



**CODEVINTEC**

Tecnologie per le Scienze della Terra

## Induced Seismicity and Geothermal Monitoring



**Nanometrics expertise includes the deployment of geothermal monitoring networks in seismically active areas, as well as temporary deployments to support geothermal exploration activities.**

### Risk Assessment and Hazard Mitigation

Through the deployment of surface and near-surface arrays, Nanometrics monitors the following in realtime:

- > Enhanced geothermal (EGS) operations
- > Induced seismicity monitoring during and post stimulation
- > Background seismicity assessment
- > Cap rock integrity
- > Subsidence

Nanometrics provides key information to facilitate full visibility into the effects that operations may have on the surrounding environment.



## Seismicity and Geothermal Monitoring

The Nanometrics team will assess the potential seismic risk inherent to a region and design real-time solutions in response to production and environmental monitoring needs.

Nanometrics offers a range of wireless and satellite transmission options to link remote operations back to a central data processing facility.

Nanometrics systems consist of fixed or portable, standalone stations that can be moved between production sites or repositioned to target specific areas of interest.

These systems can be purchased or leased and are offered on a turn-key basis, including site preparation, system installation, ongoing maintenance and centralized data processing.



## Complete Freedom of Station Placement

Nanometrics offers communication options based on Libra VSAT systems as well as traditional GPRS modems. Libra provides customers with a private network with ultra-low latency as well as a range of options for remote site placement, including hostile or isolated terrain unsuitable for cellular, telephone or radio communications.

Libra remote stations can be installed anywhere there is a clear view of the satellite. Consuming as little as 6W of power, Libra remote stations can be solar powered and are completely independent of any established ground infrastructure.





## Data Management

From detection to notification in ~30sec

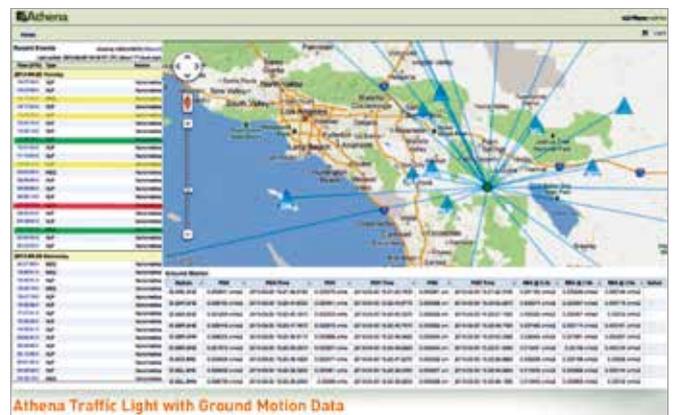
### Data Processing

- > Mission critical infrastructure supports operations 24/7 to ensure data availability
- > The system acquires data not only from your private network, but also from local and regional networks operated by government agencies in Canada, the US and around the world
- > Continuous on-line quality control confirms network performance and readiness
- > Magnitude calibration against regional networks
- > On-line real-time processing provides immediate feedback within seconds of an event
- > Analysts review of all significant activity in the region and its relationship to natural seismicity and operations
- > Regular reports on seismic activity in the region and its relationship to operations, if any, are provided



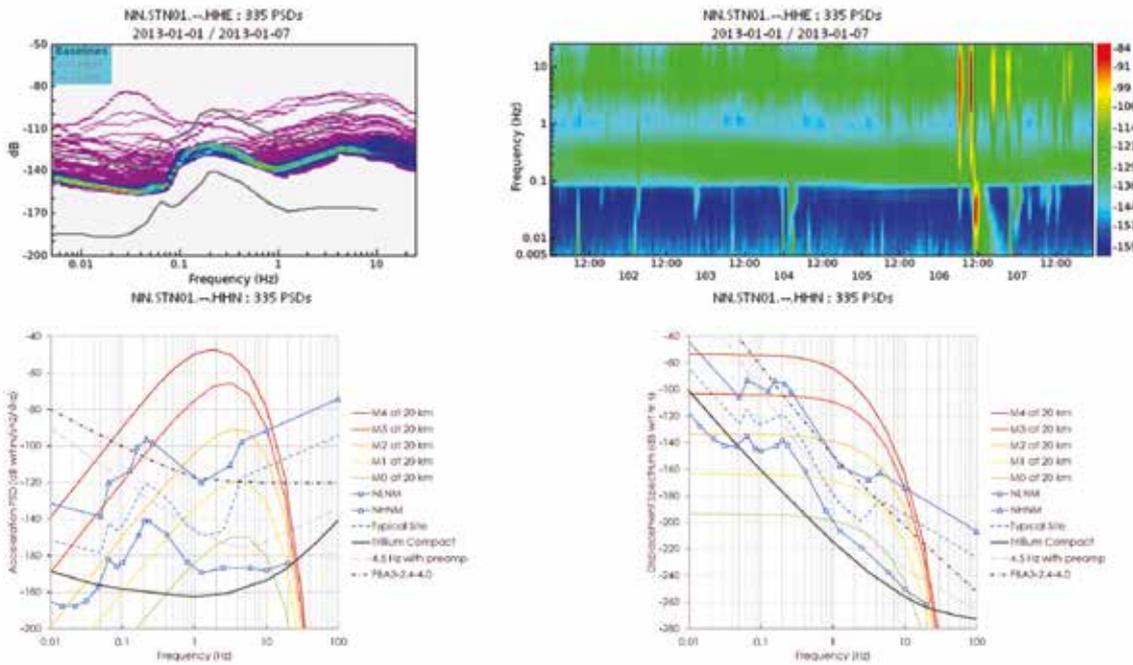
### Real-time Operational Feedback

- > Immediate feedback to customer personnel via "traffic light" display
- > Publications and notifications posted on secure data channels including web portable (Athena), SMS and email
- > Real-time ground motion data provides estimates of whether an event was felt and where it occurred



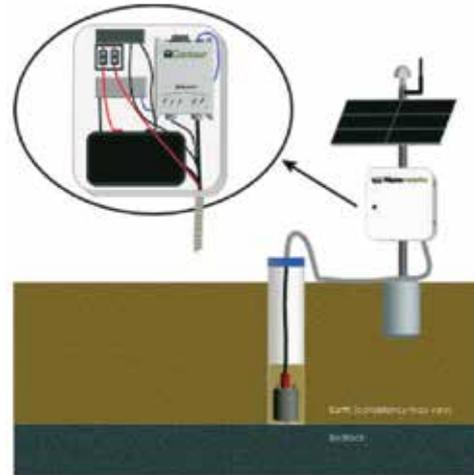


Nanometrics network design specialists perform detailed modeling of the region to ensure the network objectives for minimum detection threshold and location accuracy are met. This includes comprehensive site noise analysis, event spectra modeling and location accuracy contouring.



Event spectra model in both acceleration PSD and displacement spectra. Event spectra are expressed in different units to emphasize location and magnitude accuracy.

- > Nanometrics offers proprietary low noise seismometers that facilitate microseismic monitoring at the surface as well as induced seismicity in the region.
- > Regional seismicity monitoring requires broadband sensor technology capable of identifying, locating and evaluating low frequency events that may occur naturally in the vicinity of operations. These events produce signals well below the 4.5Hz corner frequency of a typical geophone.
- > The required signal to noise ratios are typically best achieved by burying sensors at depths from near surface (1 to 2m) up to 30m. Nanometrics offers a range of broadband direct burial sensors that can go as deep as 300m.



## Communication options by key specifications

### LIBRA VSAT

#### KU-BAND VSAT, CONTINUOUS REAL-TIME DATA

Power consumption	<4.5 watts typical (total site)
Data latency	<5 seconds typical
Data availability	>99.9% typical
Antenna	1.2 m typical

### CELLULAR

#### GPRS, 3G AND 4G MODEM OPTIONS

Power consumption	<7 watts typical (total site)
Data latency	Depends on cellular provider, <10s typical
Data availability	Depends on cellular provider and coverage
Antenna	Omni and high gain directional options