GEOSPACE® Technologies

PASSIVE SEISMICS

Exploiting Real-Time Analytics

Geospace has been thoughtfully preparing to expand our traditional offerings to the Oil and Gas market with the addition of real-time analytics. Our Passive Seismic Roadmap is now coming to fruition with systems able to monitor the earth for specified sources of seismic energy, automatically.

Our commitment to providing such revolutionary capability was demonstrated in mid-2018 with the acquisition of Quantum Technology Sciences. For more than 20 years, Quantum has served the Security and Surveillance market delivering geophysically-derived actionable information and in so doing, redefining the capabilities of passive seismic monitoring.

Passive seismic-acoustic systems persistently listen to a defined volume of earth, air, or water for seismic-acoustic sources of interest. Whether sensed via omni-directional sensors, axial sensors, or coherent arrays, our systems continuously acquire data and convert it to valuable information, automatically.

To do this successfully requires profound expertise in the two fundamental elements: data acquisition and analysis. Geospace has been delivering robust, proven acquisition systems for decades, be it large scale networks such as our Permanent Reservoir Monitoring (PRM) solutions or wireless systems such as our GSX/GCL and OBX offerings. Quantum has been doing the same on the analytic front supporting missions with a broad range of geophysical scales ranging from global nuclear treaty monitoring to artillery range sustainment to systems operating on the edge performing unattended surveillance or key asset security.

Now, together, our synergy allows Geospace to be the OEM of a complete end-to-end system solution we intend to deliver to Subsurface Storage Management applications where induced seismicity is a key indicator of reservoir integrity. No other organization has our combined expertise.

SIGNAL AND INFORMATION PROCESSING

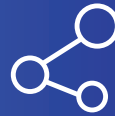## Transforming Waveform Data to Results, Automatically

Our real-time seismic analytic systems have been operational for quite some time, and whether they are operating on a single channel of data or thousands of channels, the fundamentals remain the same.

Detect signal of interest

Associate signal to source event

**Classify signal & identify source**

Locate the Source

Quantum has built a number of these analytic systems to meet various missions and applications. Our most recent and sophisticated offering is now integrated with Geospace's GeoRes data acquisition capability on the front end. While the nature of the application requires significant system complexity, all of our systems start with a simple waveform. Continuous data streams are processed in time, frequency, and space executing detection and feature extraction algorithms. The resultant alphanumerics are consolidated into discretized objects upon which information analytic processing occurs beginning with sequential alphanumeric data accumulation. Multi-dimensional tracking helps build signal classification which leads to source identification, and localization is performed leveraging a variety of sophisticated techniques. It always starts with a waveform and ends with a result.

EXAMPLE ANALYTIC APPLICATIONS

Miner-Sense

Automatic Monitoring of Quiet Impacts

Miner Sense leveraged Quantum's seismic acoustic detection and ranging technology (akin to SONAR and RADAR for the geophysical domain) called SADAR® to monitor for subterranean impact sources in a subterranean local area using surface sensors. Miner Sense's mission was to detect and locate miners entrapped in a catastrophic underground mine collapse who were trained to hammer on roof bolts at prescribed intervals and sequences. The system detected and located the energy while classifying it as human hammering. Quantum also delivered a similar system for the US Army to deploy at artillery ranges. This system used surface sensors to detect and locate fired artillery round impacts to classify those that did not explode as UXO (unexploded ordnance).
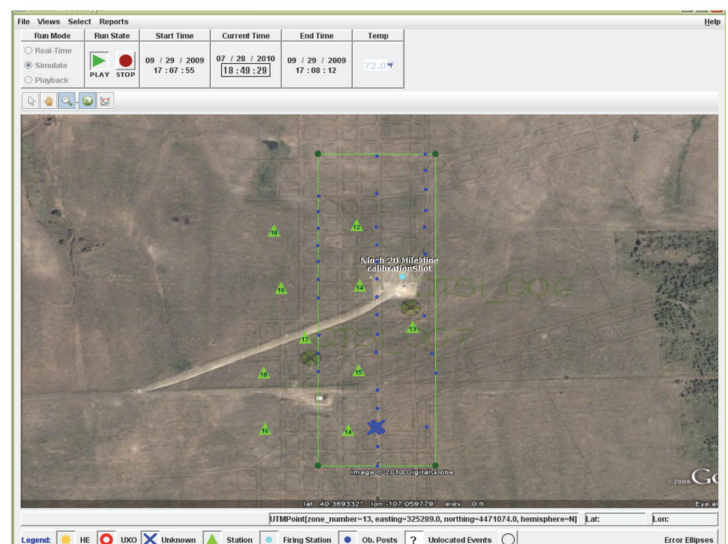

Surface sensor systems (green triangles) detecting and locating miners (blue "X") over 1000' underground inside a very large, active, long seam coal mine.

U.S. National Data Center (USNDC)

Real-time Critical National Security Mission on a Global Scale

Quantum designed, developed, and maintained Phase 3 of the USNDC, which ingested thousands of channels from a global network of sensors, producing near real-time seismic event bulletin and discriminating natural earthquakes from "unnatural" subsurface nuclear explosions. This mission-critical system never ceased operations and detected, classified, and located hundreds of low magnitude events each day persistently searching for the proverbial nuclear needle within the earthquake haystack.
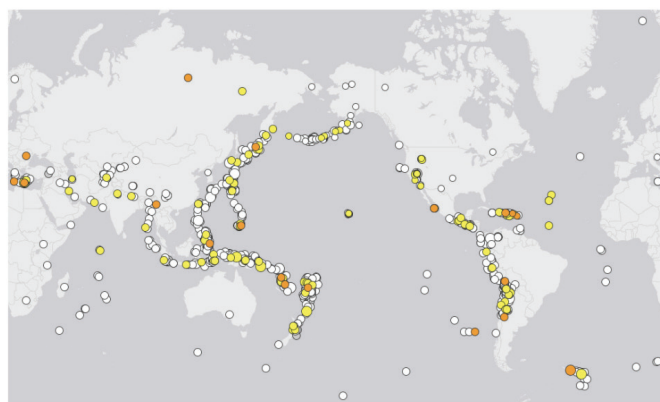

At left, a representative example of global stations used by the USNDC to produce a persistent event bulletin at right.

Tunnel Construction Detection
Underground Surveillance Simplified

Also leveraging SADAR, Quantum's subterranean tunnel monitoring system identifies and locates the active excavation of underground tunnels by detecting and classifying sources of a non-impact nature, such as mechanical hammer drilling or electric motors. This system was blind tested overseas on an active military base, demonstrating effective noise and clutter cancelation while isolating the source of interest.
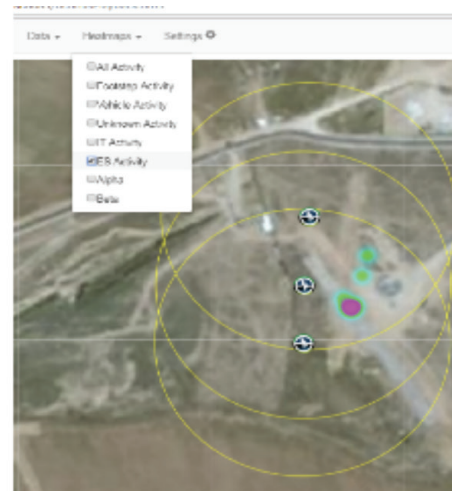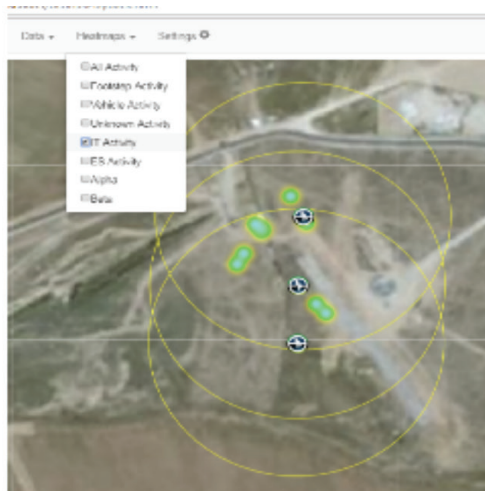
Four layers of results are shown for the same two-hour time period. Above left, the red shows all sources of energy. The yellow shows only the contribution of energy from footsteps, the green shows human digging on the surface, and the magenta is subterranean mechanical digging, the source of interest. All results were produced automatically and in near real-time.

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RESERVOIR INTELLIGENCE

Geospace Persistent Permanent Reservoir Monitoring System

Geospace is proud to introduce Persistent Permanent Reservoir Monitoring (PPRM), a technology founded on the passive seismic expression associated with reservoir manipulation from either the extraction or insertion of fluids out of, or into, the subsurface.

Our PPRM systems are comprised of two parts. The first is quality data acquisition for which our sensors and proven PRM acquisition systems have set the standard for traditional active source imaging of the earth's upper crust. Our acquisition systems have now expanded to include SADAR, which offers the benefit of near-surface deployment but with a reduced station constellation. The second part of our PRM systems are automated, real-time, persistent analytics that inform, alert, and if desired allow for higher order interactive analysis.

PPRM systems are designed to contribute to the MVA function of subsurface fluid storage by detecting and accurately locating microseismicity. Clusters of microseismicity in time and space are indicative of fracturing, and high resolution locations reveal if the cluster of events are occurring, undesirably, in an overlying strata. However, for this information to be socially relevant, it must be actionable.

Monitoring, Verification, and Auditing (MVA) systems must produce actionable information.

Human health and safety are the singular priority when undergoing the expense and complexity of fluid sequestration. Once it is in the ground, it is important it remains there, with confidence. In order to be actionable, indicators of potential leaks must be automatic and produced in near real-time. Should the reservoir become compromised, knowing it before a leak reaches the surface ensures proactive procedures can be followed and the public's trust remains intact.

PPRM DATA ACQUISITION

- Geophone PRM
- SADAR®-E
- OptoSeis™ Fiber PRM

PPRM DATA ANALYTICS

STORAGE