On-demand Ocean Bottom Nodes (OD OBN) for low-cost reservoir monitoring

Jorge Luis Lopez*, Samantha Grandi, Diego Juliano (Shell Brasil); Alexandre Augusto Cardoso da Silva, Reinaldo Carvalho da Silva (Petrobras); Valter Beal (SENAI CIMATEC); Shaun Dunn (Sonardyne); Cristian Nevoso (Saipem)

Abstract

We present an innovative system for 4D seismic acquisition to monitor reservoirs flexibly, on-demand and at low cost. The solution uses nodes, which are designed to remain on the seafloor for five years, recording seismic data autonomously and monitoring the deformation of the seabed. The system uses an AUV to control the nodes via acoustic communications and to extract the seismic data via optical laser communications. Prototype nodes have been tested in shallow and deep water, and a pilot plant is under construction to manufacture a pilot system for deployment in a Brazilian pre-salt field.

The nodes operate for 5 years, autonomously and without intervention, recording 500 days of seismic data, and measuring seabed deformation continuously. The node design had challenging specifications: low power seismic recording and communications systems to reduce the number of batteries; compact design and ease of ROV handling for efficient deployment; depth rated to 3,000 meters; size, shape, and mass to achieve desirable seabed coupling pressure; housing materials with endurance guaranteed for 5 years of immersion in corrosive seawater; low-cost manufacturing commensurate with predicted high-volume node production. The system includes aluminum node housing and protective plastic cover; node controller module; 4C/24 bits seismic recorder module; acoustic communications module and transducer; optical communications module and optical modem; power management module; large capacity battery packs; pressure, temperature, inclinometer sensors.

The FlatFish AUV is used to localize and interface with the nodes to perform several missions, including system health checks, internal clock-time synchronization, to start and stop active and passive seismic surveys, seafloor geodesy data upload, and data delivery to user. It is equipped with subsea acoustic and optical communication modems that allows data exchange between nodes and vehicle: long-range, low-bandwidth acoustic communications and short-range, high-bandwidth optical communications. Seismic data harvesting requires optical communications of 8 min transmission time for a 60-day seismic survey.

Two node concepts were selected for prototyping: a cylindrical node, which is more difficult to machine from a block of aluminum, but easy to assemble and a three-tubes concept that uses ready-made tubes but is more complex and has more parts to assemble. A set of Concept Demonstrator nodes, able to record seismic data, were tested in 2100m of water in July 2021 during an OBN survey in the Sapinhoá field. The first communication tests between nodes and the FlatFish took place in June 2022 in Saipem´s test facility in Trieste, Italy. The tests revealed needed improvements in node assembly and in the firmware of the optical communications module. The next batch of tests involved the first use of the FlatFish in deep water and took place in Q4 2022 during another OBN survey and during a set of inspection tests in the BC-10 field. The test in BC-10, in 1750m of water, demonstrated the optical data harvesting and a set of missions accomplished using acoustic communications.

The three-tubes concept was selected to be manufactured at scale, in a pilot plant currently being constructed in Salvador, Brazil, and later deployed in a pre-salt field. For a typical area of 100 km2 produced by a FPSO, 625 nodes would be required if set on a 400m grid. In the Brazilian pre-salt, there are more than 30 FPSOs in operation or planned which may benefit from OD OBN.

Compared with other permanent reservoir monitoring systems, with nodes resident on the seabed for 5 years OD OBN provides a solution that is updatable, adaptable to larger or denser areas, flexible in upfront investment, and resilient to individual node failures. Compared with conventional OBN, surveys can be acquired with greater repeatability and shorter lead-up time, resulting in faster and more accurate data for reservoir management. The removal of the node handling vessel reduces cost, footprint, and human exposure. The technology has been tested in deepwater and will be scaled up and enter commercial deployment in Brazil and elsewhere from 2025.