Offshore Seismic Monitoring: deployment of a seismometer on the bottom of a conductor pipe of the oil platform Rospo Mare C

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Extending seismic monitoring to offshore areas is among main INGV's aims; OBS Lab is contributing to the achievement of this goal with technological development of submarine systems and scientific missions. Offshore real-time systems not only provide oceanographic data but also allow improving the hypocenter computation, under certain operative conditions. On May 2018 a Framework Agreement to start a scientific collaboration was signed by the Ministry of Economic Development - General Department for the Safety of Mining and Energy (DGS-UNMIG), the INGV and Assomineraria (an Italian association for the Mining and Oil Industry). Subsequently, DGS-UNMIG, INGV, and EDISON Spa, as member of Assomineraria, signed an Implementing Agreement for the purpose planned in the Framework Agreement.
As a first implementation of the Agreement, the conductor pipe D (c.p. D) of the platform Rospo Mare C (RSM-C), in the offshore of Vasto (CH), was made available for seismic and multiparametric monitoring by EDISON. An Ocean Bottom Seismomenter (OBS) will be installed on the bottom of this conductor pipe to acquire the seismic data; these will be transmitted in real-time, through the EDISON network, to the INGV seismic monitoring center.
Oil platforms are subject to winds, sea currents and waves. The forces exerted by these agents excite the vibrational mode shapes of these complex structures. In addition, the extraction process generates mechanical noise too. As the vibrations propagate to every part of the structure and to the surrounding seabed, they can interfere with the seismic data acquisition system, reducing the signal to noise ratio. A preliminary analysis was carried out in order to evaluate this reduction. In this regard, a FEM modal analysis of the conductor pipe D, appropriately constrained, was carried out, following the method described in [Cammalleri and Costanza, 2016]. For the same purpose, the natural frequencies of other existing platforms were collected from literature [Jiammeepreecha et al., 2008; Raheem et al., 2012; Weldeslassie, 2014]. The selected works refer to platforms structurally similar to RSP-C, all supported by four legs. Furthermore, the frequencies of marine waves (in the area of the RSM-C) and those related to Von Karman's vortices (caused by sea currents flowing around the c.p. D) were considered. All these frequencies are summarized in Table 1.

Table 1 Frequencies to evaluate the signal to noise ratio.

[Hz]					
	Nat. Freq. of platforms structurally similar to RSP-C				
Nat. freq. c.p. D	[Jiammeepreecha]	[Raheem]	[Weldeslassie]	Marine waves	Von Karman
0,3	0,8	1,1	0,25	0,05 - 0,15	0,03
0,8	0,8	1,1			0,06
1,5	2	1,4			0,12
2,5		3,6			0,15
3,7		3,6			

The frequencies of marine waves and of Von Karman's vortices are very close to the first natural frequency of the c.p. D. The platforms structurally similar to RSP-C have the first five natural frequencies in the range 0.25-3.6 Hz, close to the first five natural frequencies of the c.p. D (0.3-3.7 Hz).

The preliminary analysis shows that the installation of an OBS on the bottom of the c.p. D is feasible but some disturbances and noise are to be expected, especially between 0.1 and 5 Hz, which is also an important frequency range for seismic data analysis. The seabed inside the conductor pipe is constituted of pelites with a low resistance to the penetration. For this reason, the sensor must be buried in order to achieve a good coupling with the sediments.

The installation system, shown in Figure 1a, minimizes the influence of disturbances on the acquired data, by burying the sensor in the sediments. In order to facilitate the burying and the extraction process two conical caps are attached to the bottom and top side of the sensor. The system includes a hydraulic circuit (in red) which conveys a flow of water, from the top of the c.p. D to the seabed. A downward jet of water, coming out from below the seismic sensor, digs a hole in the sediments, where the sensor is slowly self-buried under its own weight. The assembled system consisting of sensor and two cones weighs 16.6 kg in air, and 7.9 kg in water. The hydraulic circuit can be activated again in the recovery phase to facilitate the recovery of the sensor from seafloor. In order to optimize the burying system, a dispersing nozzle was designed, Figure 1b-c, which, in addition to digging out the sediments, moves them away from the central area. This nozzle produces a downward jet to dig the sediments, but also five upward jets, parallel to the generatrix of the lower cone, to remove the sediments dug from the central area. Fluid dynamic analyses with finite element method were carried out in order to design the channel sections and orientations (Figure 1d-e). The flow rates in the six channels obtained by the numerical simulation were finally verified by the experimental tests (Figure 1-f).

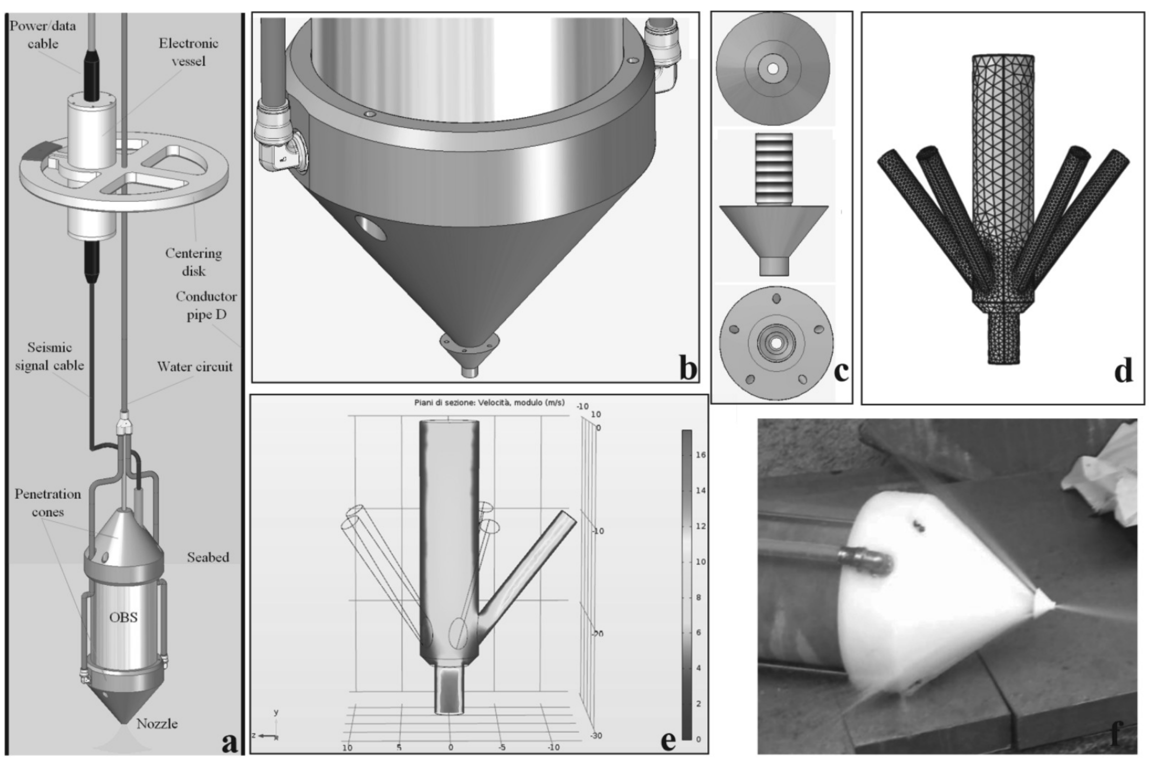

Figure 1 a) Self-buried system; b) 3D assembly of the dispersing nozzle with the system; c) views of the nozzle; d) discretized liquid domain of the nozzle; e) velocity (modulus) on the diametral level; f) experimental test on flow rates.

The whole system was tested in shallow waters. The burying (Figure 2a-b-c) lasted about 10 minutes, while the extraction (Figure 2-d) lasted about 4 minutes. The tests were carried out with the nominal flow rate of 0.2 L/s (12 L/min).

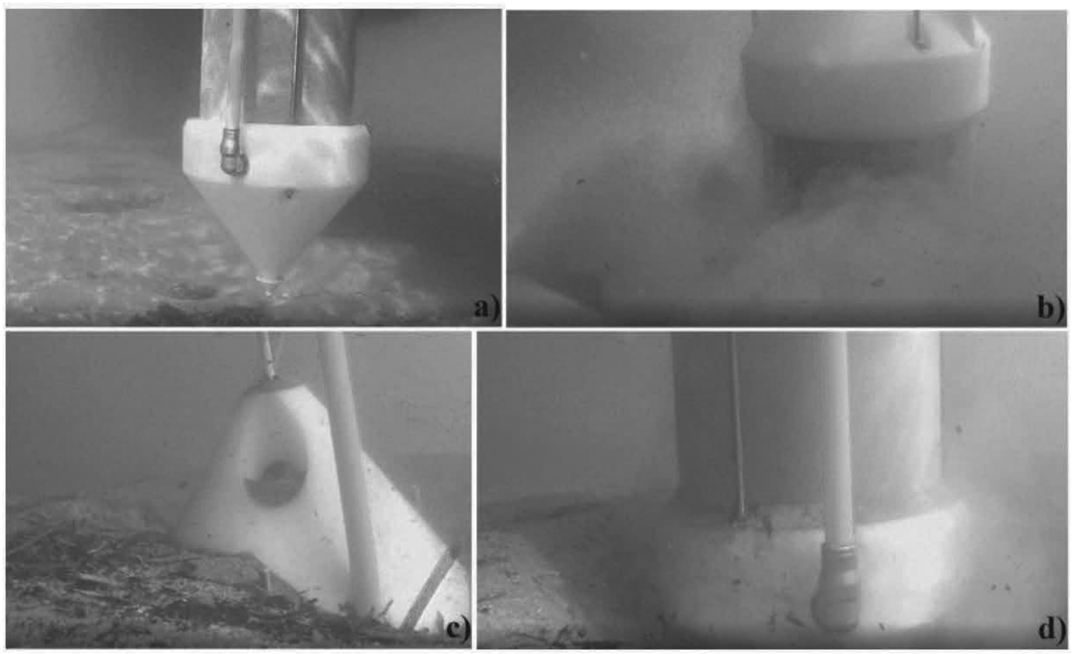

Figure 2 a): system before the contact with the seabed. b): during self-burying. c): sensor completely buried. d): during the extraction phase.

The system is essentially composed by an underwater seismometer, Nanometrics Trillium OBS 120 s, placed on the bottom of the c.p. D, and by a data acquisition system based on a Guralp DM24 digitizer inside the electronics vessel (Figure 1a and 3). A 150 m long marine cable, carrying data, GPS signals and power, connects the vessel to the surface unit. The core of the surface unit is a Guralp EAM-U digital acquisition system, hosting a SEEDLink server. The server will be accessible from the INGV seismic monitoring center, where a SEEDLink client will continuously receive the seismic data [https://ds.iris.edu/ds/nodes/dmc/services/seedlink/, https://geofon.gfz-potsdam.de/waveform/seedlink.php].

References

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