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Selecting MEMS Accelerometers for Offshore Seismic Exploration With Ocean Bottom Nodes

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Introduction

Seismic exploration is essential for locating natural resources and supporting geotechnical and CO_2 storage applications. Offshore operations, which account for approximately 45.6% of global recoverable reserves, have encouraged the adoption of Ocean Bottom Nodes (OBNs) due to their superior data quality and deployment flexibility, despite higher costs.

Integrating Microelectromechanical Systems (MEMS) into OBNs offers a promising, cost-effective alternative with benefits such as compact size, low power consumption, and scalability. However, challenges remain, particularly the high noise floor that limits detection of weak seismic signals. Recent advances in sensor design, signal processing, machine learning, and sensor fusion with MEMS arrays show potential, but experimental validation in OBN settings is limited. This work, using data from a Permanent Reservoir Monitoring system, aims to:

- Review and evaluate the minimum selection criteria for MEMS accelerometers suitable for seismic exploration applications;
- Analyze seismic data acquired by a PRM system to identify the operational limitations of the current acquisition equipments;
- Select commercial MEMS accelerometers that meet the technical specifications required for seismic exploration projects, or identify combinations of accelerometers that together fulfill these specifications.

Method and/or Theory

A comprehensive review and evaluation of the most recent literature was conducted to identify the critical performance parameters required for MEMS sensor selection. Concurrently, real seismic data from a PRM installation were analyzed using mathematical and spectral techniques such as Power Spectral Density (PSD) and Allan Variance, among others. These analyses were employed to determine the current performance boundaries of the acquisition systems in operation at the site.

Based on the insights derived from the literature review and empirical data analysis, a set of candidate sensors was selected. The selection process also considered the feasibility of applying advanced signal processing algorithms to enhance the signal quality of the proposed sensors, thereby ensuring their viability in seismic exploration contexts.

Results and Conclusions

Preliminary data analysis enabled the estimation of essential performance thresholds for MEMS sensor selection. These include a noise floor on the order of 1 μg/√Hz, a minimum sensitivity of 2.36 μm/s², and a sampling interval of 0.25 ms. Based on these criteria, several commercially available MEMS accelerometers from different manufacturers were evaluated, and a subset was identified as suitable candidates for seismic applications. Further work will focus on validating the performance of these devices under controlled and field conditions, as well as evaluating the impact of digital signal processing strategies on data quality enhancement.