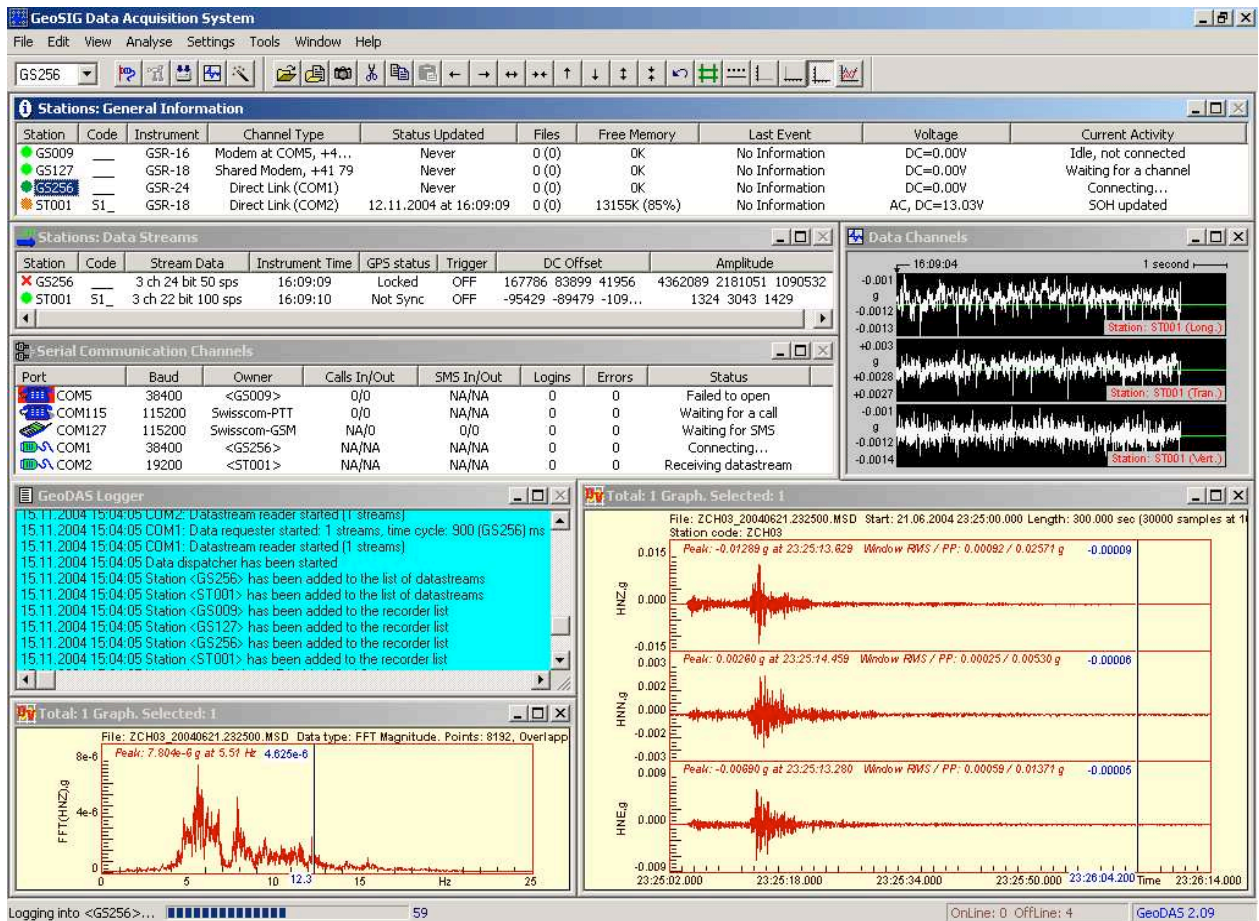**GeoSIG**
swiss made to measure

GeoDAS NPP Features

Introduction

This document summarizes the features and functionalities of the GeoDAS used in the NPP seismic Instrumentation Projects.

This document is intended be studied together with other GeoSIG technical documents relating to NPP instrumentation to grasp the full context and the concepts mentioned.

If supplied within the context of an NPP Seismic Monitoring System, a special version of GeoDAS software is delivered to be used to perform data analysis of the recorded time history, perform alarm and announcing if the analysis determines that the seismic event has exceeded software thresholds established by the structural engineers and operators of an NPP.

Summary of Operation

Site-specific parameters are set into the recorders in order to prepare the Rata Recording Units (DRU) to detect and record any events. The event files are kept in the recorder memory, which is a flash memory card. As soon as new event occurs the relevant recorder settings like time, date, serial number, type of sensor and trigger level are attached to the data file are saved to the recorder's memory.

This event file will be automatically downloaded to the CPU computer. Further, the event files are processed and analysed for Seismic, OBE and optionally SSE checks. Further analysis is possible with the Off-line Data Viewer (ODV) feature under manual mode.

In normal operation mode of the system, the CPU downloads event files from each DRU automatically. At any time, a user can download any event recording manually by means of the Event Manager.

The recorders operate according to the specified settings, even without being connected to the CPU computer, since the data is saved in the recorders memory.

The system computer performs a Response Spectra Analysis (RSA and RSV) of the data record to determine the acceleration at the various frequencies. The structural SSE and OBE levels for the location of the accelerometer may be entered into the system and the RSA compared against the SSE and OBE levels established for each site.

When the calculated response spectra exceeded the OBE or SSE levels, the computer will force the Annunciator module (GAN) to activate SSE and/or OBE level exceedance alarms. The system may also be set up to automatically print out the time history, RSA with OBE & SSE levels, and Cumulative Absolute Velocity (CAV) on a printer connected to the system.

The OBE or SSE alarm on exceedance of the related alarm levels is a combination of the following calculations:

- RSA: Acceleration Response Spectrum
- RSV: Velocity Response Spectrum
- CAV: Cumulative Absolute Velocity
- PGA: Peak Ground Acceleration (optionally, by request)

If all the above listed calculations are done, the resulting Boolean formula is:

OBE or SEE = (RSA or RSV or PGA) and CAV

Any of the above four calculations can be enabled and disabled individually.

Once the event data has been recorded in the individual DRU, it remains in the non-volatile flash memory until removed by an authorized operator. Once an event has occurred the event record will be automatically downloaded to the central system computer located in the central control panel where the GeoDAS software will automatically perform an analysis of the time history record. Within a few minutes the computer will have performed the preliminary analysis of the seismic event and if structural levels have been exceeded provide an appropriate alarm making the system fully compliant to the new NPP guideline and requirements.

The alarm threshold levels may be individually set on each channel. The recording alarm threshold will cause the time domain recording of all acceleration signals exceeding the alarm threshold.

Authorized structural engineers and managers have found it useful to access the computer via the LAN and download a particular event record for further analysis on their a computer at their desk. GeoSIG provides a site license for the use of the GeoDAS software package allowing the use of the analysis package on as many computers as the customer requires. GeoDAS allows limited and controlled access at various levels to maintain security and allow for the effective maintenance and operator control to the system.

GeoSIG recommends that the customer establishes internal operating procedures for system test and maintenance including a procedure for copying and archiving event records. A Read/Write CD drive or another backup device is provided for that purpose. The system performance, hard drive disc file space, computer memory and recording module non-volatile memory has been sized to satisfy the system requirements and provide reliable long-term operation.

The software has two modes of operation:

- Standard, where the software is in the so-called "autodownload-mode", downloading and analysing automatically any events
- Extended, where the user can stop the autodownload-mode and login to the DRUs manually

Seismic Check

After an event is recorded the CPU computer will retrieve the recorded data from the DRUs for further analysis. Any reserved units will not be used for seismic check. Automatic analysis after retrieval of data in the computer will decide if the event is seismic or non-seismic. The decision whether an event is seismic or non-seismic is based on several tests listed below.

Table 1. Seismic / non seismic event detection

Number	Tests for 'seismic event detection'	Non-seismic Event if…	Seismic Event if…
1	Number of DRU locations with recordings	Only 1 recorder triggered	2 of 6 recorders triggered
2	Duration	Duration is below 2 s	Duration is above 2 s
3	Maximum frequency of the spectral peak	FFT shows frequency peak above 33 Hz	FFT shows frequency peak below 33 Hz

The operator can repeat any of the tests referred to in the above table in deciding whether the event is classed as seismic or not. In case of several DRUs triggered, the exact trigger times are compared. If the differences are below three seconds, the recordings are classified as one event. The typical limits for the seismic check parameters are as follows:

Table 2. Seismic check parameter settings and ranges

Parameter	Minimum	Maximum	Standard Setting
Number of DRU locations triggered	1	6	2
Duration [s]	1	10	2
FFT Peak [Hz]	5	50	33

The event is declared seismic if all criteria are fulfilled; otherwise it is treated as non-seismic, and OBE/SSE calculations are not performed

Non-Seismic Event

After a non-seismic event the operator presses first the "ACK" button on alarm-panel to acknowledge the alarm and then presses the "RESET" button to clear the alarm so that:

Table 3. Non-seismic event actions

Alarm	Action
Alarm-panel:	"EVENT" indicator lamp goes out
Alarm Relays:	"EVENT" relay goes back to normal state
Monitor:	Displays the results of the performed seismic check

The parameters defining the criteria for qualifying the recorded event as "non-seismic" will need to be reviewed after a training period to verify that the filtering applies is correct.

Seismic Event

In case an event is classified by the system as seismic, RSA, RSV, optionally PGA, and CAV calculations are performed and the results are compared with allowed levels for the following criteria to establish its degree of severity and activate further alarms / relays. Results of the tests are displayed on the CPU computer monitor and are printed, too.

OBE/SSE Check

The OBE and SSE alarms are generated solely by the CPU computer utilizing GeoDAS and the alarm-logic. It simply converts the received string to the appropriate electrical signals to drive the relay and alarm lamps.
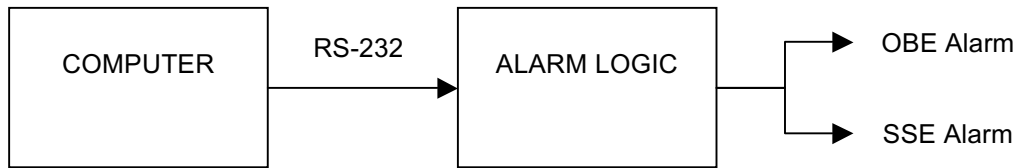

Figure 1. OBE/SSE Alarm topology

In case of the event is classified as seismic by the system, RSA, RSV and CAV calculations are performed and the result is compared against levels for the following criteria:

Table 4 Exceedance of individual OBE criteria

OBE/SSE Calculation	Criteria exceeded if…
RSA	• At least one component site level is exceeded
RSV	• At least one component site level is exceeded
PGA (optionally)	• At least one component site level is exceeded
CAV	• At least one component greater than 0.16 g-s[1]

All parameters for the described calculations are set using the configuration dialog below. It is accessible through the GeoDAS Menu Settings -> Event Checks. For detailed information, please refer to the GeoDAS User Manual.

Figure 2. Event check parameters window

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[1] The unit [g-s] is used in the NRC Regulatory Guide 1.166 and refers to integrated acceleration in [g] over time in [s]. Within the Seismic Instrumentation project all CAV values are treated in [mm/s]. 0.16 g-s corresponds to 1'570 mm/s.

GeoDAS NPP Features

If the event calculation shows exceedance of OBE or SSE site levels, the computer sets the OBE or SSE alarm and the following alarm will occur. OBE or/and SSE alarm will be reset manually by the operator.

Table 5. OBE, OBE max. acceleration, CAV event actions

Alarm	Action
Alarm-panel:	• "OBE" or/and "SSE" indicator lamp flashes
Alarm Relays:	• "EVENT", "OBE" or/and "SSE" relay active
Monitor:	• Displays the results of the performed OBE/SSE check

Display of Processing Results

For each event recording, results of seismic, as well as OBE/SSE checks are displayed in a table. The below figure shows an example of the "event check results" window.

Figure 3. Event check results window

For each event, a context menu can be accessed (right-click) with the following functions:

• The printing of any report can be repeated or forced manually at any time after an event.
• Each event can be manually re-checked for Seismic, OBE or SSE.

After each event recording retrieved from the system that is classified as 'seismic', a report will be printed automatically by the system, giving a summary of the check results (first page) and detailed waveforms for each DRU (one page per unit).

An example report is illustrated in a separate document.

The software can be programmed such that the report will be printed also if an event is not classified as 'seismic'. The waveforms included in the detailed waveform plots are:

1. Time-history (3 components)
2. RSA plot showing limits (3 components)
3. RSV plot showing limits (3 components)
4. CAV plot showing limits (3 components)
5. PGA plot showing limits (3 components) - optional

A report can be regenerated and reprinted at any time manually again. There will be a provision for the user to enter event-specific comment, such as earthquake magnitude.

Processing Time Estimation

The timeline of system triggering / analysis is indicating in the next table. It is based on typical record length of some 50 seconds (30 seconds shake + 10 seconds pre-event and 10 seconds post-events) acquired at 100 sps. The recorded file has a size of 45 kByte and has a download time of 12 seconds at 38400 bps.

Table 6. Step by step estimated elapsed time

Pos	Activity	Duration	Start	End
1	Earthquake waves hit the plant	0	00:00:00	00:00:00
2	From the continuous measurement stream, the trigger system, after applying band-pass filtering detects an acceleration exceedance.	Few ms	00:00:00	00:00:00
3	Seismic recorders report trigger to alarm module. Alarm module applies Boolean logic to define if recording must occur or not.	Few ms	00:00:00	00:00:00
4	Alarm module applies Boolean logic to define if an alarm has to be generated.	Few ms	00:00:00	00:00:00
5	Common alarm received in the main control room.	Few ms	00:00:00	00:00:00
6	The computer is continuously monitoring the recorders for new recorded event.	50 seconds	00:00:00	00:00:50
7	The computer detects recorded events. An event condition is declared and it will downloads files as soon they are ready.	6 x 15 = 90 seconds	00:00:50	00:02:20
8	Analyse process start by verifying if event is seismic (number of triggered stations, duration and main frequency).	10 seconds	00:02:20	00:02:30
9	OBE and SSE exceedance is checked.	30 seconds	00:02:30	00:03:00
10	OBE / SSE exceedance alarm generated is event is of seismic origin.	Few ms	00:03:00	00:03:00
11	The event report is printed.	30 seconds	00:03:00	00:03:30

The main control is alarmed that an event occurred immediately when the earthquake hit the plant [5].

OBE/SSE alarm is (in case of exceedance) generated after about 3 minutes [10].

The event report is typically available after 3.5 minutes [11].

Logging

Within the CPU computer the events and results listed below will be logged. This allows the user to have complete information about the alarms and the time they were performed.

Table 7. Logged information

Type	Logged information
System trigger	Source, date and time
OBE, OBE max. acceleration, CAV Alarm	Source, date and time
Power Loss	Source, date and time
System Error	Source, date and time
Test Results	Values, date and time