

GeoSIG



**a Swiss manufacturer of seismic
monitoring and dynamic measuring
instruments**

Measuring Solutions

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Transmitting

GeoSIG Transmitting Systems

Processing

GeoDAS

ARTeMIS

Conclusion

Usage of the data

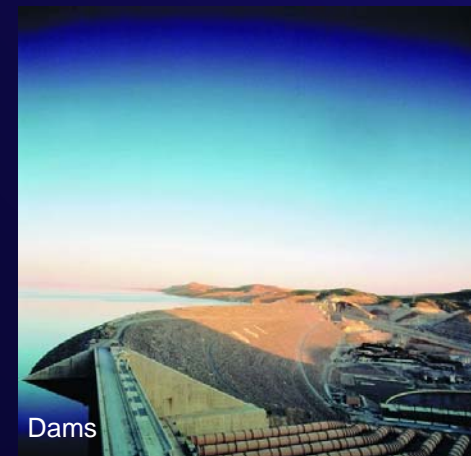
Who can use



Bridges



Tunnels



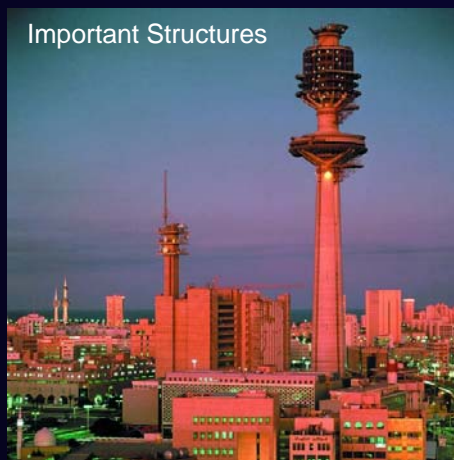
Dams



Urban Areas



Power Plants



Important Structures



Historical Buildings

And more...

Application areas of instrumentation and monitoring

Possible causes of vibration / motion / displacement

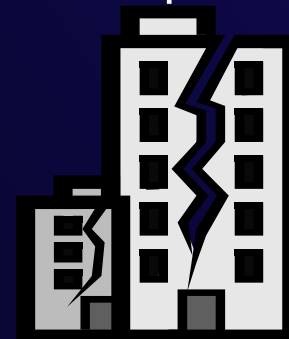
Traffic



Blast



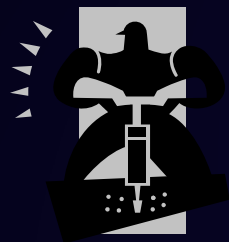
Earthquake



Settlement



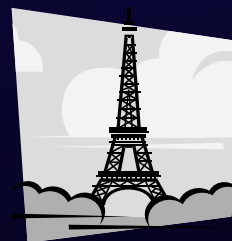
Construction



Wind



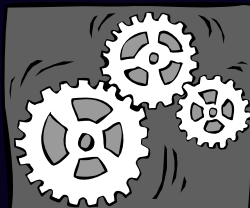
Aging



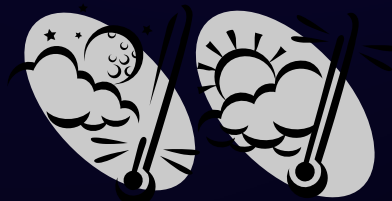
Fluids



Machinery



Temperature



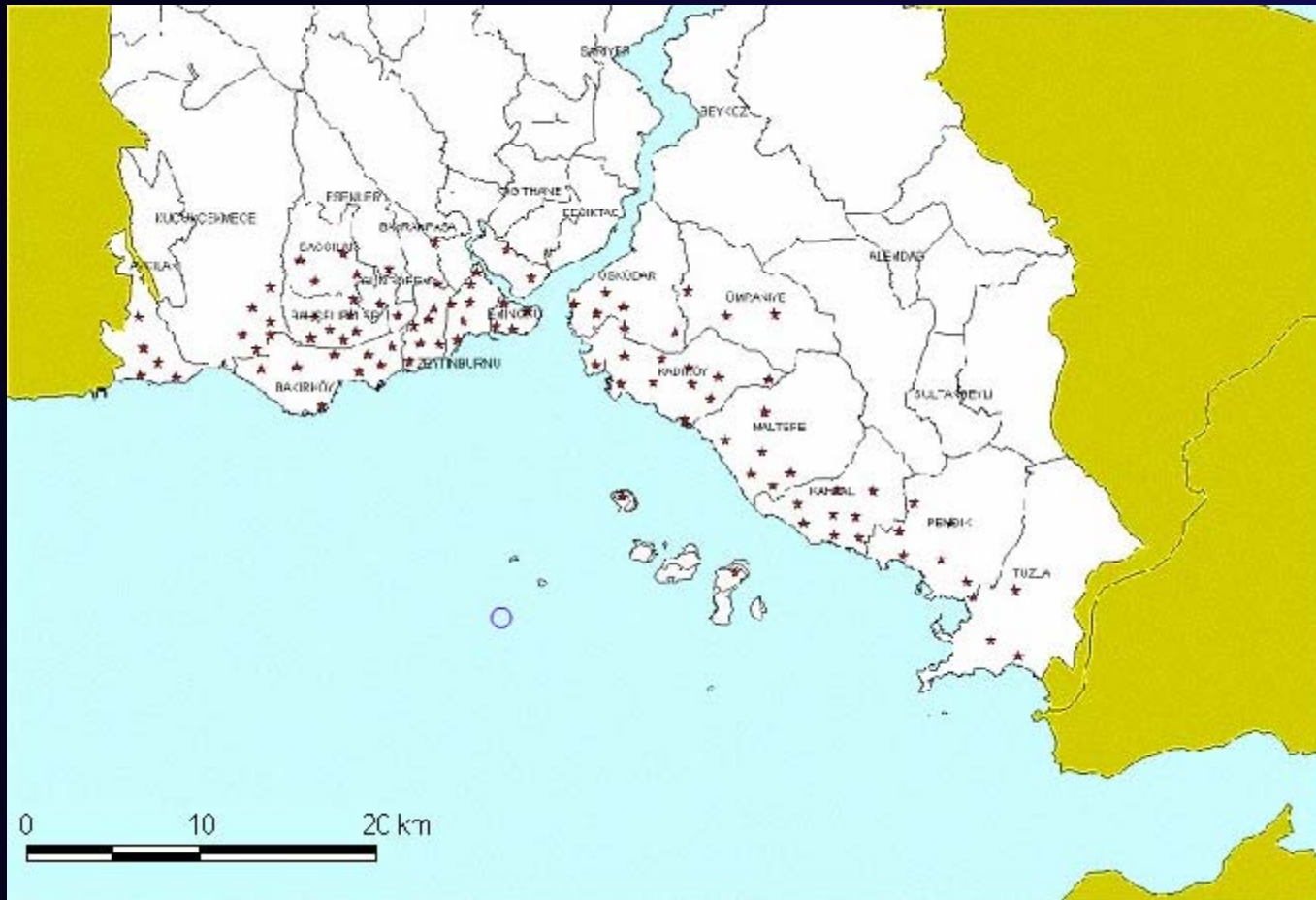
Application areas of instrumentation and monitoring

Earthquake Early Warning



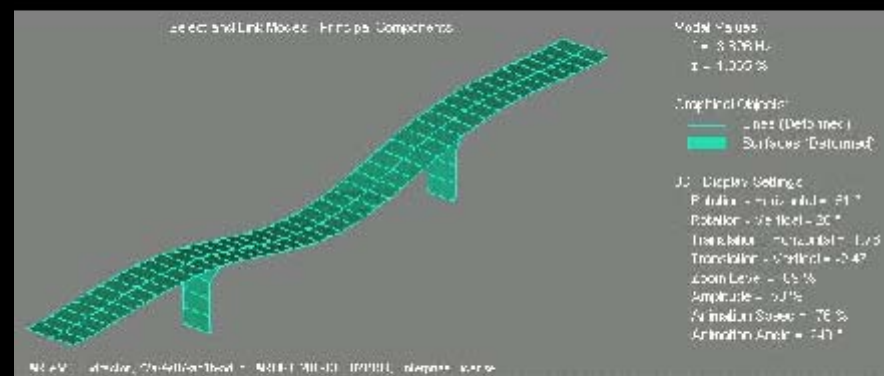
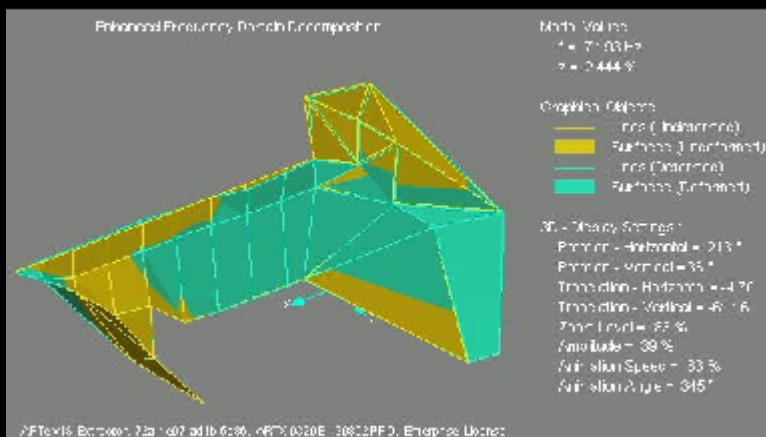
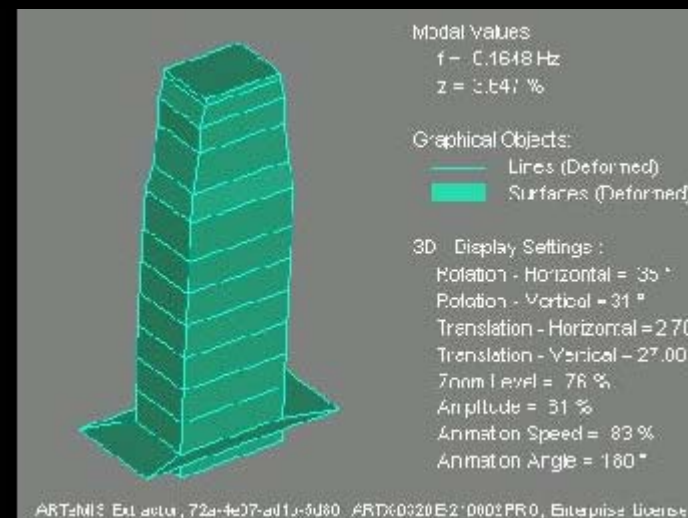
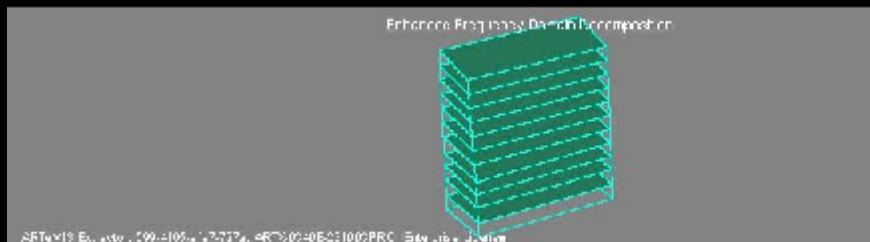
Application areas of instrumentation and monitoring

Earthquake Rapid Response

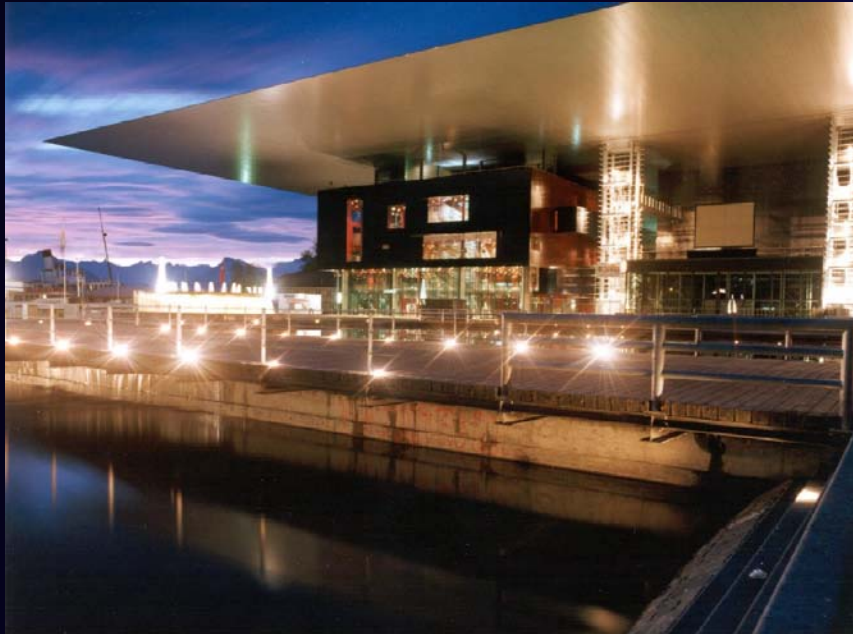


Application areas of instrumentation and monitoring

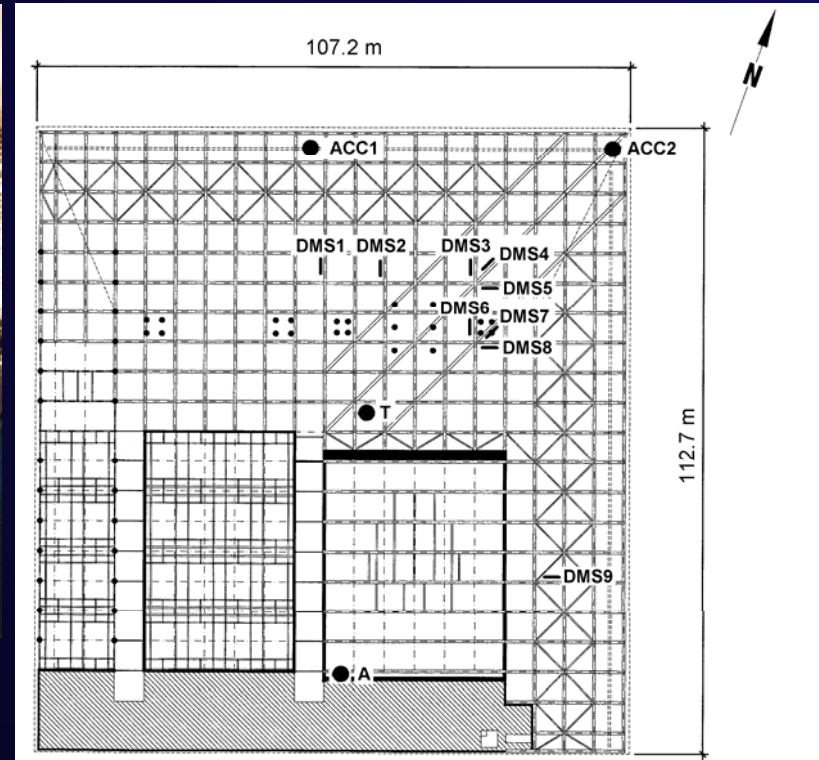
Structural Modal Analysis



Application areas of instrumentation and monitoring



Monitoring for a Roof



Advantages of instrumentation and monitoring

Damage prediction and assessment

Hazard assessment

Behaviour analyses

Area / region planning

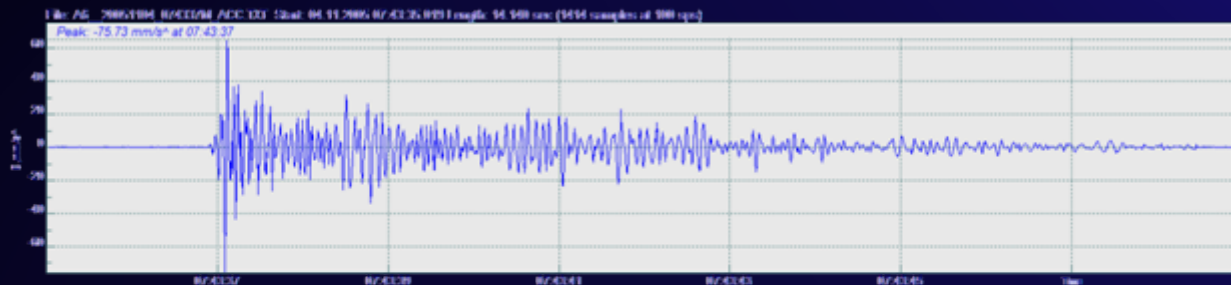
Preventative measures

Risk mitigation

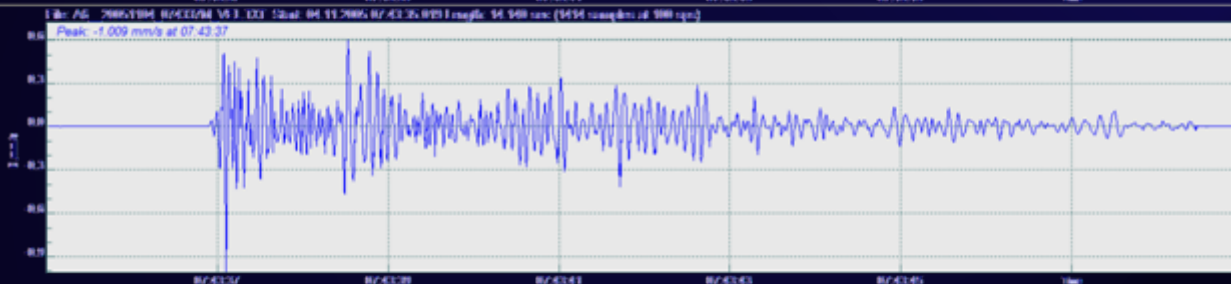
Scientific data accumulation

What to measure?

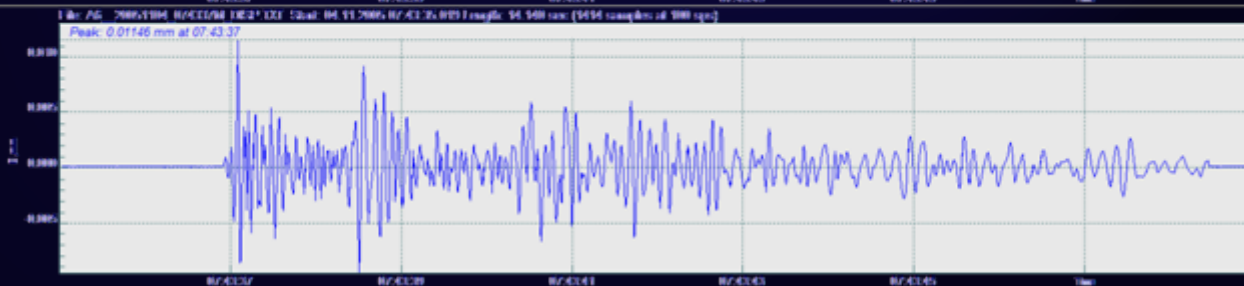
Acceleration



Velocity

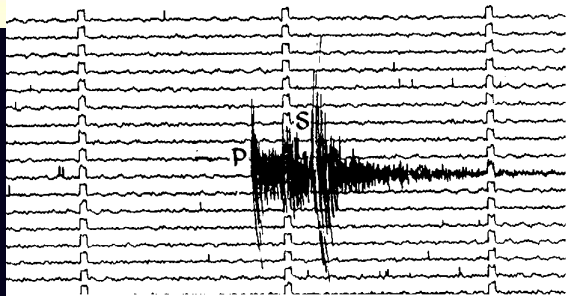


Displacement

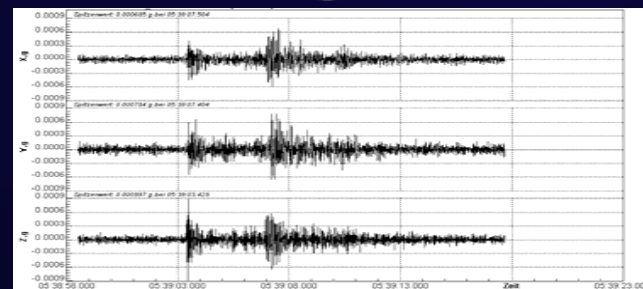


How to measure?

Old: Analog



Modern: Digital



The digital recording furthermore makes it easy to convert from acceleration to velocity and from velocity to displacement

Acceleration \int Velocity \int Displacement

The basic device: Sensor

AC-2x Series Accelerometers

Full Scale Range

$\pm 0.2, \pm 0.5, \pm 1$ or ± 2 g for ± 10 V diff. at output
 $\pm 0.1, \pm 0.25, \pm 0.5$ or ± 1 g for ± 10 V diff. at output

Bandwidth

0.1, 0.2 Hz (1 pole) ~ 100, 200 Hz (1 pole)

Dynamic Range

> 96 dB (16 Bit) or > 108 dB (18 Bit)

Axes

1, 2, 3

Cross Axis Sensitivity

± 1 % typical ± 3 % maximal

Downhole Version

AC-2xDH



The basic device: Sensor

AC-6x Series Accelerometers

Full Scale Range

± 2 g, optional ± 0.5 , ± 1 g

Bandwidth

DC ~ 100 Hz, optional 200 Hz

Dynamic Range

> 120 dB (18 Bit)

Axes

1, 2, 3

Cross Axis Sensitivity

< 0.2 %

Downhole Version

AC-6xDH



The basic device: Sensor

VE-1x Series Velocity Sensors

Full Scale Range

± 1 , ± 10 or ± 100 mm/s

Bandwidth

1Hz ~ 315 Hz

Dynamic Range

> 96 dB or better

Axes

1, 2, 3

Cross Axis Sensitivity

< 0.1 % of full scale

Downhole Version

VE-1xDH



The basic device: Sensor

VE-2x Series Velocity Sensors

Full Scale Range

± 1 , ± 10 or ± 100 mm/s

Bandwidth

4.5 Hz ~ 315 Hz

Dynamic Range

> 96 dB or better

Axes

1, 2, 3

Cross Axis Sensitivity

< 0.1 % of full scale

Downhole Version

VE-2xDH



The basic device: Sensor

VE-3x Series Velocity Sensors

Full Scale Range

Geophone Sensitivity 27.3 Vs/m

Bandwidth

4.5 Hz ~ 315 Hz

Dynamic Range

> 96 dB or better

Axes

1, 2, 3

Cross Axis Sensitivity

< 0.1 % of full scale



The basic device: Sensor

VE-5x Series Seismometers

Full Scale Range

2 x 400 (800) V/m/s
optional 2 x 500 (1000) V/m/s

Bandwidth

1Hz ~ 50 Hz (-3 dB)

Dynamic Range

> 120 dB

Axes

1, 2, 3

Cross Axis Sensitivity

$\pm 1\%$ typical $\pm 3\%$ maximal

Downhole Version

VE-53DH



What to do with the sensor signal: Digitising

1 - Amplification

The output signal from sensors can be very small and must first be amplified to be processed further.

The amplifier must not only have low noise but must also be free of amplitude and phase distortions.

The noise of an amplifier can be defined as the noise referred to the input i.e. the noise level is the smallest input signal which can be resolved.

The other main source of noise is the coupling (cable) between the sensor and the amplifier.

What to do with the sensor signal: Digitising

2 - Analog to Digital Conversion (ADC) or Digitising:

To sample an analog signal with an AD converter, two variables are of interest:

Sampling rate:

Controls how many samples are taken per second
ie. sampling instances per second

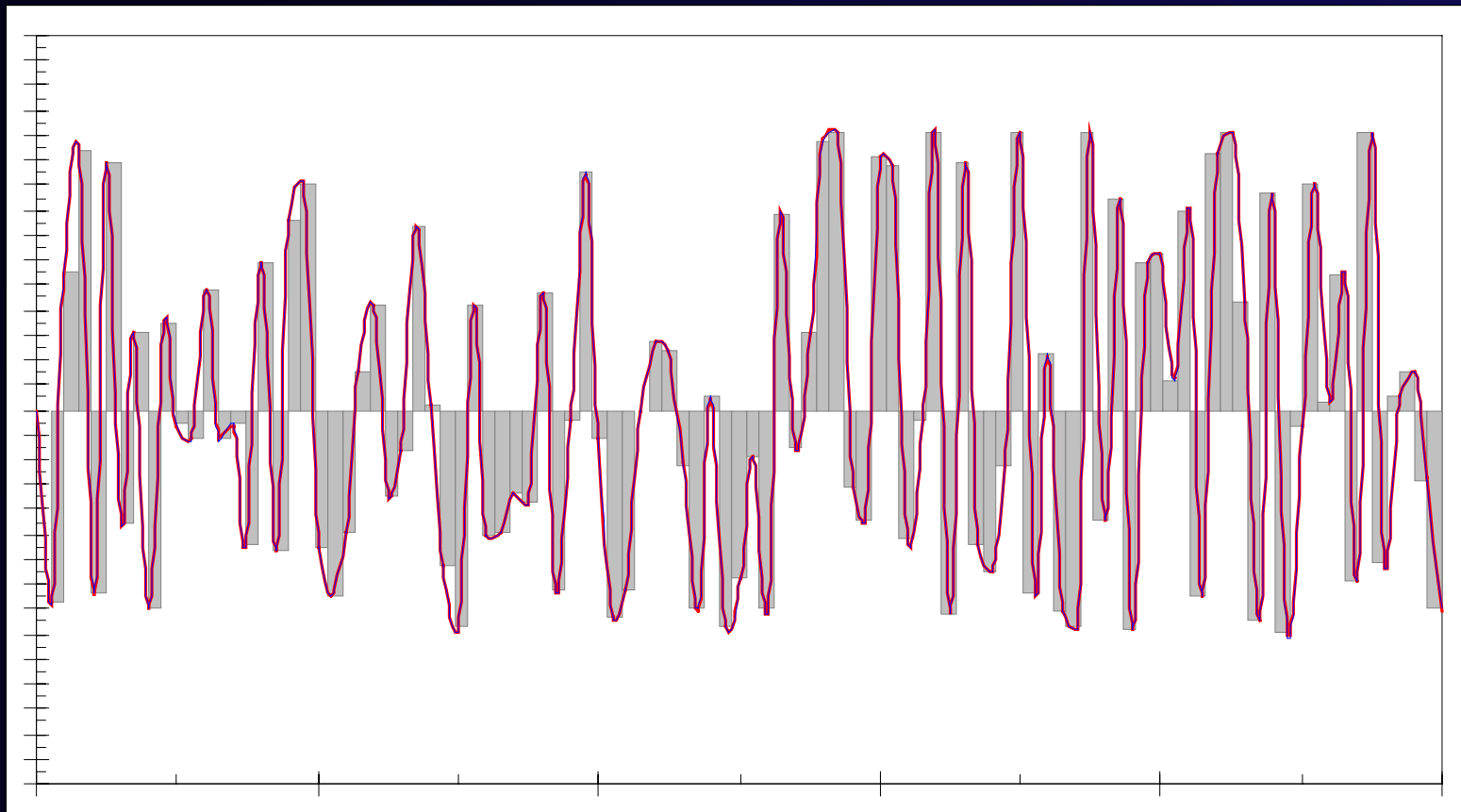
Sampling precision:

Controls how precise the sampled signal is quantified
ie. quantisation

At each sampling instance, the ADC checks the input signal and picks the closest number within the sampling precision.

What to do with the sensor signal: Digitising

High sampling rate
High sampling precision



What to do with the digitised signal: Recording or Monitoring

Main tasks for a Recorder:

- Read data from one or several digitisers, the sensors can be internal or external
- If digitised data do not have a time stamp, perform the time stamping of the data
- Store data in a ring buffer on storage medium
- Check incoming data for events (perform triggering) and optionally store only real events
- Provide communication with the outside world for change of parameters and download / transmission of data

What to do with the digitised signal: Recording or Monitoring

GSD / GSR-12 / 16 Digitisers and Recorders

Dynamic Range or [Least Significant Bit %]

[12 Bit: 0.025 % of full scale]

[16 Bit: 0.0015 % of full scale]

Resolution or [RMS Noise]

12 Bit / 16 Bit respectively

Sampling rate / Bandwidth

800, 500, 400, 200, 100 SPS /

315, 125, 100, 50, 25 Hz

Pre-event / Post-event

1 to 20 seconds / 1 to 100 seconds

Memory / Capacity

Removable or Fixed / 128 MB (exp. to 2 GB)

Battery / Autonomy

12 VDC, 6.5 Ah / 2 days

Communication (serial ports)

1 PC/RS-232 or auto dial modem

1 GPS



What to do with the digitised signal: Recording or Monitoring

GSD / GSR-18 Digitisers and Recorders

Dynamic Range or [Least Significant Bit %]

111 dB RMS @ 100 SPS

108 dB RMS @ 200 SPS

Resolution or [RMS Noise]

[5 mV @ 100 SPS]

[7 mV @ 200 SPS]

Sampling rate / Bandwidth

100, 200, 250 SPS / 40% of sampling rate

Pre-event / Post-event

1 to 32 seconds / 1 to 999 seconds

Memory / Capacity

Removable or Fixed / 128 MB (exp. to 2 GB)

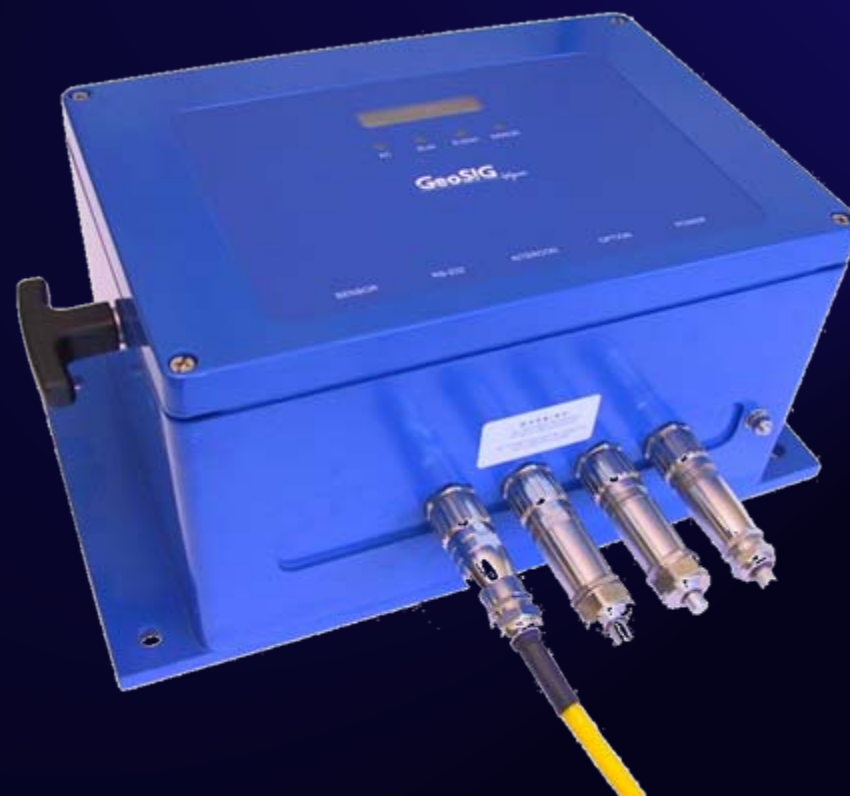
Battery / Autonomy

12 VDC, 6.5 Ah / 2 days

Communication (serial ports)

1 PC/RS-232 or auto dial modem

1 GPS



GSR-18AH is shown on the picture

What to do with the digitised signal: Recording or Monitoring

GSD / GSR-24 Digitisers and Recorders

Dynamic Range or [Least Significant Bit %]

132 dB @ 50 SPS

130 dB @ 100 SPS

128 dB @ 200 SPS

Resolution or [RMS Noise]

21.9 Bit @ 50 SPS

21.6 Bit @ 100 SPS

21.2 Bit @ 200 SPS

Sampling rate / Bandwidth

50, 100, 200 SPS / 40 % of sampling rate

Pre-event / Post-event

1 to 32 seconds / 1 to 999 seconds

Memory / Capacity

Removable or Fixed / 128 MB (exp. to 2 GB)

Battery / Autonomy

12 VDC, 6.5 Ah / 2 days

Communication (serial ports)

1 PC/RS-232 or auto dial modem

1 GPS



What to do with the digitised signal: Recording or Monitoring

GBD / GBV-316 Digitisers and Recorders

Dynamic Range or [Least Significant Bit %]

[0.0015 % of full scale]

Resolution or [RMS Noise]

16 Bit

Sampling rate / Bandwidth

25, 50, 100, 200 SPS /

20 Hz or 50 Hz

Pre-event / Post-event

1 to 32 seconds / 1 to 999 seconds

Memory / Capacity

Onboard / 16 MB (exp. to 32 or 64 MB)

Battery / Autonomy

12 VDC, 6.5 Ah / 2 days

Communication (serial ports)

1 PC/RS-232 or auto dial modem

1 GPS



What to do with the digitised signal: Recording or Monitoring

GCR-16 Recorders

Dynamic Range or [Least Significant Bit %]

[0.0015 % of full scale]

Resolution or [RMS Noise]

16 Bit

Sampling rate / Bandwidth

1000, 800, 400, 200 SPS /

315, 315, 100, 50 Hz

Pre-event / Post-event

0.1 to 5 seconds / 0.1 to 60 seconds

Continuous Recording (Ringbuffer)

Peak Value or Effective Peak Recording

Advanced Recording Modes

Memory / Capacity

Removable or Fixed / 128 MB (exp. to 2 GB)

Battery / Autonomy

12 VDC, 6.5 Ah / 2 days

Communication (serial ports)

1 PC/RS-232

1 GPS



What to do with the digitised signal: Recording or Monitoring

GNC-CRx Central Recorders

Channels

Upto 48 Dynamic channels

Dynamic Range or [Least Significant Bit %]

[0.025 % of full scale]

Resolution or [RMS Noise]

12, 16, 18, 24 Bit

Sampling rate / Bandwidth

(800), (400), 200, 100 SPS /

(315), (100), 50, 25 Hz

Pre-event / Post-event

1 to 32 seconds /

1 to 999 seconds (for 18 Bit, 24 Bit)

Memory / Capacity

Removable or Fixed /

128 MB (exp. to 2 GB) per RMC Card

Battery / Autonomy

12 VDC, 6.5 Ah /

4 days divided by number of RMC cards

Communication (serial ports)

1 PC/RS-232 or auto dial modem

1 GPS



What to do with the digitised signal: Recording or Monitoring

CR-4 PC Based Recorders

Channels

Upto 120 Dynamic and more than 500 static channels

Dynamic Range or [Least Significant Bit %]

[0.0015 % of full scale]

Resolution or [RMS Noise]

16 Bit

Sampling rate / Bandwidth

50, 100, 200, 500, 1000 SPS /

DC to 52 Hz (200 SPS) or

DC to 264Hz (1000 SPS)

Pre-event / Post-event

1 to 100 seconds /

1 to 100 seconds

Memory / Capacity

PC based recording

Battery / Autonomy

12 VDC, 100 Ah /

1 day

Communication

Full PC capabilities



Full size CR-4, under EMI testing



Custom sized CR-4



Portable CR-4, complete with sensors

What to do with the digitised signal: Recording or Monitoring

CR-5 PC Based Recorders

Channels

Upto 120 Dynamic and more than 500 static channels

Dynamic Range or [Least Significant Bit %]

[0.0015 % of full scale]

Resolution or [RMS Noise]

16 Bit

Sampling rate / Bandwidth

50, 100, 200, 500, 1000 SPS /

DC to 52 Hz (200 SPS) or

DC to 264Hz (1000 SPS)

Pre-event / Post-event

1 to 100 seconds /

1 to 100 seconds

Memory / Capacity

PC based recording

Battery / Autonomy

12 VDC, 100 Ah /

1 day

Communication

Full PC capabilities



What to do with the digitised signal: Recording or Monitoring

SMS / SAS Seismic Monitoring, Alarm and Switch Systems

Channels

Upto 48 Dynamic channels

Dynamic Range or [Least Significant Bit %]

[0.025 % of full scale]

Resolution or [RMS Noise]

18 or 24-bit

Sampling rate / Bandwidth

100, 200, 250 SPS /

40% of sampling rate

Pre-event / Post-event

1 to 20 seconds / 1 to 100 seconds

Memory / Capacity

PC based or Station based recording /

PC capacity or 128 MB (exp. to 2 GB) per RMC Card

Battery / Autonomy

Per requirement

Communication

Full PC capabilities

Recording, advanced analysis and annunciation according to latest or custom regulations



What to do with the digitised signal: Recording or Monitoring

AS-1x Seismic Alarm / Switch

Frequency Range

0.1 Hz to 12 Hz

0.1 Hz to 50 Hz (selectable)

Resolution or [RMS Noise]

12, 16 or 18 bit

Switch / Relay

2 each / 3 each

User Selectable Setpoints

Low Alarm: 0.002 to 2 g

High Alarm: 0.002 to 2 g

Relay Contacts

2 for Alarm Levels

1 for Equipment Fault on error/warning

Normally Open or Normally Closed

Battery / Autonomy

12 VDC, 6.5 Ah / 2 days

Communication (serial ports)

RS-232



What to do with the digitised signal: Recording or Monitoring

GSR-12 / 16PC Recorders

Dynamic Range or [Least Significant Bit %]

[12 Bit: 0.025 % of full scale]

[16 Bit: 0.0015 % of full scale]

Resolution or [RMS Noise]

[< 1 Bit peak to peak for 12 Bit differential mode]

[< 4 Bit peak to peak for 16 Bit differential mode]

Sampling rate / Bandwidth

25, 50, 100, 200, 500, 1000 SPS per channel /
25% of sampling rate

Pre-event / Post-event

1 to 100 seconds / 1 to 100 seconds

Memory / Capacity

PC based recording

Battery / Autonomy

12 VDC, 1.2 Ah / 2 Hrs (autonomy of the Notebook PC)

Communication

Full PC capabilities

Optional:

1 PC/RS-232

1 GPS



What to do with the digitised signal: Recording or Monitoring

IA-1 Internet Accelerograph

Dynamic Range or [Least Significant Bit %]

± 4 g
[0.0015 % of full scale]

Resolution or [RMS Noise]

16 Bit
[0.5 mg RMS]

Sampling rate / Bandwidth

100 SPS (optional 50, 60, 75, 150, 300 SPS) /
DC to 42 Hz

Pre-event / Post-event

Continuous recording

Memory / Capacity

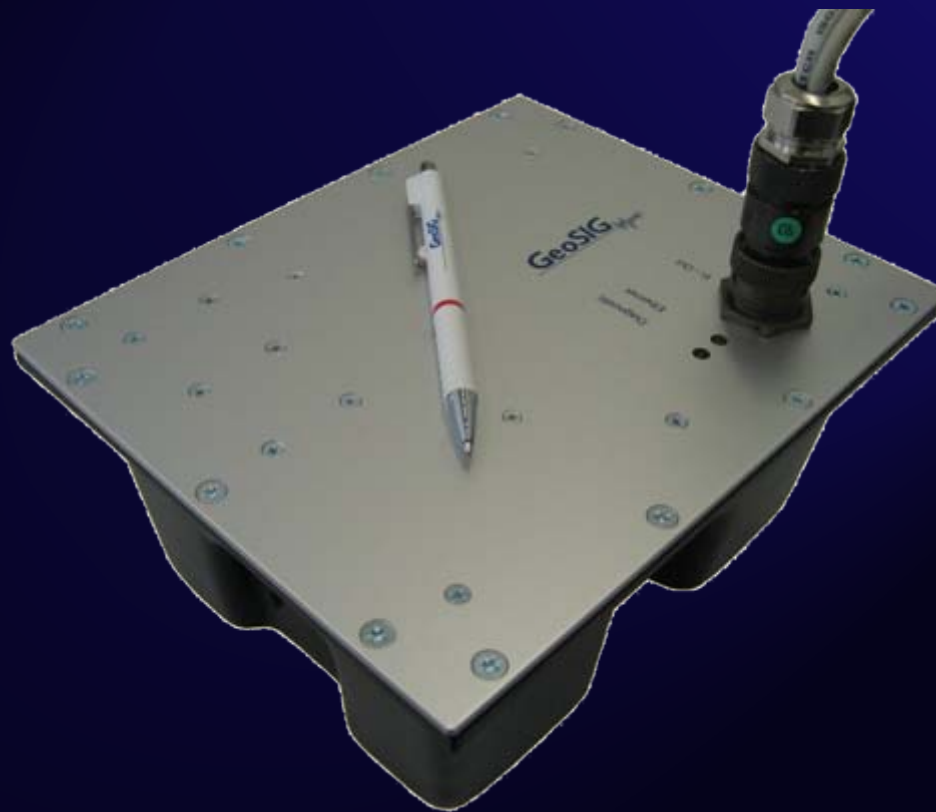
80 Mbyte RAMDisk / PC based recording

Battery / Autonomy

6 VDC, 12 Ah / > 6 hours

Communication

RS-232 (setup)
RJ-45 Ethernet – Internet/Network
PC (linux) capabilities



What to do with the stored data: Transmitting / Processing

Transmitting / Downloading

The stored event data can be either:

- Downloaded to a local computer
- Transmitted to a remote data acquisition centre

for further processing

Downloading can be performed by means of standard hardware communications methods such as RS-232 connection or similar

Transmitting the stored data involves methods utilising simple to much sophisticated communication devices

What to do with the stored data: Transmitting / Processing

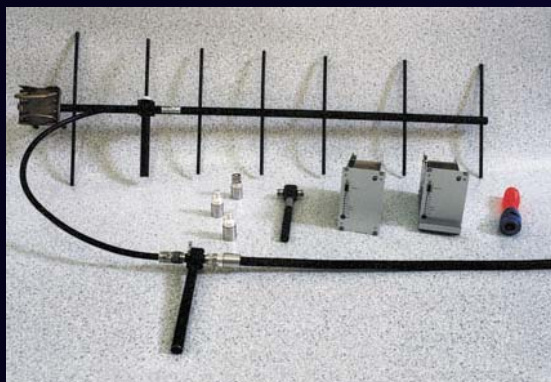
Transmitting

Transmitting data to remote centres may be performed via:

- Simple land lines (telephone/modem) or internet
- Radio Telemetry
 - UHF / VHF
 - Spread Spectrum
- GSM / GPRS
- Satellite communication (VSAT)

What to do with the stored data: Transmitting / Processing

GeoSIG Transmitting Solutions



GS-TCV Telemetry Transceiver



GS-SSR Spread Spectrum Transceiver
shown with
GSS Multichannel Data Acquisition System



GSM equipped
GSS Multichannel Data Acquisition System

What to do with the stored data: Transmitting / Processing

Processing

The data can be evaluated / analysed using dedicated computer software, as well as mainstream data analysis software

The most productive software would be the one that is able to acquire the data from the specific recorder (data acquisition) via downloading / transmitting

Such an approach also improves the quality of the data used and consistency of the results due to compatibility issues

What to do with the stored data: Transmitting / Processing

GeoSIG Software Solutions - GeoDAS

State-of-the-art, data acquisition and processing application running under Windows[®] 9x/2000/NT4/XP for GeoSIG Digitisers and Recorders

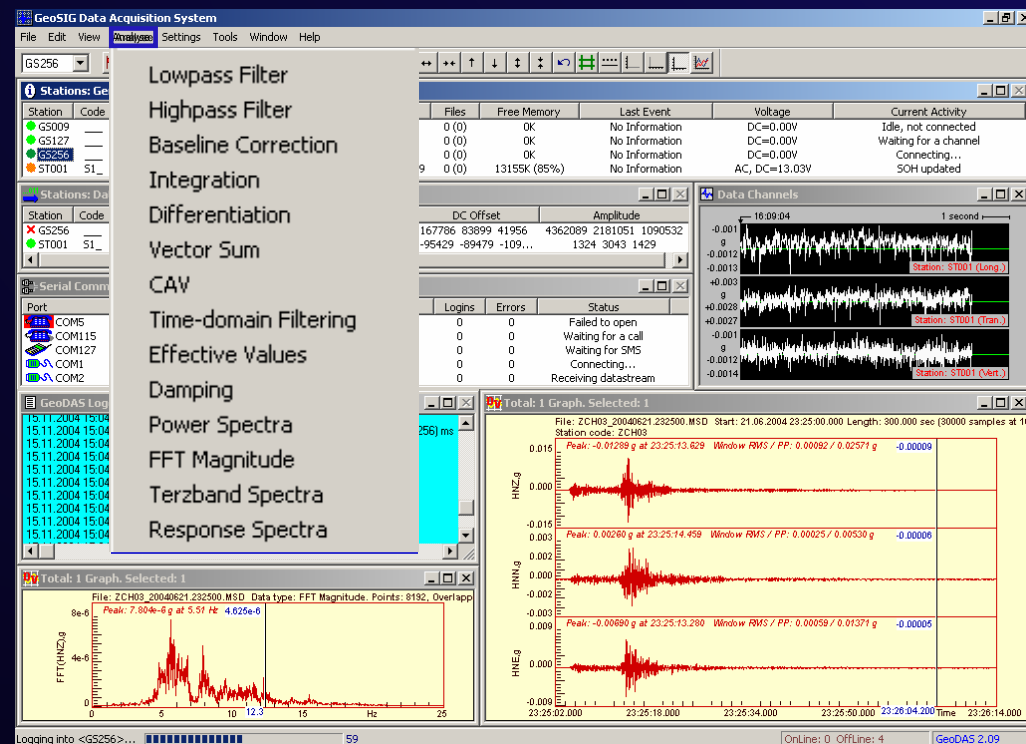
Features:

Capability to login to local or remote GeoSIG instruments for:

- Event downloading
- Near real-time data streams
- Full configuration and setup
- State of the Health monitoring

Off-line Data Viewer

Data Analysis



What to do with the stored data: Transmitting / Processing

GeoSIG Software Solutions - ARTeMIS[®]

Innovative Modal Analysis software under Windows[®] 9x/2000/NT4/XP

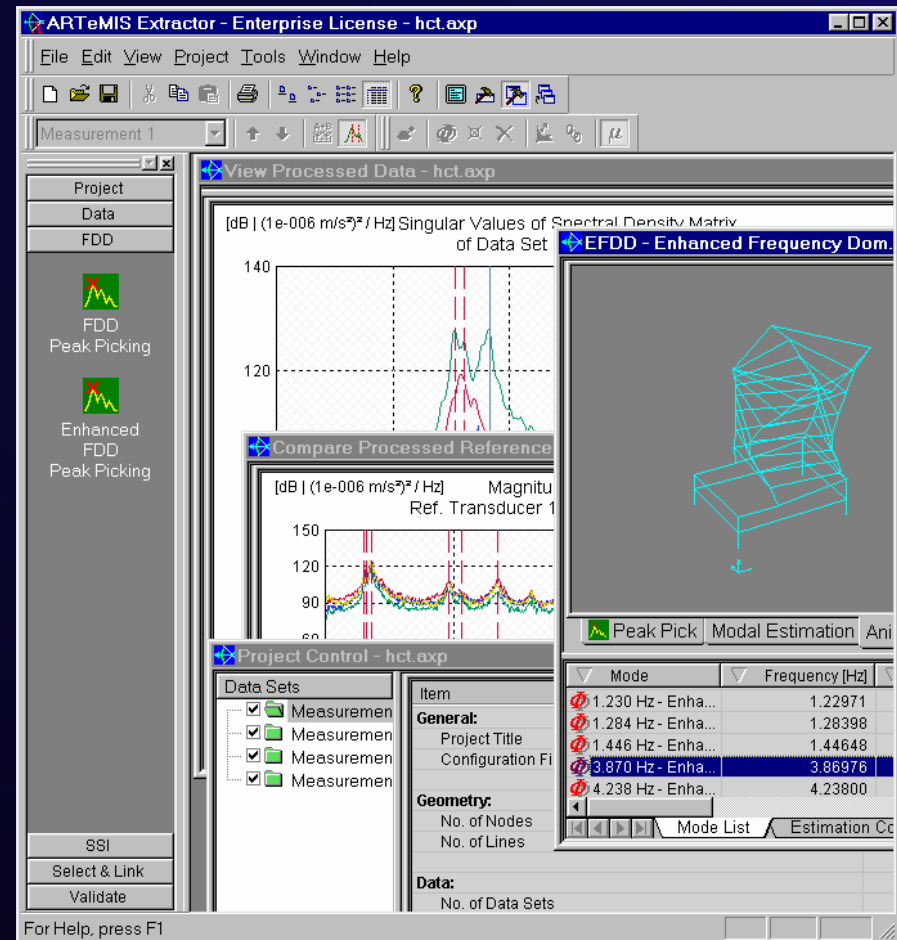
For any structure, accurately and precisely estimates:

- Natural frequencies of vibration
- Associated mode shapes
- Modal damping

from measured responses only

Features also:

- Signal processing tools
- 2D displaying of spectral densities and correlation functions
- 3D geometry validation and mode shape animation



Conclusion

There are several uses of the obtained / processed data:

- Early warning
- Rapid response
- Structural analysis / Design verification
- Monitoring / alarm / shutdown
- Rehabilitation
- State of health
- Fatigue and load estimation

Conclusion

Finally numerous professions and institutions can utilise the results:

- Engineers
- Scientists
- Decision makers
- City and region planners
- Maintenance organisations
- Investors
- Insurance / Re-insurance industry

And any individual who deals with vibration or motion monitoring and who needs:

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