# INTEGRATION OF TECHNOLOGIES FOR IMPROVED RESERVOIR RECOVERY

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## Abstract

There are several options in the industry today when considering the technologies to be used in a seismic program. Consideration must be made when designing the survey, the acquisition technique to be used and what technologies to apply that ultimately result in improved recovery from the objective(s). These technologies include not only the traditional towed streamer arrays, ocean bottom cable systems and ocean bottom autonomous nodes, but also as to what type of seismic source, sensors, source/receiver positioning techniques, quality control processes and methodologies and even the personnel assisting with the survey operations. Attention to these details must start in the initial planning stages and be implemented during the survey acquisition and data processing, through product deliveries. These processes will involve several disciplines within and outside the geophysical community. Integrated discussions are ongoing, which will in due course, improve probabilities for improved recovery.

This paper draws attention to the detail required to adapt and integrate technologies and disciplines to assist the geophysical community in the improvement of reservoir recovery from a geophysical equipment manufacturer's point of view.

A manufacturer's system design goals are to push the boundaries of today's technology to increase system speed, improve the quality and integrity of the seismic data being collected, and while improving and extending the life of the equipment, and subsequently reducing the cost of ownership.

Current trends suggest the need for real-time recording of more seismic channels for higher resolution imaging and increased spatial sampling. Permanently installed reservoir monitoring systems is the primary driver for the increased capacity through the need for multi-component and single point receiver recording.

Over the last several decades, there has been an exponential growth in the number of seismic channels per crew from 12-24 channels in the nineteen-sixties to the large crews of today nominally operating 4,000 to 6,000 channels. This trend continues today with several contractors talking in excess of 20,000 channels, especially when needing multi-component data.

The challenge for manufacturers is how to implement the latest and future technology into systems that meet a competitive price, while improving product reliability.

The major costs on seismic crews are people, transportation and equipment maintenance. A cost reduction is driving manufacturers to design and manufacture smaller, lighter field equipment that is stronger and subsequently more reliable. In pursuit of these design goals, investing and incorporating new manufacturing and testing technologies and processes, will improve product quality. These development efforts are continually increasing the active life of instrumentation, cables, and electronics to ensure their *in situ* reliability.

In the marine environment, a versatile and yet economical system that addresses both the shallow-water market (less than 150 meters) and the deep-water market, 3,000 meters and greater, would be ideal. These deeper water depths present new challenges to the seismic industry, primarily with cable handling, system reliability at depth, and operation logistics. Fostering key alliances and business relationships are essential to enduring this installation environment.

There are several trends emerging in system architecture for large-scale recording systems are the requirements for processing power and software that in previous generation systems was always housed in the centralized recorder, is now being distributed to in-field modules (distributed electronics). This allows for localized QC of sensors and instruments, plus data stacking and correlation, in some cases. ASIC (Application Specific Integrated Circuit) and software, rather than hardware based systems, provides this capability. These systems must have the flexibility to operate efficiently in all environments.

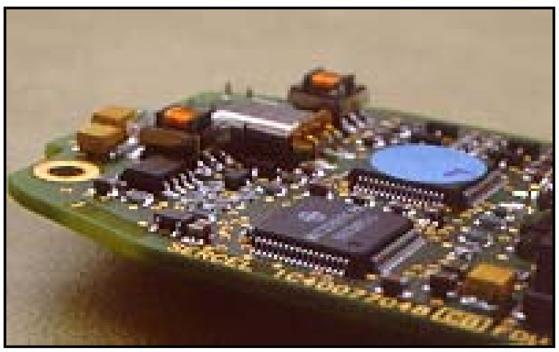

*Figure 1: ASIC Technology*

We are also seeing rapid development on two fronts, single point receivers and the digital sensors. Single geophone recording provides higher data integrity, improved resolution through better static analysis. Statics are calculated per receiver rather than an average value over the complete geophone array. This method can also provide higher spatial sampling and the opportunity for target oriented array forming. This means shooting a prospect with a very high density of channels and then processing the data for the optimized image at the depth of interest.

The digital sensor has been developed and is a result of MEMS (Micro Electro Mechanical Systems) technology. The coil and spring technology of a geophone is now being transformed on to a very small silicon substrate to form a MEMS accelerometer (Chip). The major advantages of this technology over a geophone are that is provides a direct digital, superior performance and is very small. This type of technology is fully commercialized is beginning to revolutionize seismic data in terms of channels and should further stimulate the use of 3C, 4C acquisition and the "Instrumented Oil Field".

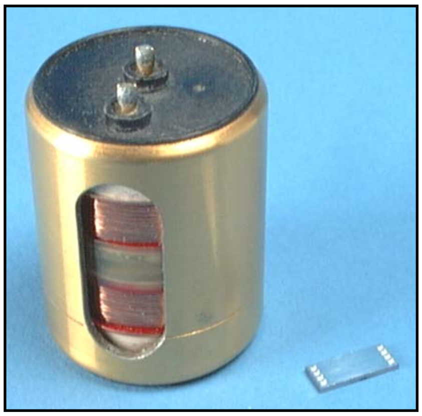

*Figure 2: Conventional Geophone and a Digital MEMS Sensor*

Adopted from the communications industry, permanently deployed systems have incorporated fault-tolerant system architecture. Adding redundant power and data telemetry wires to the cable construction and incorporating a system backbone architecture or looped-back cables, provides the best means to improve system performance and extend the system's life while *in-situ*. Additionally it is equally important that handling equipment be designed to be 100% compatible with the system, being deployed and/or possibly retrieved.

Cabled systems provide the ability for the in-sea equipment and sensors to be tested during and after deployment, as well as during data acquisition. Technology exists to allow for real-time data QC and data transmission to shore based systems and personnel, via a surface platform's (TLP, SPAR, etc.) communication system.

Nodal systems, or non-cabled systems, evolved from deep-ocean seismometers, which have been used by research institutions, universities, and governmental agencies, such as the USGS, to monitor tectonic and volcanic earthquake activities. Similar to cable systems, where sensors (geophones) are in contact with the seafloor, the nodes autonomously or semi-autonomously record continuous data locally, until the units are eventually retrieved or until the battery power has drained below operational levels.


*Figure 3: Autonomous four component node*

The upsides for nodes are similar to those with cabled seabed systems, repeatability due to improved signal to noise performance, multi-component sensors, works well in obstructed areas; crew can be easily mobilized on vessels of opportunity.

HSE compliant deployment and retrieval methodologies are being employed by service companies to insure that the deployed equipment is laid within specification and more importantly in a benign and safe manner.

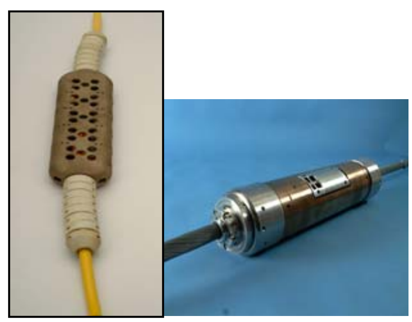

*Figure 4: Types of permanent reservoir monitoring systems*

**Conclusion**

Each field presents it own unique challenges. These challenges may be; geophysical, geological, environmental or logistical, either way a 4D solution exists today. Integrated systems and techniques can be employed to be image and characterize each reservoir despite the challenges. Whether it's an integration of seabed cabled and node systems due to subsurface obstacles, nodes and towed array surveys to enhance the towed array dataset with wide azimuth multi-component data, or the addition of down-hole sensors to compliment surface seismic activities.

Seismic instrument manufacturers continue to be on the cutting edge of technology developing cost effective large channel systems. Technology, today and tomorrow, will be an integral exploration and production tool, which will help to better understand the reservoir changes over time.

## Acknowledgments

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