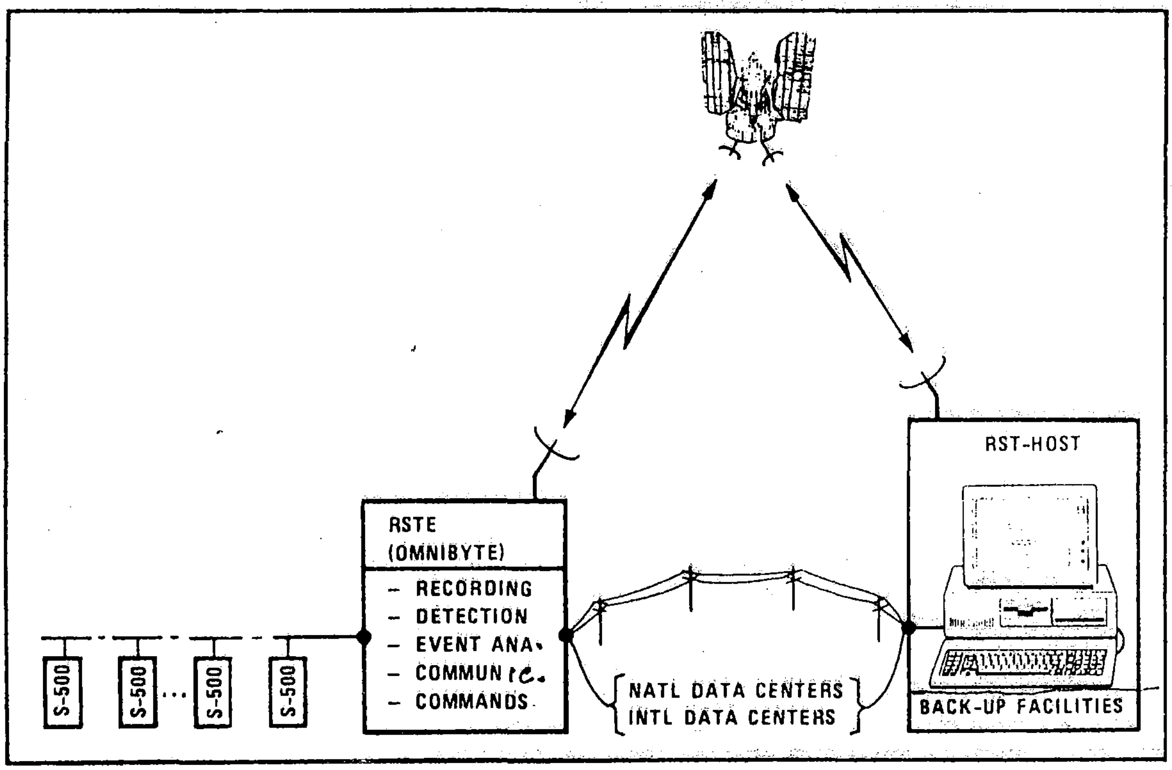

Fig. VII.6.1 Illustration of the RSTE/RST concept (Remote Seismic Terminal (Enhanced)). The RSTE is a specialized minicomputer system in the field whose main tasks are to sample, control and analyze outputs from an array of seismometers. It is remotely controlled, including options for software modifications, from an RST or host computer which even may be of the 'personal computer' type. Back-up facilities may comprise a printer, and extra data storage on disk or tape. The only similarities between the RSTE and RST are the communications protocols for transfer of selected 'raw' data and analysis results from field to host, and down-loading commands in the RSTE system from the RST. National and international seismological data centers may be granted permission to independently extract data and/or analysis results from the RSTE or RST.

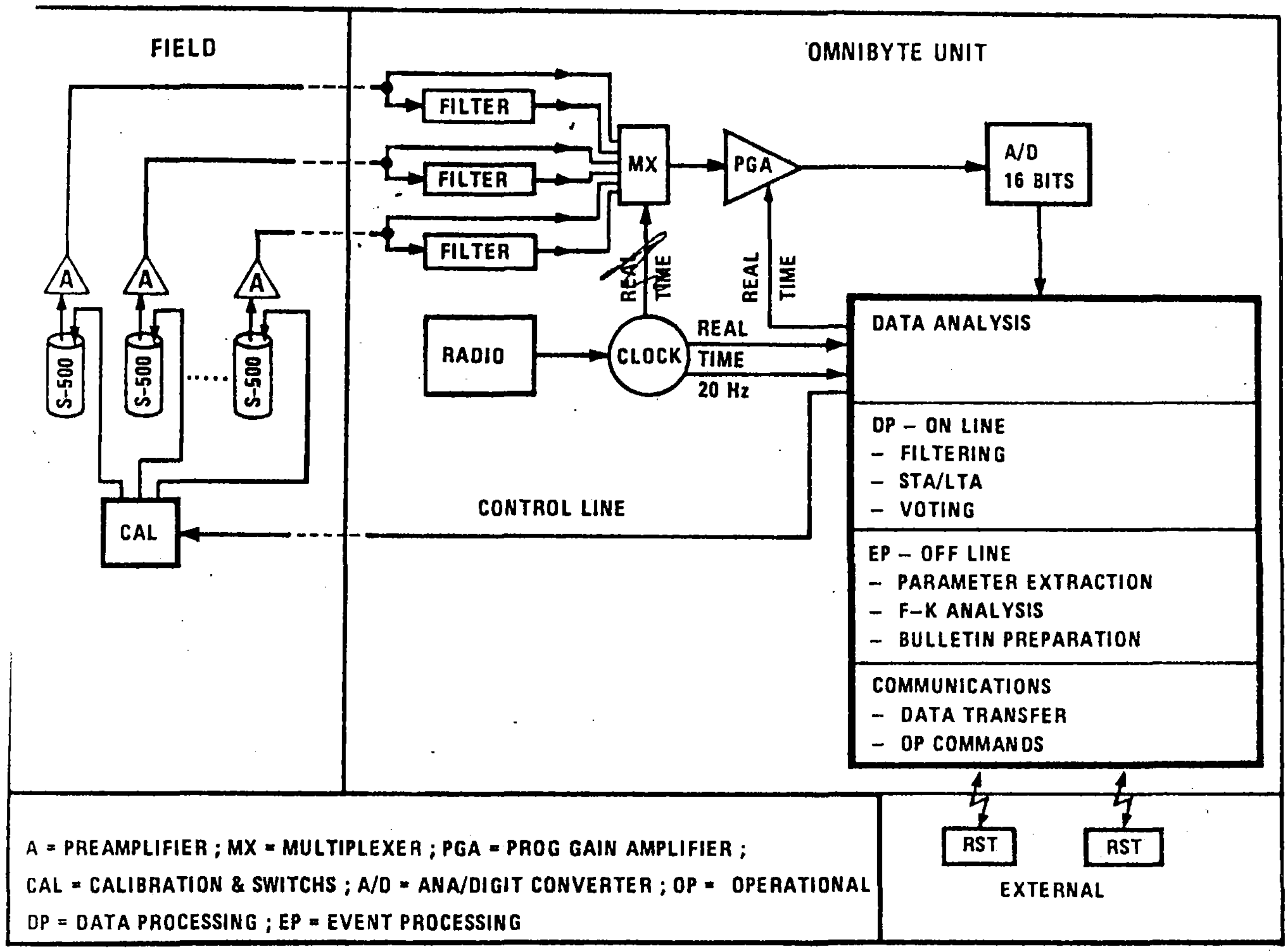

Fig. VII.6.2 The RSTE hardware configuration as detailed in text plus the essential steps involved in the data analysis centered on the powerful OMNIBYTE minicomputer. Using a multiplexer the A/D converter can handle up to 32 channels, which, if desired, permits seismometer inputs to be split in two, for example, an unfiltered and an analog-filtered channel. Such an option would reduce the CPU-load during the on-line detection processing.