6. Publishable Summary

In the near future the oceans will supply a substantial part of human and industrial needs: the oil and gas industry will move to ever deeper waters and renewable energy will be harvested from the seas in offshore wind farms and with tidal, current and wave energy converters. Furthermore minerals such as cobalt, nickel, and copper, rare earths, silver and gold will be mined from the seafloor (deep sea mining). To this end, new offshore and port infrastructure will need to be built, maintained and repaired.

Nowadays, the major part of subsea and offshore operations is done by divers in dangerous missions. This is true for all construction, repair and maintenance work in shallow waters, be it in the offshore renewable energy sector, the port infrastructure sector or dealing with subsea cables and pipelines. Since the number of available divers is limited and their deployment is very expensive, the dependency on their work represents a real threat to the offshore industry. The SWARMs project aims to solve this problem by extending the use of unmanned underwater vehicles (autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs)). This will be achieved by enabling AUVs and ROVs to collaborate in a cooperative mesh, thus increasing the reliability of AUV/ROV operations. Since in such a collaborative mesh vehicles can combine their functionalities, new applications become feasible. Additionally the SWARMs project will increase the autonomy of AUVs and improve the usability of ROVs by introducing new operator assistance functions for intuitive control. This will substantially reduce training times for operators which nowadays take up to five years. In contrast to present day subsea machinery, the SWARMs system will be very versatile, allowing seamless integration of new robots from different manufacturers. There is thus no need any more for tailor-made systems without any re-usability. This will increase the cost-efficiency of AUVs/ROVs and make them accessible to industries with less financial strength than the oil and gas industry. This way, by reducing the costs of offshore operations and making new applications possible, SWARMs will increase Europe's competitiveness in the offshore and subsea sector. Moreover, the technologies developed within this project will also give Europe a head start in the emerging deep sea mining business where new subsea technologies will also be needed.

In detail, in order to achieve these goals we will develop:

- An intelligent human-machine interaction and control tool, including protocols for human-machine shared autonomy, task planning and operator assistance functions.
- A situation awareness/environment characterization platform to combine information coming from sensors (acoustic, vision, RFID) on different vehicles. This will allow a 3D representation of the environment. As a new approach to orientation and object recognition, RFID technology will be used to supplement the guidance of the underwater vehicles.
- Intelligent coordination and decision-making algorithms for mission re-planning and re-synchronization to cope with the harsh and unpredictable subsea conditions.
- A robust communication network to allow messaging between cooperating vehicles (based on acoustic transmitters)
- A semantic middleware to enable robots from different manufacturers to collaborate and combine their capabilities. This will be based on the concept of robots as a service.
- A methodology for the efficient design, validation and verification of save underwater operations.

Early in the project there will be a first testing phase at the PLOCAN facility on the Canary Islands and, towards the end of the project, SWARMs' achievements will be demonstrated in two field tests in the Black Sea and along the Norwegian coastline in different scenarios:

- Offshore maintenance operations in offshore wind parks and oil platforms: for example, the scouring around the foundations of offshore wind turbines will be repaired by refilling sediment in the washed-out areas and then levelling the seafloor. This will require the collaboration of AUVs capable to do bathymetry and heavy subsea machinery moving the sediment. As the development of heavy machinery is out of the scope of this project, this use case will be demonstrated on a smaller scale using ROVs instead of heavy machines.
- Monitoring of pollution due to hydrogen sulphide and oil spills: deploying a swarm of collaborating robots will enable the surveillance of a large area in short time.

- Support to construction processes in subsea environments: levelling of the seafloor prior to the construction of a new pier, support during the installation of pipelines.

Besides enabling future growth and job creation in the European blue economy, SWARMs will also help protecting the environment by making it possible to detect pollution and holding polluters responsible. Science and education can also profit from the SWARMs approach as it will make the use of AUVs/ROVs less cost intensive and more versatile, thus opening up new possibilities for universities and research institutions.

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