Submission code: XBZRWPVXBZ

See this and other abstracts on our website: https://home.sbgf.org.br/Pages/resumos.php

Challenges for PRM design and feasibility analysis in highly obstructed oil fields: Geophysics, Engineering and PRM Market in FEED studies

Júnior Bresolin (Petrobras), Carlos Eduardo Borges de Salles Abreu (Petrobras), Paulo Neves Côrtes (Petrobras), Yuri Cesar Figueiredo Costa (Petrobras), Tomaz Ballve Vargas (Petrobras)

Challenges for PRM design and feasibility analysis in highly obstructed oil fields: Geophysics, Engineering and PRM Market in FEED studies

Abstract

Seismic acquisition technology has experienced transformative advancements, evolving from the early use of 2D and 3D azimuthally limited surface seismic streamers to the recent successes of Ocean Bottom Nodes and other full-azimuthal systems, including fiber optic-based technologies. Permanent Seismic Monitoring (PRM) has gained traction over the past thirty years, with fifteen projects established in the North Sea and three off the Brazilian coast. This technology involves the permanent installation of optical fibers and associated equipment on the seabed, coexisting with a wide array of oil production infrastructure, such as rigid and flexible pipelines, umbilicals, Christmas trees, and more. This necessitates strong collaboration among geophysics, geology, and subsea, equipment, and reservoir engineering to ensure the project's success. In this paper, we present and detail a Front-End Engineering & Design (FEED) methodological workflow aimed at assessing the technical and operational feasibility of deploying a PRM over Búzios field, a highly obstructed supergiant oilfield located in the Santos Basin off the southeastern coast of Brazil.

Introduction

Seismic reservoir monitoring is a technology that has become an integral part of reservoir management tools aimed at optimizing oil and gas production (Caldwell, 2016). The deployment of sensors on the seabed has significantly enhanced the overall quality of seismic data by improving the signal-to-noise (S/N) ratio. This advancement allows for the recording of very low frequencies and long offsets, as well as capturing the complete wavefield in a realistic three-dimensional (3D) manner. From the standpoint of seismic data quality and the speed of data utilization in decision-making, this system represents a new generation of offshore seismic technologies. It collects seismic data in full azimuth, unlike traditional streamers that operate in limited azimuth. Additionally, access to the recorded information is not constrained by the need to deploy and retrieve sensors, as is the case with nodes, allowing for rapid availability of data for routine reservoir management. When considering the investments and returns involved in Life of Field Seismic Monitoring (LoFS), following the Value of Information (VoI) methodology proposed by Dias et al. (2024), permanent technology becomes an attractive option for fields with long productive lifespans, as multiple monitoring campaigns can be conducted without the costs associated with sensor deployment and collection.

The main uncertainties regarding the feasibility analysis of a PRM project, beyond those inherent uncertainties related to geographic location (such as water column height, seabed relief, and metoceanographic variables), include: 1) Interference with seabed structures during the production development phases of the field, and 2) A restricted and highly specialized PRM market, currently dominated by only two companies supplying the system on a commercial scale.

Main uncertainties

The main uncertainties regarding the feasibility analysis of a PRM project, beyond those inherent uncertainties related to geographic location (such as water column height, seabed relief, and metoceanographic variables), include (i) crossings between PRM and bottom structures, and (ii) a restricted and highly specialized PRM market, currently dominated by only two companies supplying the system on a commercial scale.

While an unobstructed seabed facilitates the permanent deployment of seismic cables, ensuring consistent contact with the ocean floor throughout the Life of Field Seismic Monitoring (LoFS) and providing the repeatability essential for 4D seismic studies, the presence of rigid, flexible, and umbilical pipelines adds significant complexity to the design and planning of a Permanent Reservoir Monitoring (PRM) system. The inability to cross certain pipelines, along with the complexities associated with their installation and maintenance, necessitates a thorough examination of the interactions between the existing engineering structures in the field and the PRM system—whether they are pre-existing, concurrently installed, or planned for the future. This careful analysis aims to maximize seismic coverage while adhering to stringent safety engineering standards.

Unlike conventional seismic Nodes projects, which have a relative variety in the supply of goods and services, PRM projects currently have only two suppliers in the market and will be referred to here as “X” and “Y” henceforth. Another uncertainty relates to the capacity of each supplier’s technology, which is distinct, to meet the technical requirements required for such a complex scenario.

Method

To mitigate the above mentioned uncertainties and consequently enable the feasibility analysis of PRM in a highly obstructed field, a conceptual FEED project was proposed and signed in two separate contracts between Petrobras and companies “X” and “Y”, suppliers of PRM technology, for the elaboration of their system designs.

FEED can be described as the development of a problem or opportunity whose result is an engineering design, not necessarily definitive, but with a sufficient set of objectives that have target specifications (Devon et al, 2015). The schematic in Figure 1 shows the pre-contractual and contractual stages, and the inputs from the geophysics and engineering areas working together during the one-year period for the execution of the project. After defining uncertainties 1 and 2, the following steps were implemented:

Step 1 – Pre-FEED: Meeting and alignment of focal points from the major geophysics and engineering areas and their subareas: reservoir geophysics, seismic acquisition, subsea engineering and platform engineering. Each of them contributed different inputs to the FEED study while market assessment was carried out. Then, a contract was drawn up with all the requirements for PRM design and companies “X” and “Y” were contracted separately.

Step 2 – FEED: After both suppliers agreed to provide the engineering design service, the next six months were dedicated to developing two subsea layouts of the PRM and their components. Using the inputs gathered in the previous step, companies “X” and “Y” developed the layouts of their monitoring technologies, seeking maximum seismic coverage of sensors and respecting crossover criteria and exclusion zones.

Step 3 – Final PRM Design: Combining the two results of Stage 2, a final PRM Project was prepared, considering the progress and rapprochement between the areas of geophysics and engineering achieved over the six months and the technical market possibilities.

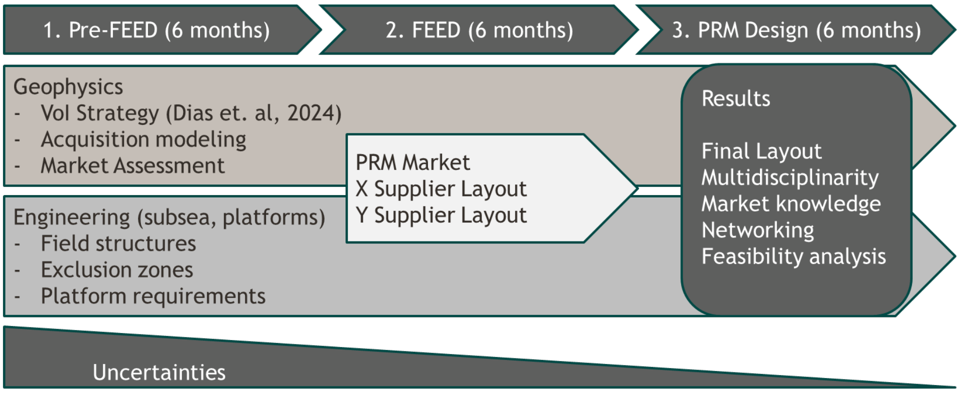

Figure 1: Illustration of the FEED steps, a strategy used to reduce uncertainties and increase the feasibility analysis of a PRM system in a field highly obstructed by underwater structures (Búzios). Joint participation of the engineering and geophysics teams and the technology supplier market, composed of companies “X” and “Y”.

Preliminary results

The evolution of seismic coverage during FEED is illustrated in Figure 4. On the left, the initial hypothesis is that linear cables can be laid on the seabed without obstructions. On the right, the cables need to be adapted to provide seismic coverage and meet the crossing criteria.

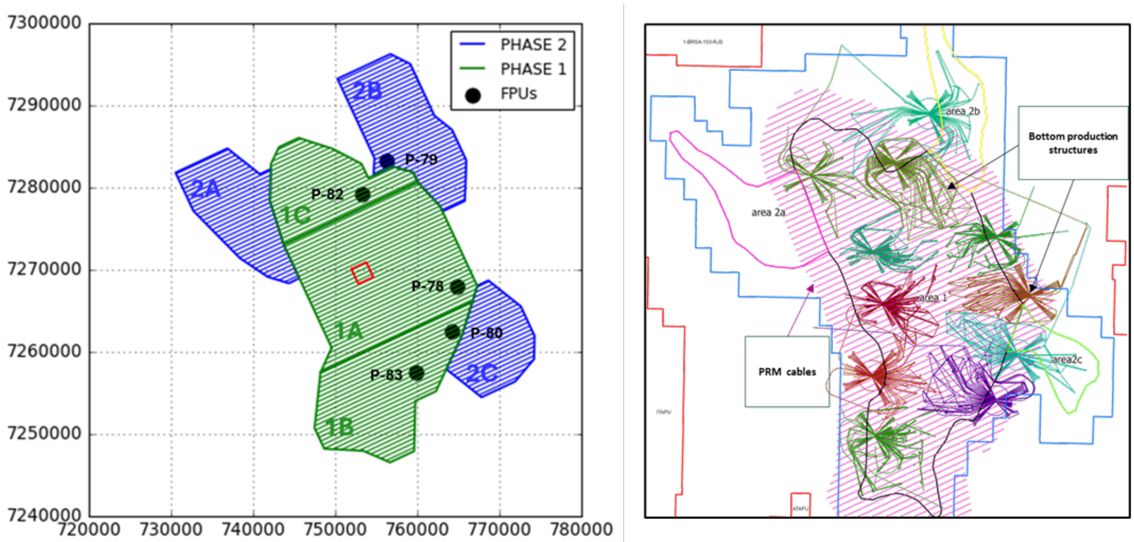

Figure 2: Seismic coverage under improvement over six months (FEED).

Conclusions

The FEED approach has tackled the two main uncertainties mapped, as they have shown the possibility of (i) providing minimum seismic coverage with the installation of the PRM in a field highly populated by pipelines; and (ii) the market indicates the capacity to provide products and services, existing or to be developed, to meet the geophysical and engineering criteria required for the system.

The optimal design of a PRM project is a process of continuous improvement, and can be improved as the installation date approaches, if contracted, since the forecast for the inclusion of future pipelines and their maintenance also improves over time. The system feasibility analysis does not depend exclusively on these factors but is strongly supported by them and has effectively grown throughout the FEED projects.

References

Caldwell, J., 2016, Seismic Permanent Reservoir Monitoring (PRM) – Major Multi- Disciplinary Engineering Projects. SPG/SEG Beijing 2016 International Geophysical Conference.

Dias, R., Salgado, M., Silva, R., Borges, F. and Pereira, C., 2024, Where, when, and how to acquire seismic data? A new VoI methodology to support decisions: EAGE Annual, Oslo.

Devon, R., and Jablokow, K., 2015, Teaching Front End Engineering Design (FEED). Penn State University.

Salah Al Ali, Shaikh Al Habshi, Ameed Al Ashqar, and Saud Bin Ruken, 2019, FEED Competition for Mega Upstream Projects. Abu Dhabi International Petroleum Exhibition & Conference 2019, Abu Dhabi, UAE.