GeoWatch

June 2003, Issue 19

GeoSIG

Table of contents

- Foreword from the CEO 1
- GeoSIG Announces the Deployment of the Revolutionary Internet Accelerograph, IA-1 1
- Structural Monitoring and Measurement System for Beli Iskar Dam, Bulgaria 5
- New Manual of Seismological Observatory Practice (NMSOP) is Published by IASPEI 5

Foreword from the CEO

Many metropolitan areas around the world are under earthquake hazard. To reduce the risks associated with potential seismic activities in an area, one has to be able to define the vulnerability of the lives and assets under concern, as well as the potential hazard. A significant step towards achieving such a goal is to construct a high density and reliable seismic network.

Seismic networks for urban disaster management and seismic monitoring require numerous instruments to be able to cover the whole area under interest. The costs associated with such networks are usually beyond the reach of many research or public institutions. Furthermore, direct and indirect complexities such as finding willing and cooperative location owners for station installation, or setting up reliable and continuous data communications with the network center, and keeping up with the maintenance of such a network usually discourage many of such organisations.

Under a comprehensive cooperation with Geological Survey of Canada, GeoSIG is proud to present a ground-breaking solution to especially high density networks, the Internet Accelerograph, IA-1.

While we present in this GeoWatch this exceptional instrument; regarding the capabilities and potential uses of IA-1, as well as considering how rapid the internet usage and related infrastructure has been growing since the last decade, we believe that IA-1 opens up a new era in the history of seismic monitoring, with an unlimited potential for the future.

Also in this issue of the GeoWatch you will find a brief case report from the Beli Iskar Dam instrumentation in Bulgaria, as well as news from IASPEI on the New Manual of Seismic Observatory Practice.

Christoph Kündig

GeoSIG Announces the Deployment of the Revolutionary Internet Accelerograph, IA-1

Early in 2003, Geological Survey of Canada (GSC) and GeoSIG agreed to combine their expertise on development, production and international distribution of a revolutionary three-component strong-motion seismograph, specifically for use in urban areas, under the name Internet Accelerograph, or IA-1. The IA-1 had been under design; development and testing for some time at the Pacific Geoscience Centre (PGC), an institute of the GSC.

The IA-1 is introduced to the seismic community during SSA 2003 Annual Meeting in San Juan, Puerto Rico, between 29 April-2 May 2003. During which detailed information about the instrument was presented and the actual instrument was displayed. The following paragraphs are adopted from the poster prepared by Andreas Rosenberger, Ken Beverly and Garry Rogers of GSC, presented in the SSA 2003 meeting:

Introduction

Urban seismology requires dense networks of seismic instruments of varying sensitivity. While few highly sensitive instruments with a resolution greater than 120 dB will serve as reference stations, limitations in resolution and sensitivity are acceptable for the majority of instruments in a noisy urban environment.

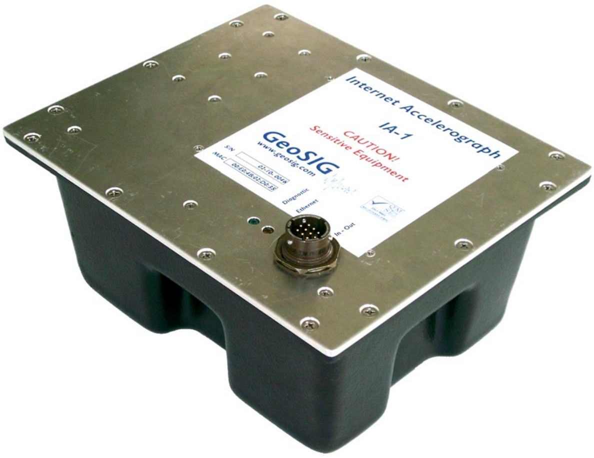


Figure 1. Revolutionary IA-1, an all-in-one and affordable solution to high density networks

Due to the very large numbers of instruments required, it is of critical importance, that installation, maintenance and data retrieval is organized in a simple and efficient way.

The IA-1 design and development project emerged from these facts and soon a prototype was constructed, which was thoroughly tested in Canadian and German facilities.

Furthermore, one-hundred instruments were built initially and about 30 instruments have been deployed to-date in a field test as a pilot project, in a 5 by 8 kilometer area covering parts of the cities of Vancouver and Richmond in British Columbia, Canada as illustrated in Figure 2.

Figure 2. Five by eight km pilot project area in the Cities of Vancouver and Richmod, British Columbia, Canada.

Instrument

IA-1 features the following innovative concepts:

- Inexpensive mass-production acceleration sensors are used in a special arrangement to increase their sensitivity.
- An embedded computer performs data acquisition, signal processing and Internet communications.
- The instrument itself does not have an accurate clock but maintains accurate time by synchronizing with Internet timeservers.
- A public domain operating system performs real-time processing with better than 10 ms absolute timing accuracy.
- Three component accelerometer, digitizer and Internet data server are combined in one compact instrument.
- Derivative data, such as ground velocity, ground displacement and spectral intensity are computed as continuous data streams in real time.
- Events and event parameters are reported to a data-center in near real-time.
- Data retrieval and full control over acquisition parameters is accomplished over the Internet.

Tests

Prototypes of the IA-1 were extensively tested on shake-tables at Zentrum für Angewandte Raumfahrt und Mikrogravitation (ZARM), the Mechanical Engineering Faculty of the University of British Columbia (UBC) and the Institut de Recherche d'Hydro-Quebec (IREQ) [1].

The instrument response to a 1 octave/minute 5 to 50 Hz sweep on the slip-table of IREQ's electrodynamic

Figure 3. IREQ Shake Table testing of the IA-1 prototype

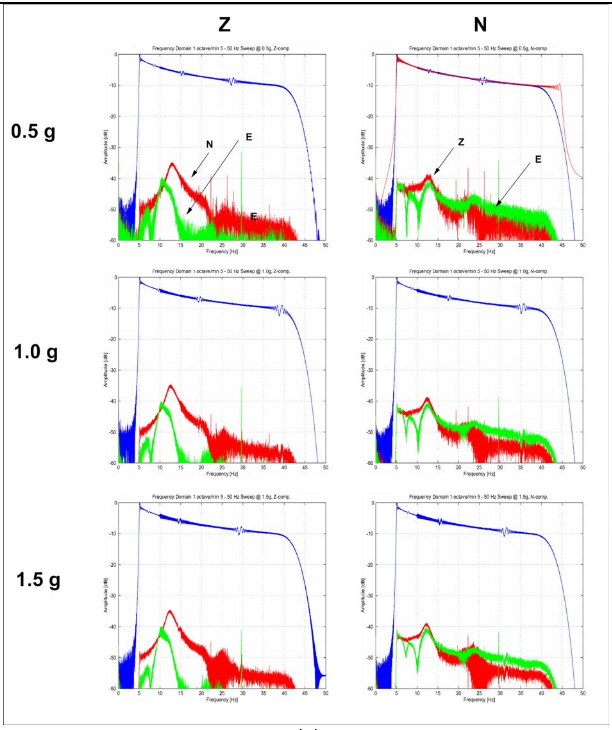
shaker (Figure 3) is shown in the example in Figure 4(a) for the frequency domain and Figure 4(b) for the time domain.

Noise tests were conducted at PGC, where the instruments were installed in a seismic vault and the data recorded during a seismically quiet time were analyzed. Time and frequency domain representations of the instrument's self noise are shown in Figure 5(a) and Figure 5(b) respectively.

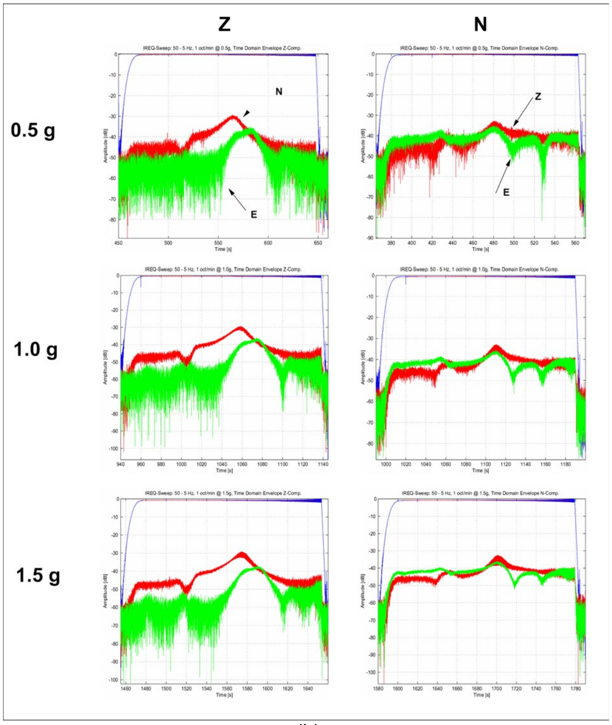
Timing

Timing accuracy is critical in a seismic recorder, which does not have its own precision clock. In IA-1, time synchronization is maintained by means of the Internet Network Time Protocol (NTP). The internal non-precision clock is thus continuously synchronized to highly accurate time sources.

In order to measure timing accuracy, the signal of a ramp generator, which was phase-locked to a GPS pulse-per-second (PPS) source, was injected into one of the digitization circuits of a prototype instrument (Figure 6). The rise time of the ramp was measured over several days while the instrument was synchronized to a NTP server. The residual timing error is shown on Figure 7, with values typically smaller than 10 ms which is equivalent to one sampling interval in the digitized signal.



(a)

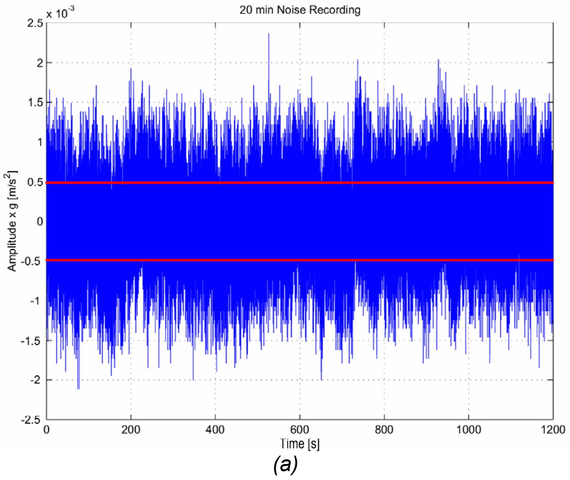


(b)

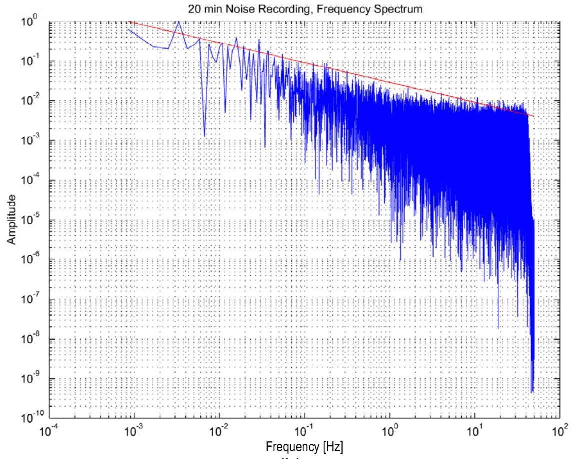
Figure 4. (a) IREQ Test, 1 octave/minute sweep: Spectra of Z-, N- and respective cross-components at 0.5, 1.0, and 1.5 g. The theoretical response is superimposed in the upper right panel. (b) IREQ Test, 1 octave/minute sweep: Time domain data (envelopes) of Z-, N- and respective cross-components at 0.5, 1.0, and 1.5 g.

Deployment and Networking

Communications infra-structure in larger cities is usually well developed and traditionally some strong motion instruments were tied in to the telephone network using Digital Packet Data (CDPD), Global System Mobile (GSM) or General Packet Radio Service (GPRS)



(a)



(b)

Figure 5. Illustration of the instrument noise floor; (a) Time domain: RMS noise level is 0.4896 mg, shown as solid red lines; (b) Frequency domain: As a reference the red line shows the theoretical, purely thermal (1 / sqrt(f)) noise level

services. The most cost-effective infrastructure is, however, provided by the Internet.

Experience with the growing pilot station network in Vancouver, British Columbia, for example, shows that Internet services are either readily available at any site or can be obtained at relatively little expenses.

It is fairly easy in urban areas to arrange instrument locations with “always on" high speed Digital Subscriber Line (DSL), TV-cable or direct links to the Internet. Candidate locations can range from schools, governmental or private offices and warehouses to private residences.

In order to built and maintain successful partnerships with people and organizations who would allow a dense seismic network operator to install an instrument on their premises and on their computer network, a seamless and uncomplicated integration of the instrument into the local network is critical. Owing to the superior networking design of the IA-1, no computer network expertise is required from these prospective partners; the instrument adapts to their networks rather than requiring changes in the local network configuration.

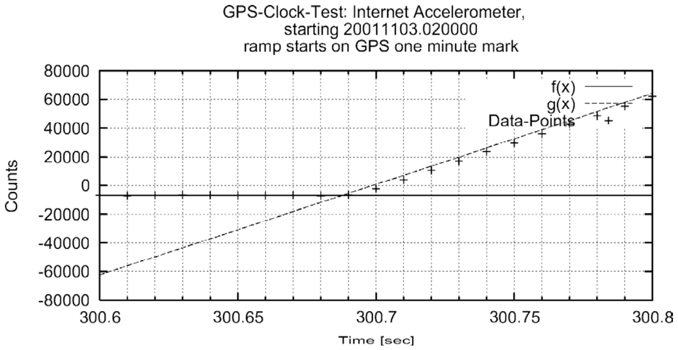


Figure 6. Measuring timing accuracy: Data from a GPS triggered ramp generator are used to determine overall time-delay and -jitter. The true rise time of the ramp is computed as the intersection of the two interpolated lines f(x), g(x).

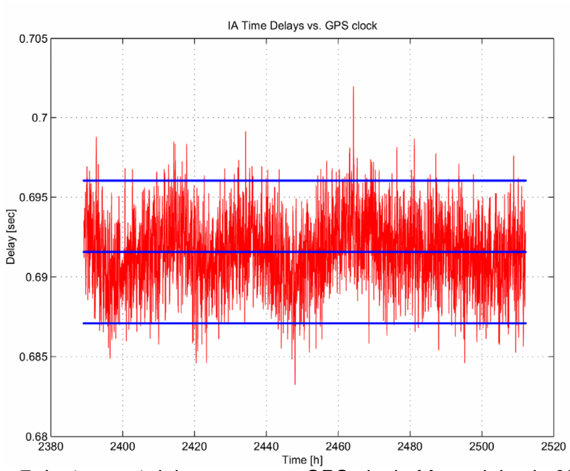


Figure 7. Instrument delays versus a GPS clock. Mean delay is 691 ms with a standard deviation of ± 2.2 ms. The mean delay is due to the instrument's digital decimation filter. The solid lines show mean and twice the standard deviation. Diurnal variations, due to temperature changes in the laboratory manifest themselves as a 24 h period sinusoid.

IA-1 can operate from a private IP-address range and a Network Address Translating (NAT) router as well as from behind a traffic controlling Firewall. It supports static and dynamic IP address assignments. The only requirements are access to at least one Internet time-server and very limited access from the instrument out to the Internet and into one particular host computer at a network center. Connections from a LAN out to the Internet are generally tolerated by even the most rigorous network administrator. Additionally, IA-1 uses an authenticated and encrypted channel to further secure connections from the instruments.

Maintenance

The procedures and configurations that were used for communicating with the pilot network of instruments as well as their maintenance have turned out to be robust and reliable. The pilot network communications survived the "MS-SQL worm" infection of late January 2003 with a quick recovery from Internet outages.

The instruments can be controlled entirely over the Internet. Acquisition parameters can be adjusted, trigger-parameters can be changed and even part of the network environment can be re-configured over the Internet.

Unless some physical damage occurs, it is foreseen to actually visit an instrument in a network once every three years to replace the backup battery. As a reference the prototypes have now operated for almost two years without interruption and interference in PGC's seismic vault. The first production instrument within the pilot network was installed on November 20, 2002 in the City of Richmond. It is operating continuously and has not been visited since.

The pilot system interfaces with a small database containing sites, contacts and instrument specific data. Reports of the status of each instrument are automatically generated daily and forwarded by e-mail to PGC staff members. A map displaying instrument locations and simple status information is automatically generated every hour.

Pilot Project Specifics

During normal operation each instrument acquires and stores three component DC to 42 Hz acceleration data in a ring-buffer the size of about two and one-half days worth of data in MiniSEED format. Data are assembled in 5-minute files that can be retrieved from the instrument at any time. Data from all or a select group of instruments can be retrieved almost instantaneously by a simple request to one computer at the PGC.

Data streams of continuous 0.1 Hz to 42 Hz acceleration, velocity and displacement are computed by the instrument in real time, but currently not stored.

Only if an event is detected by a short time average, long term average ratio (STA/LTA) algorithm, peak values from those data streams are determined for a certain, configurable time interval.

These values are subsequently reported as peak ground acceleration (PGA), velocity (PGV) and displacement (PGD) in a brief message to a host computer at the PGC. They can then be forwarded by e-mail to a group of users or as a short message service (SMS) to a group of cellular phones.

This mode of operation is however, merely experimental. Once most of the instruments in the Vancouver/ Richmond area are deployed the focus will be on the network capabilities of that group of instruments. Triggers from individual instruments will be subjected to a spatial filter, which will declare an event only, if a significant number of neighboring instruments have triggered simultaneously.

Moving from simple STA/LTA ratios to a spectral intensity trigger algorithm [2] is also planned in the near future.

PGA and PGV as reported from the instruments will ultimately be used to compute instrumental intensities [3] and to generate a shake-map with reports from all stations in near real time.

Technical Specifications

Please visit our web site to obtain the latest product leaflet and technical specifications of the innovative IA-1.

References

1. Rosenberger A., "*PGC Internet Accelerometer, Test and Calibration Procedures*", unpublished report, PGC 2002.

2. Katayama T. et al., "*SI-Sensor for the Identification of Destructive Ground Motion*", Proceedings, Ninth World Conference on Earthquake Engineering, Tokyo-Kyoto, 1988.

3. Sokolov V., and Wald, D. J., "*Instrumental Intensity Distribution for the Hector Mine, California, and the Chi-Chi, Taiwan, Earthquakes: Comparison of Two Methods*", Bulletin of the Seismological Society of America, Vol. 92, No. 6, pp 2145-2162, 2002.

Structural Monitoring and Measurement System for Beli Iskar Dam, Bulgaria

The Beli Iskar Dam is situated 60 km from Sofia in the Rila National Park, at the foot of the Moussala Summit and at elevation of approximately 1,800 m. It was constructed in the period 1935-1945 and put into service in 1948. The main function of the Dam is to balance the natural run-off of the Beli Iskar River and to provide water to the communities in the Rila Mountain region and parts of Sofia.

The dam is of concrete gravity type, with a maximum height of 51 m and a crest length of 533 m.

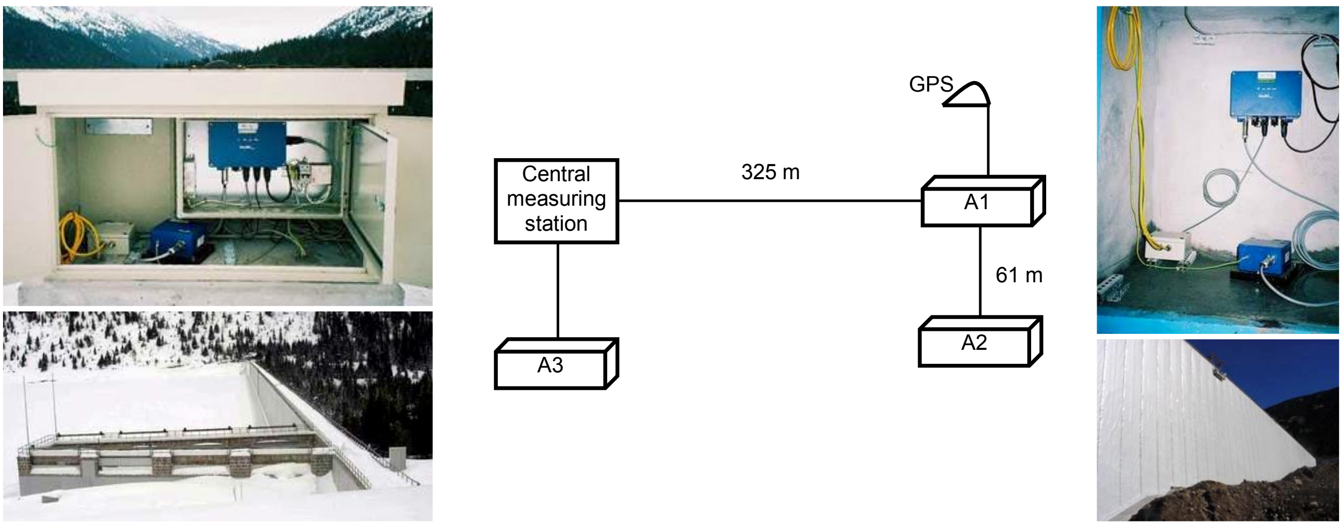
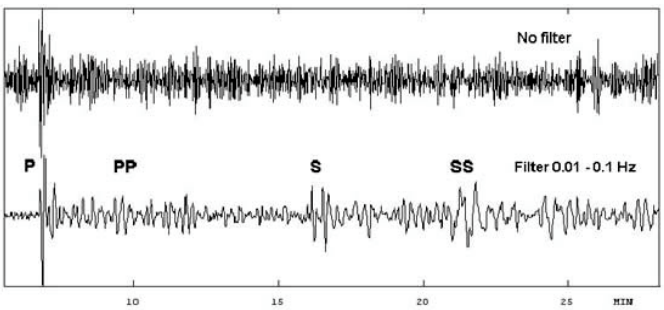


*Figure 8. Beli Iskar Dam, structural monitoring and measurement system**

Structural monitoring and measurement system, which was implemented by Start Engineering JSC, Sofia, in the Beli Iskar Dam consists of 3 GSR-16 strong motion recorders and 3 AC-23 triaxial accelerometers. The system has an alarm interface for seismic alarm as well as equipment failure. The state-of-the-art GeoDAS software is utilized to conduct the operations of the system, in terms of data acquisition, processing and alarm generation.

*: Photographs are courtesy of Start Engineering JSC and Sofiyska Voda AD, Sofia, Bulgaria

New Manual of Seismological Observatory Practice (NMSOP) is Published by IASPEI



International Association of Seismology and Physics of the Earth's Interior (IASPEI) is a multinational organization, which aims to encourage researchers who are studying earthquakes, propagation of seismic waves, Earth's internal structure and properties as well as continuous processes of its interior. Furthermore, IASPEI organizes cooperation between different countries to facilitate, initiate or coordinate respective scientific research activities and discussions on all aspects of the seismology.

"The science of seismology depends critically on data collected at hundreds of observatories world-wide. These observatories are operated by a variety of agencies, staffed by seismologists and technicians whose training and interests vary widely. They are equipped with hardware and software ranging from very traditional analog technology to highly versatile and sophisticated digital technology. While in industrialized countries the observatory personnel normally have easy access to up-to-date technologies, spare parts, infrastructure, know-how, consultancy and maintenance services, those working in developing countries are often required to do a reliable job with very modest means and without much outside assistance.

To ensure that the data from these observatories can be properly processed and interpreted once it has been acquired and compiled, it is necessary to establish protocols for all aspects of observatory operation which may effect the seismological data itself. In addition, competent guidance is often required in the stages of planning, bidding, procurement, site-selection, and installation of new seismic observatories and networks so that they will later meet basic international standards for data exchange and processing in a cost-effective and efficient manner. The most successful such effort to date has been the Manual of Seismological Observatory Practice. The most recent edition of the Manual of Seismological Observatory Practice was published in 1979 as Report SE-20 of the World Data Center A for Solid Earth Geophysics. It was reprinted in 1982, but has been long out of print. For many years the Manual has been effectively impossible to obtain.

Seismology has undergone a technological revolution since publication of the Manual, driven by cheap computer power, the development of a new generation of seismometers and digital recording systems with very broad bandwidth and high dynamic range, and the discovery of the Internet as a vehicle for rapid, large-scale data exchange. As the seismological community switches from analog to digital technology, many sections of the 1979 Manual are becoming obsolete or irrelevant, and the Manual contains no guidance in many areas which have become of critical importance." *

Consequently, a new and updated manual under general guidance and editorship of Prof. Dr. Peter Bormann, GeoForschungsZentrum, Potsdam, Germany is now available.

This www based and e-updated manual hosts 37 authors from 9 countries, for about 1250 pages of drafts, which were reviewed extensively both within the associated IASPEI Work Group and by 30 external reviewers from 10 countries.

Researchers and interested individuals can reach this valuable information source through the url: http://www.gfz-potsdam.de/bib/nmsop_formular.html

or by directly contacting

Prof. Dr. Peter Bormann
GeoForschungsZentrum Potsdam
Division 2: Solid Earth Physics and Disaster Research
Telegrafenberg E428
D-14473 Potsdam
GERMANY
Phone: +49 (331) 288-1202
Fax: +49 (331) 288-1293 or 1204
Email: course@gfz-potsdam.de

*: Quoted from the Manual of Seismological Observatory Practice web page.

Please Note:

Due to summer holidays our offices will be closed from 28th July until 10th August 2003