

Offshore

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World Trends and Technology for Offshore Oil and Gas Operations

*Does new technology
reduce drilling times?*

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Gulf
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Map**

Permanent ocean bottom seismic systems to improve reservoir management

Active and passive monitoring solve imaging problems

For effective management, operators need more timely information about the reservoir during its life. Commercially available well bore monitoring systems measure parameters such as temperature, pressure, flow rate, and composition. These use both established electronics technology and the newer optical techniques that promise performance reliability improvements.

Ocean bottom seismic (OBS) systems measure reservoir responses to production including:

- Fluid movement
- Change in location of oil/water contacts, gas/water contacts, and gas/oil contacts
- Identification of reservoir zones that are not being drained
- Changes in hydrocarbon saturation and pressure.

In addition to active seismic data, OBS systems provide passive, microseismic data, adding to the benefits of permanent deployment. Passive data provide continuous rather than intermittent information and raise extraction efficiency by helping to reveal oil and gas reservoir activity in real time.

Data quality challenges

Increased uptake of 4D seismic has driven development of cost-effective, permanently deployed

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oysed OBS cable systems. During conventional 4D surveys, marine streamers are towed behind an acquisition vessel. Permanently deployed OBS networks – cables with integrated seismic sensors on the seabed – mitigate issues associated with streamer data, including repeatability and lack of multi-component acquisition.

Streamer data do not always have sufficient resolution and richness to adequately image subtle changes in seismic response from reservoir production. Ocean-bottom, multi-component data provide data quality necessary for robust reservoir monitoring and help solve a number of imaging issues that conventional streamer data cannot, including imaging through gas clouds, imaging of low-impedance reservoirs, and improved analysis of fracture orientation and density.

Streamer 4D surveys also suffer from a lack of repeatability due to changes in acquisition conditions such as streamer and source positioning and ocean conditions. Changes in sur-

face infrastructure, like platform additions, can make subsequent 4D surveys impossible for parts or all of a field. Permanent OBS systems allow far more consistent acquisition conditions between 4D surveys. The result is more precise imaging of subtle reservoir production-based seismic response changes.

Streamer data are always contaminated by water-borne multiples from energy reverberating between the ocean surface and seabed. Summation of the hydrophone and Z-axis signals from ocean bottom sensors effectively eliminates these problems. In addition, this same technique dramatically extends the acquisition window, an important consideration in many offshore areas.

Subsea infrastructure of the field can restrict acquisition. Pre-deployment modeling and the resulting optimized placement of ocean-bottom sensors help minimize the impact of infrastructure obstacles.

System deployment and integration challenges

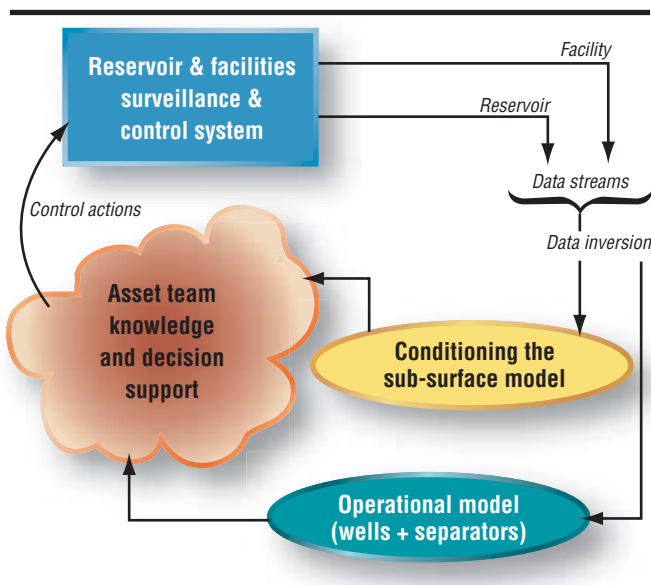
High capital and operational costs have prevented wider acceptance of the current retrievable OBS systems. The complicated designs required to handle cable deployments drive up capital costs. Operational costs increase due to the:

- Time required to deploy equipment and make it operational
- Number of vessels required to perform the acquisition
- Acquisition geometry and overall system reliability issues.

In addition, other issues include accurate positioning and heading measurements in deeper water, data artifacts from gimbal systems, and in-line/cross-line data signature differences due to undesirable sensor/cable coupling.

The design of permanently deployed OBS cables will be influenced by the oilfield practices used to hook up widely dispersed satellite wells. The techniques used to connect the power and communications of production control systems will also make a substantial contribution to their design.

Deployment and installation challenges vary greatly depending on whether the system is to be applied in a deepwater subsea development or in a shallow-water platform installation.



Monitoring seismic reservoir activity, actuation and control systems, and production flow measurement software fundamentally interact in the sub-sea loop of the automated oilfield.

Installing relatively short OBS cables and connecting them to a subsea data collection point can simplify operations.

ABB's development and deployment of the Troll Pilot subsea processing system in the North Sea demonstrates the company's ability to provide abundant power and data transmission support for an OBS system's operation. Typically, OBS systems are expected to require 20 kw of power. An OBS cable comprising 10,000 sensor nodes will require approximately 1 gigabit/sec data rate at the surface data collection point. Substantially improved optical fiber communications can achieve the data rates demanded by OBS systems. ABB has demonstrated the ability to transmit data over 200 km using optical fiber and high sensitivity optical modems. A new 100 mb/sec modem will ultimately be required for the more complex OBS systems, but thanks to existing technology, this is regarded as an "engineering development project" challenge rather than research and development.

Previous OBS deployments

Considering the strong interest in this technology, there have been surprisingly few applications during the past five or six years. The first permanent OBS system deployment was in the North Sea's Foinaven field in 1995. This system was equipped with only hydrophones, and the cable was trenched and deployed in 450-500 m of water. The system's most recent data was

The market is driving toward permanent reservoir monitoring enabled by 4D and micro-seismic data collection.

acquired in 1998.

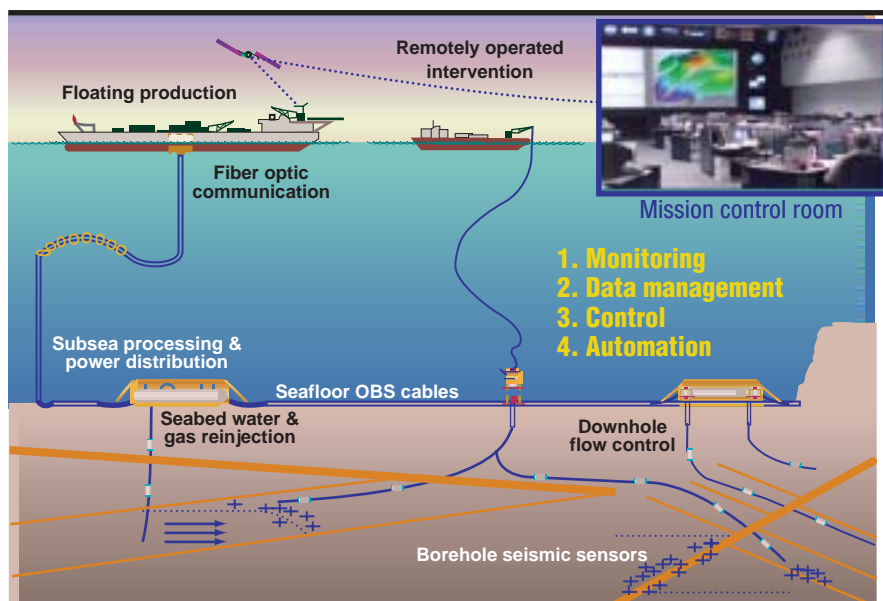
In 1997, an experimental Input/Output retrievable OBS array was deployed in about 90 m of water in the Gulf of Mexico's Teal South field. Although regarded as a technical success, it highlighted key deployment and operational problems, including vulnerability of unburied cables to the perils of fishing.

ABB and I/O share recent involvement in a single cable OBS trial from a North Sea platform. Analysis of data from that installation is in progress.

Permanent installation configurations

Successful 4D/4C permanent OBS systems must meet or exceed operators' reservoir imaging objectives and must be cost effective. It is essential to consider field and reservoir size, structural geology, acoustic characteristics, reservoir depth, and water depth.

Optimal installation requires extensive, pre-deployment seismic modeling to ensure that reservoir imaging objectives are not compromised by platform installations, subsea produc-



The automated oilfield will integrate 4D/4C OBS monitoring systems with existing subsea infrastructure power and telemetry systems.

tion equipment, and pipelines. GMG/AXIS, an I/O subsidiary with extensive experience in multi-component survey modeling, makes certain that imaging objectives are met.

The ABB-I/O alliance's unique ocean-bottom architecture consists of blocks of ocean-bottom sensors connected to backbones. The configurable

plex tasks. They mandate the team approach.

Permanent monitoring promises to be a challenge to E&P companies because of the large amounts of data generated. New data management and interpretation techniques are needed to take full advantage of the continuous stream of data from the reservoir. To ensure the most up-to-date reservoir interpretations and to optimize production, real-time data collected must be processed and made quickly available to a number of E&P disciplines including geophysicists, reservoir engineers, production engineers, and field operations personnel. This is all part of delivering the automated oilfield.

Plans

Besides analyzing results from the North Sea trial system deployment mentioned previously, I/O and ABB are discussing applications of permanent OBS systems with a number of operators. These relate to assets ranging from deepwater subsea to shallower water platform installations, indicating a global market for this technology.

The market is driving toward permanent reservoir monitoring enabled by 4D and micro-seismic data collection. The alliance partners believe that this makes permanent OBS systems the key delivery mechanism.

It is well established that broad acceptance of new technology in the petroleum industry takes time. The alliance is therefore focusing on what are seen as the key issues for acceptance: cost reduction, reliability, and improved data quality. As operators increase their comfort level that these issues are being addressed, it is expected that more OBS systems will be routinely installed as part of the subsea system infrastructure in many development projects around the world. ●

The automated oilfield

ABB and I/O have formed a strategic alliance to provide permanently deployed 4D/4C OBS monitoring systems. These integrate with existing subsea infrastructure power and telemetry systems for either subsea or platform-based field developments.

ABB's vision of the "oilfield of the future" is that it will be operated as a single industrial process, optimizing oil and gas production from the reservoir through wells and through subsea and surface facilities. In short, it will deliver the automated oilfield to the market. The company is developing its ideas by working with prominent E&P customers and partners to test assumptions and solutions.

The major driving factors include the need for better operational information and improved production results at lower costs, resulting in improved net present value for producing assets. In addition, its delivery will satisfy the concerns over the growing shortage of skilled exploration and production staff.

A number of technical building blocks are already available or in an advanced stage of development. These are principally in the areas of monitoring seismic reservoir activity, actuation and control systems, and production flow measurement software.

ABB Offshore Systems has focused its monitoring portfolio on monitoring beyond the wellbore. This includes its microseismics monitoring systems and data interpretation services.

Input/Output, a leading provider of seismic imaging technology with particular expertise in sensor technology, has developed the VectorSeis technology platform, a micro-electro-mechanical systems based multi-component sensor ideally suited to ocean-bottom, 4D/4C reservoir monitoring.

I/O's all digital VectorSeis technology platform is ideally suited for ocean-bottom as well as in-well and land seismic acquisition system applications. The VectorSeis OBS product line addresses shortcomings of present multi-component ocean-bottom technology. These sensors operate at any angle, measure deployment angles directly and eliminate the need for gimbal receiver units that can create data artifacts. All three of the accelerometers have identical seismic responses and high vector fidelity at all tilt angles unlike omni-directional geophones. High vector fidelity, coupled with improved linearity and bandwidth, makes these sensors ideally suited to record the full vector wavefield. I/O's patented cable de-coupling design reduces mechanical cross-coupling between cables and the sensor systems. These innovations result in the highest quality 4C data.



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