

Land Acquisition Update: Nodal Seismic Acquisition

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Summary

Seismic acquisition equipment has gone through a major transformation in the last 10-15 years. Gone are the crews with thousands of kilograms of cable, batteries and geophone strings. The newer nodal seismic recording systems do not have any cables, they contain either geophones or Micro-Electromechanical Systems (MEMS), Global Positioning Systems (GPS) for timing and location, batteries and memory and they are extremely lightweight.

These systems are autonomous and the data are recorded on local memory that is then downloaded at the transcriber station that both harvests the data and charges the batteries (induction based) at the same time.

This is an extreme change from the cabled systems of the past. Nodal crews are smaller, safer and faster. However, since the data are not reviewed in real-time, there is the potential for issues with data quality control.

In this presentation we will review some of the systems and highlight some of the differences in the various product offerings.

Historical Breakthroughs in Seismic Acquisition

Some of the earliest earthquake detection systems, such as the Seismoscope (c. 134 AD), simply detected a threshold of ground motion and the general direction of the source (**Figure 1**).

The first seismograph was developed in 1890. It was securely mounted onto the surface of the earth so that when the earth shakes, the entire unit shakes with it EXCEPT for the mass on the spring, which has inertia and remains in the same place. As the seismograph shakes under the mass, the recording device on the mass records the relative motion between itself and the rest of the instrument, thus recording the ground motion (**Figure 2**).

Multichannel cable-based exploration seismic systems, like the DFS V, were very popular in the 70s, 80s and 90s with telemetry-based systems hitting the market shortly after that (**Figure 3**).

Cableless and nodal seismic acquisition systems are now used almost exclusively in most parts of the world for land seismic programs (**Figure 4**).

A Summary of Nodal-Seismic Acquisition Systems

Weight

Nodal systems can either be geophone-based, MEMS-based or even piezoelectric-based recording data in either velocity or acceleration units. These autonomous nodes are extremely lite weighing between 150g and a few kgs with most in around the ½ kg mark. That means the field-deployed recording equipment for a 10,000-channel nodal recording system will weigh about 5,000kgs. A similar 10,000 channel cable recording system will weigh approximately 77,600kgs. That's almost 16 times heavier for a cable crew compared to a nodal crew.

The weight difference may be the single biggest advantage. The weight and size of the equipment increases the mobilization and deployment effort starting with organization and storage, loading, trucking, staging space and location, field transport to station locations (heli, quad, truck, snowmobile, on foot). In most cases, nodes can be deployed on foot with vehicle supported drop points.

With a reduction in weight comes a significant upside to QHS&E. Less tripping hazards, fewer lifting related injuries or sprains, less fatigue and fewer vehicles.

Battery Life

Most nodal systems have a battery life of between 20 and 50 days which in most cases (in North America) should be sufficient for the entire job. Battery management on a cable crew is an important part of the crew logistics and in maintaining continuous recording. If a surprise battery failure occurs on a cable crew in a remote location of a 3D program, significant delays can shut down recording.

Memory

Typical memory storage capacity is 16 GB non-volatile flash memory. At a 2ms sample rate, this is roughly 30 days of continuous recording, depending on the system.

GPS

Global Positioning Systems (GPS) are crucial for milli-second timing accuracy but also for approximately 0.5m position accuracy. The location accuracy is important when conducting stakeless programs.

Uptime

There can be significant uptime improvements with nodal systems. For example, most cabled systems require that every cable on 2D or 3D spread is working properly. Any

damaged cables have to be replaced before shooting can continue. Cable damage can be caused by animals, vehicles and water leakage. Overnight cable breaks for road crossings need to be reconnected every morning and this can lead to delays. Consequently, urban seismic (in cities) greatly benefits from using nodal systems (**Figure 5**). Copper theft can also be a cause for concern with some cabled systems.

Testing

Testing such as distortion, gain, phase, resistance, sensor noise, sensor tilt, temperature, auto DC offset calibration and response accuracy are all possible using Bluetooth connectivity but the testing is not as rigorous as it used to be with cabled systems.

Geophone vs MEMS

The trade-off between geophones and MEMS-based systems is one of weight versus power consumption. This is most notable when going from single component to 3-component systems. A noticeable increase in weight for a 3C geophone and almost a tripling of power consumption for 3C MEMS.

An important factor in the demise of MEMS acquisition was the high noise floor, especially at low frequencies. However, the advantage was the flat spectrum. Recent advances in MEMS technology has led to a convergence of the applications of broadband seismometers, such as measuring earthquakes, induced seismicity monitoring and passive seismic with conventional active seismic. However, broadband seismometers are more than a magnitude more expensive than the highest quality MEMS. We are not suggesting that broadband seismometers do not have unique applications just that MEMS technology is closing in on the historical broadband applications.

Conclusions

Nodal and cableless seismic recording systems are becoming more common. They allow for greater productivity, cost savings and improvements in HSE. Their major perceived downfall is that they do not allow for real-time noise monitoring, the state-of-health of the active spread of the seismic patch, potential data loss for dead stations and hence data quality. However, historically, actual data harvests are typically over 99%. It is unlikely that cableless systems will completely replace the cabled version. However, it is likely that the different systems will be matched to the environment in which they are working. Some international jobs may see both cableless and cabled systems combined and most acquisition companies will probably be offering both systems for a while to come.

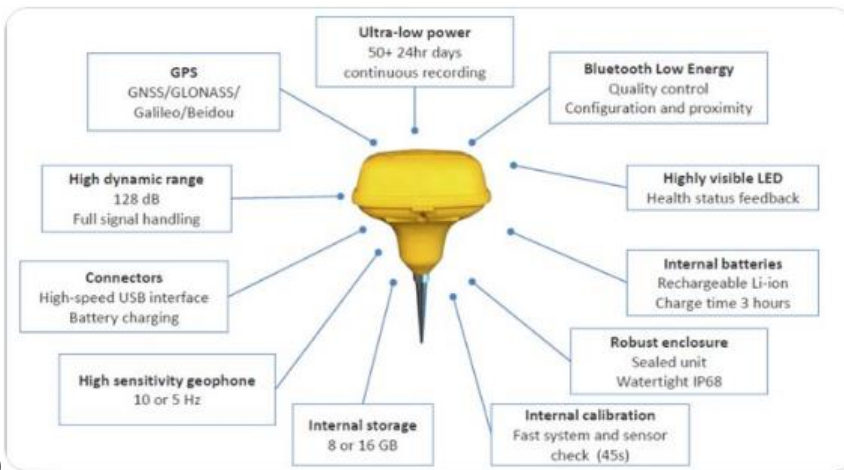


Figure 1 (Left): The Seismoscope was comprised of dragons, drop balls and frogs. The dragons held the drop balls in their mouths until experiencing ground motion from a particular azimuth. The azimuth of the incoming event correlated with the position of the frog into which the ball fell.

Figure 2 (Right): As the seismograph shakes under the mass, the recording device on the mass records the relative motion between itself and the rest of the instrument, thus recording the ground motion.



Figure 3: A cable system typically has lots of cable! The cable is used to transmit power, data and to connect different receiver lines to each other. Note the larger batteries that are necessary for providing power to multiple channels. These batteries can weigh up to 15-20Kg and may be a source of injury on a line crew (strains and sprains). The takeout spacing on a cable system will be designed to work for most jobs but in Alberta, say, group intervals can be as small as 5m and as large as 25m.



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Figure 4 (Left): A typical seismic node. Note that everything is internal to the node weighing in at approximately 0.5kg.

Figure 5 (Right): An example of urban seismic, in this case in West Los Angeles.

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