D9.11 Cooperation framework with other projects (v2)

Work Package 9: Dissemination, Exploitation and Standardization

ECSEL Joint Undertaking
Electronic Components and Systems for European Leadership

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Abstract	This deliverable depicts the cooperation with other projects in terms of SWARMs promotion and knowledge discussion, including common key interesting points to be shared among other projects and stakeholders.

Document History

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1. Introduction

This document presents the results achieved in Task 9.3, as described in the DoW of the SWARMs project. Two main goals were defined for this task: to cooperate in the promotion and motivation of fruitful interaction, as well as knowledge sharing and discussion through the organization of joint events or any other form of dissemination activity; and a cooperative or coordinated approach towards standardization, which would eventually have a higher impact in such entities, giving further strength to any potential initiative or interaction of that nature.

During the project, efforts focused on the cooperation and interaction with other projects in order to promote and spread the project results. To describe the cooperation plan defined by the partners participating in this task, a set of cooperation activities organized by partners were presented in the first version of the document (D9.10). In addition, a set of different conferences, workshops and EU hosted events were identified as interesting to encourage SWARMs project partners to participate in them.

For this second version of the document, the results of the aforementioned plan as well as the updates to the contents included in the first version (D9.10) have been included in order to reflect the achievements regarding the cooperation activities.

2. Shareable key interest points

This section contains the key points within the SWARMs project scope that partners found interesting to be shared with other external projects. These points were identified, in a first round, by the partners working within Task 9.3, and in a second round, including the contributions provided by task external partners. For this deliverable, the points have been refined according the latest interests of partners.

A) T9.3 Partners

ACCIONA aims at improving the quality and safety of the underwater operations involved in the construction of marine structures such us the underwater gravel beds, which the reinforced concrete caissons, used to build port quay walls, are set on. So far, especially for small port infrastructures, gravel beds are built using divers. In the case of the construction of ports or near-shore structures ACCIONA aims at performing survey operations without the use of vessels, but deploying LAUVs from the shore. The following points have been identified as valuable for sharing:

- A Standardization of needs and requirements in marine works.
- A conceptual map of work fluxes, dependences, and ways to carry out processes involved in marine constructions.

UPM identified the following key interest points to be shared:

- A middleware architecture, implemented into a middleware solution to be deployed in several robot platforms.
- A context awareness framework has been designed tailored to the SWARMs architecture.
- A set of map matching methods
- Low bandwidth communication frameworks

The main goal for **PLOCAN** is to find synergies with other ongoing national, European or international projects in order to enrich the projects results. It is also interesting to find new proposals or emerging related projects to collaborate with. These collaboration actions shall be extended during the whole project lifecycle.

As a demonstration centre, among other commitments, PLOCAN is interested mainly in the design and operational methods which can then be applied to other project demonstrations and trials. In this sense, we are also very interested in the validation and verification methodologies. Some of the most interesting points that can be shared with other projects from SWARMs are:

- The know-how related to the SWARMs architecture in order to be adapted to other swarms of vehicles such as underwater gliders. These are one of the most used observation vehicles in the projects PLOCAN is involved in, and the high level scheme of operational organization that is present in SWARMS can be used in future projects.
- The design and operational methodologies obtained from WP2, which can be applied to other marine autonomous vehicle projects, and demonstrations.
- All the knowledge obtained from the validation and verification methods of the use cases and scenarios in T2.5, and the use cases in T2.6. The outcomes from these tasks will enrich future real demo situations that will take place in PLOCAN.
- SWARMS RF and underwater communication scheme design. As PLOCAN is also working in some RF and underwater communication related projects and proposals, such as the ERAKLES project, the outcomes related to these aspects can become useful in the future.
- The whole Task 8.3, related to the organization of the SWARMS Early Trials provided us with a vast knowledge about organizing other similar events like this one. This has been useful in other ongoing projects such as H2020 EUMRobots, H2020 Atlantos and Nexos FP7, where PLOCAN has an active role in the demonstrational aspect.

TECNALIA identified the following key interest points to be shared:

- best practices for developing planning and re-planning algorithms both for surface and underwater environments
- high level planning algorithms for resource management and scheduling
- vehicle level planning algorithms for motion planning problems and for coverage problems
- SWARMs ontology
- DDS based middleware for low-bandwidth and high-latency environments
- Methods for automatic detection of landmarks in sonar images

HI Iberia participates in SWARMs providing the following key work:

- Interfaces from task T2.7 which implement connections from external components to the middleware in WP3. HI Iberia leads the effort.
- Parts of the information model produced in T3.2, in the form of an ontology. HI Iberia leads this effort.
- Parts of the middleware produced in task T3.3, specifically related to communications using DDS over RTPS.
- Integration of these efforts in the demonstrators produced in WP8.

The most obvious shareable interest from the project for HI Iberia is the ontology produced in WP3. This is separated in two key areas:

- Domain-specific (underwater and surface vehicles and operations) ontology elements that can be reused in similar projects. This may include innovative aspects such as the incorporation of fuzzy or uncertain values in the ontology for elements that might vary over time or not be fully specified.
- Higher level ontology concepts that can be used cross-domain. This is of particular interest for HI Iberia as the company is active in providing solutions based on semantics (e.g., please see the related projects SAMi2 and ARGOS in Section 3) but is not active as of the start of SWARMs in the domains of implementation in the project. Thus, the reuse of useful cross-domain concepts and sub-ontologies (e.g., a generalization of the management of fuzziness) could be of particular interest to strengthen HI Iberia's offerings in other fields.

In addition to these core shareable results identified at the beginning of the project, other elements that may lead to reusable contents are as follows:

- Implementations of the DDS/RTPS based communications stack with the middleware that might be adapted to other purposes (e.g., IoT deployments with similar characteristics and constraints that are targeted by HI Iberia's business units).
- Tools and additional developments produced for the implementation of demonstrators in WP8 (e.g., testing tools for the ontology of T3.2 or for the interfaces and communications produced in T2.7).

ITAV, as an RTO and research center, was interested in sharing key SWARMs outcomes, not only with its close national industrial and academic partners, but also with related European projects and consortia being formed towards the preparation of European project proposals where it envisages to participate, apart from national or local/internal ones. Such knowledge sharing or transfer of SWARMs key outcomes are mainly linked with the following topics where ITAV was particularly active within this project:

- Communication Protocols and Network Coding schemes, such as Random Linear Network Coding (RLNC), for effective, robust and/or energy efficient data transmission over challenging and harsh communication channels, such as the maritime underwater acoustic channels.

- Context Awareness, associated data modeling, knowledge base or ontology and inherent processes are also envisaged to be shared with other European projects where ITAV plans or will actually be participating not long after SWARMs terminus.
- Image and data processing techniques, which in SWARMs were particularly oriented to overcome the impairments imposed by the maritime underwater environment and respective limitations, and that in other (upcoming) projects can be extended and/or adapted according to distinct scenarios, use cases and applications, and respective associated requirements.

UAVR, besides having the possibility to use SWARMs major outcomes towards enhancing its courses programmes, namely by including explicit use cases and actual validated results, worked in order to apply, extend and share SWARMs key achievements, not only, but mostly related with:

- Imaging processing techniques and specific approaches, as well as maps/data fusion and object identification, namely under particularly harsh conditions, such as the ones existing in the project's scenarios, and compiled in SWARMs under UNDROIP open source software toolbox made available on GitHub (https://github.com/UNDROIP/UNDROIP).
- Data communication and secure networking most promising achieved solutions will also be most likely shared, used and extended in other projects involving communication where UAVR envisages to participate or to continue participating.
- Specific data modeling, representation and implementation solutions, as well as associated technologies, which can surely be extended and/or adapted to several other distinct scenarios, use cases and applications, inclusively in different domains, in other R&I projects.

B) Other partners

BOSCH is coordinating WP7 on autonomous navigation and semi-autonomous manipulation. Within the task 7.2 a simulation environment for model based function and system development is set up. This environment is based on the robot simulator GAZEBO, which is Open Source with permissive license (Apache 2). It is published as Open Source Software at Github under the name UUV simulator.

The environment contains GAZEBO plugins for hydrodynamics, vehicles, sensors, actuators (thruster, fins), teleoperation and underwater world models. It also contains vehicles from the SWARMs partners ECA and DESISTEK. In addition a plume simulator is available which allows a simulated plume detection and tracking mission.

ONERA plans to apply SWARMs results concerning the Supervisor-Planning-Monitor embedded architecture for autonomous vehicles. Based on preliminary software developments the aim is to provide a ROS-based generic architecture which can be applied to different types of vehicles. Cooperation with projects where this architecture could be reused will be of great interest for ONERA.

WASS, as WP5 leader, works in the project to build and integrate a "multi-environment" communication network, able to manage missions of underwater vehicles from a remote ashore control station. The aim is to identify a common solution to extend performances and capabilities of "composite" swarms of robotic platforms and, if possible, to become a standard for this type of applications. Thus, any swarm of robotic platforms used to perform activities shall share information using a robust and performing communication network. This is quite easy in air and on the ground,

while it is very complicated at sea and in underwater environment, because of physical limits of the acoustic channel (the main useful communication system).

INVENTAS is responsible for developing an intuitive and user friendly user interface and ROV steering device for the SWARMS projects and worked in order to share SWARMs outcomes and experiences with upcoming related European projects as well as national projects in order to find possible synergies. Such key outcomes are mainly linked with the following topics:

- Methodology for developing advanced user interfaces and intuitive input devices for controlling multiple actors in close cooperation
- Generic icons and symbols library

SINTEF will continue to develop and utilize the methodology developed in SEATONOMY and SWARMs. The methodology is proposed used and adapted to different application areas in proposals for funding. The methodology is today used in SFI EXPOSED whose main objective is to develop knowledge and technologies for exposed aquaculture operations, enabling a sustainable expansion of the fish farming industry.

ECA has identified the following key interest points to be shared:

- 3D acoustic maps and images made by interferometric side looking sonar from AUVs
- Experience planning and re-planning AUV missions to optimize quality of such maps and images
- Methods for automatic detection of landmarks in sonar images
- Algorithms for improved AUV navigation using landmarks

TTI is responsible for the design and development of the overwater communication subsystem for SWARMS system was interested to share and/or improve the following topics/aspects in other national/international projects:

- Architecture design and deployment of robust, efficiency, highly modular and heterogeneous wideband communication networks based on the integration of different technologies
- Reliability and endurance of communication subsystems for maritime/sea environmental scenarios.
- Integration, interoperability and management of communication networking solutions with other maritime and ground Command, Control and Intelligence Systems, (borders surveillance, monitoring of protected areas, security systems, etc)

3. Related Projects

This section presents, for each partner, the final list of active and finished projects in their own companies as well as external projects that they considered to be interesting and related to SWARMs scope and objectives. The activities carried out to promote the collaboration with the aforementioned projects will be explored in section 4, where the cooperation plan is depicted.

Finished projects identified by **HI Iberia** include:

- DG-HOME project SAMi2 (http://sami2-project.eu/) led by HI Iberia in which semantics and natural language processing tools are used to semi-automatically explore social media sources (e.g., Twitter) to detect situations of interest for safety actors such as the police. In this project ontologies and other data models were used to model elements that could benefit from the incorporation of fuzziness and other high level concepts proposed in SWARMs.
- Through its participation in the FI-PPP SafeCity project (final report at http://cordis.europa.eu/fp7/ict/netinnovation/deliverables/safecity/safecity-final-report.pdf), HI Iberia gained significant contacts in the Future Internet Public-Private Partnership (https://www.fi-ppp.eu/). This includes a number of use case projects which implemented innovative solutions using the core technology produced by project FI-WARE (https://www.fiware.org/). After the ending of the PPP, the work was continued by means of the FI-WARE foundation which intends to follow the technology footsteps of FI-WARE. The contacts by HI Iberia remain relevant and connection to Future Internet initiatives and technology (such as the extensions to ontologies and the communication systems or incorporation of the results of DDS/RTPS implementation to the catalogue of FI-WARE for IoT solutions) can be explored.
- HI Iberia was a participant in FP7 project ARGOS (http://www.argos-project.eu/) in which the security of Critical Infrastructures was provided using modern technologies such as IoT sensors and Data Fusion algorithms provided by HI Iberia. As the SWARMs project may deal with such Critical Infrastructures (e.g. unique oceanic platforms such as PLOCAN), contacts gathered in this project may also be reused in SWARMs.
- HI Iberia participated in ARTEMIS project VARIES (http://www.varies.eu) in which the different facets of variability of embedded system design was examined, including aspects such as personalized builds and reconfiguration. This was further conceptualized into a fully working variability-aware build system used in fellow ARTEMIS project PaPP (http://www.papp-project.eu/). This approach could be used to produce for example personalized builds of components such as the ontology for devices or vehicles with different levels of processing or other specifications. VARIES established at the end of its execution a Center of Innovation Excellence (VARIES CoIE) to centralize post-project European research on variability which SWARMs could contact to benefit from these technologies.
- In the course of work for SWARMS T3.2 HI Iberia has detected a number of finished related projects:
    - FP7 Pandora (http://persistentautonomy.com/) “Persistent Autonomy through learNing, aDaptation, Observation and Re-plAnning (PANDORA)” intends to develop and evaluate new computational methods to make human-built robots

Persistently Autonomous. The goal was to reduce the frequency of assistance requests significantly and the key to this aim is the ability to recognize failure and respond to it autonomously. The PANDORA project is focused on three underwater tasks, one of them consisting in autonomous grasping and turning a valve with a free floating AUV.

- FP7 BRICS (http://www.best-of-robotics.org/home) "Best pRactice In robotiCS" main objectives are to significantly promote the interoperability of hardware and software components and to design and implement an integrated robotic development environment including a software repository of best practise robotics algorithms.

- Elements of documents released by PANDORA and BRICS are being considered to be used to model concepts in the SWARMS ontology in T3.2 although the ontologies themselves are confidential project results and cannot reused as is.

One ongoing project identified by HI Iberia is FP7 SUNRISE (http://fp7-sunrise.eu/) which is working on a unique federation of experimental facilities covering the diverse marine environments (seas, ocean, lakes, canals) that allow researchers to experiment with novel paradigms and solutions for the Internet of Underwater Things, associated with the EC FIRE initiative. We are currently considering contacting the project as some of their objectives (e.g., a software-defined open-architecture modem and protocol stack) seem to be very much aligned with SWARMs.

ITAV and **UAVR** have participated in the GREENET project, which although already concluded, there were still possible ways to collaborate with the respective former partners, or exploit its most promising outcomes that are related with SWARMs goals, and also by eventually joining forces, e.g. to influence standardization bodies, with respect to some common base technology shared between this project and SWARMs.

- GREENET

Current 4G-5G vision envisages higher data rates and multi standard radio interfaces to provide all the users with a continuous seamless connection. One of the biggest challenges in current wireless systems is the need to limit the energy consumptions of battery-powered devices, with the aim to prolong their operational time and avoid active cooling. Without new approaches for energy saving, there is a significant threat that mobile users will be searching for power outlets rather than for network access, thus being restricted to a single location and losing the ability to roam freely.

- Common lines with SWARMs
  - Research on beyond routing via energy efficient network coded wireless architectures

In GREENET, we moved from these preliminary but promising results related to a cross-layer design of source, channel, and network codes for the energy-efficient design of wireless networks. Our main commitment was the design of novel algorithms and codes that can efficiently work over realistic fading channels and can take into account the realistic operation of cooperative networks. In SWARMs, the knowhow on network coding approaches will be used for the

underwater acoustic communications, with the main objective of increased the severely limited point to point link throughput.

In GREENET, we designed efficient short-range cooperative MAC and Cooperative-ARQ strategies to meet energy saving requirements. In order to improve the efficiency of cooperation in the whole network, some intelligent and energy efficient mechanisms for relay selection were introduced in the designed protocols. In particular, relay selection mechanisms based on the received SNR (Signal-to-Noise-Ratio), the traffic load of the relays, the battery status, the whole energy consumption, and the requirements of the application were investigated. Also, in GREENET we analyzed the potential threats to the proposed cooperative approach, the potential attacks, the likelihood, and the potential consequences of these attacks. In SWARMs we aim at using our acquired knowledge on cooperative techniques to provide autonomous modes of operation for the communication framework, including clustering algorithms and their respective security frameworks.

- CATRENE-H2O and national P2020-PRIVACITIES

The institutions are currently participating in two other projects, one European, CATRENE-H2O, and the other that is a national smaller version of the former, P2020-PRIVACITIES, which should be completed by November 2018 and September 2019, respectively. In these two projects, some technology related with lightweight cryptography and security mechanisms could be shared with SWARMs towards the same purposes, although in significantly different scenarios and use cases, but still with similar requirements, e.g. significantly limited computational power.

PLOCAN has participated in several projects related to the use of autonomous marine vehicles in different contexts and scenarios, being some of the most relevants:

- PERSEUS (FP-7)

PERSEUS project contributes to Europe's efforts to monitor illegal migration and combat related crime and goods smuggling by proposing a large scale demonstration of a EU Maritime surveillance System of Systems, on the basis of existing national systems and platforms, enhancing them with innovative capabilities and moving beyond EUROSUR's 2013 expectations, addressing key challenges: (1) Supporting the network created by National Contact Centres, FRONTEX and EMSA through increased capabilities, including transnational exchange of useful and available information, and associated procedures and mechanisms, thereby supporting the creation of a common information sharing environment. (2) Generation of a common situational picture. (3) Improved detection and identification of noncollaborative/suspicious small boats and low flying aircraft. (4) Enhanced and increasingly automated detection of abnormal vessel behaviour, identification of threats and tracking of reporting and non-reporting vessels. PLOCAN main role in PERSEUS (that clearly linked with SWARMs project) is to conduct the offshore marine test of an autonomous surface vehicle (ASV) equipped with the innovative tools designed within the project, providing the real operational scenarios and some of the key infrastructures for its successful and safe performance.

- GROOM (FP7)

  The objective of the GROOM proposal is the design of a new European research infrastructure to use underwater gliders for the benefit of European citizens, researcher, and industry. GROOM will define the scientific, technological and organizational/legal levels, of a European glider capacity for research and sustained observations of the oceans, in line with the other European and international initiatives for marine in-situ observations. The proposal for this new infrastructure strongly relies on EuroARGO and JERICO infrastructures which are emerging and also considers the relevant international coordinating bodies such as GOOS. The proposed technological infrastructures will be based on several dedicated 'gliderports' to maintain and operate a European fleet of gliders in coordination with US, Canadian, Australian and other similar infrastructures. This new infrastructure would be beneficial for both academic oceanographic research and operational oceanography systems on which a large number of marine activities and societal applications now rely. PLOCAN gliderport is included in GROOM project as reference infrastructure for the Central-East North Atlantic. Its experience and results in GROOM will represent a great benefit within the scope and objective of SWARM project.

- LEANWIND (FP7)

  A new EU 7th Framework Programme project, “LEANWIND” (Logistic Efficiencies And Naval architecture for Wind Installations with Novel Developments) seeks to apply lean principles to the offshore wind farm project lifecycle. The primary LEANWIND objective is to provide cost reductions across the offshore wind farm lifecycle and supply chain through the application of lean principles and the development of state of the art technologies and tools. PLOCAN role in the project related with SWARM is the leadership of the Work Package for Testing and Validation Tools and Technologies (WP7). Within this WP PLOCAN coordinates the work of 15 international partners with the main objective of demonstrate the application of LEANWIND innovative tools in order to effectively reduce the operational costs of Wind Farm lifecycle.
  EURATHLON (FP7)
  This is a new outdoor robotics competition, which will invite teams to test the intelligence and autonomy of their robots in realistic mock emergency-response scenarios. Inspired by the 2011 Fukushima accident the EURATHLON competition will require a team of land, underwater and flying robots to work together to survey the scene, collect environmental data, and identify critical hazards. Leading up to this ‘grand challenge’ in 2015, will be directly related land and underwater robot competitions in 2013 and 2014, respectively. The EURATHLON competitions will be supported by annual workshops for competitors. In parallel there will be an open process of developing benchmarks to allow comparison of different robots in the EURATHLON competitions. Linked public engagement activities will connect EURATHLON with robotics research, industry and emergency services, as well as the general public. Attendance of spectators will be welcome, and we hope that EURATHLON events will attract considerable press and media attention. By targeting a specific and urgent need - intelligent robots for disaster-response - EURATHLON will provide European robotics with a platform for challenging, extending and showcasing European cognitive robotics technologies.

Some ongoing projects that have been identified by PLOCAN are: The UNDERWORLDs project which io co-funded by the Spanish Ministry of Economy and Competitiveness (50%) and by the European Regional Development Fund (50%) in the scope of the Research, Development and Innovation program focused on the Society Challenges in the framework of the Scientific, Technic and Innovation Plan 2013-2016, section 1: “Research Challenges”, R+D+I Projects, Call 2013. The objective of the UNDERWORLD project is to reevaluate the electromagnetic communications in underwater sensor networks. This milestone will be carried out as a combination of theoretical contributions, measurement campaigns, modelling, and software and hardware developments. In fact, the main value of this project is the balance between all these aspects to ultimately create an operative Underwater Wireless Sensor Networks (UWSN) to be properly prototyped towards the technological transfer to interested companies. This big challenge is feasible just due to the combination of backgrounds and complementary skills of the three involved institutions: the Poyltechnic University of Madrid (UPM), as project coordinator and the University of Las Palmas de Gran Canaria (ULPGC) and the Oceanic Platform of the Canary Islands as associated partners. The underwater communications explored on this project could be interesting for SWARMs and can be explored as an option or alternative to the existing underwater communication options. Some synergies were made between projects and some of the underwater technologies used in SWARMS have been evaluated in the project HERAKLES, which continues with the research line opened by UNDERWORLD.

The objective of the H2020 project EuroMarineRobots https://www.eumarinerobots.eu is to build an European framework in marine robotics. The goal is to open up key national and regional marine robotics research infrastructures (RIs) to all European researchers, from both academia and industry, ensuring their optimal use and joint development to establish a world--class marine robotics integrated infrastructure. PLOCAN, as member of the consortium, is exploring the ways to introduce some of the SWARMS achievements into this project.

The project SMIS - Subsea Monitoring via Intelligent Swarms is the development of an innovative system for efficient monitoring of large-scale subsea areas using team-/swarm technology. The funding for the development project has been granted with retroactive effect to 01 January 2013 by The Federal Ministry of Economics and Technology (BMWi). Within SMIS engineers and scientists are working together on a novel concept for autonomous monitoring and investigation of the marine environment based on pressure-neutral technology. Within the project the SMIS-system will comprise of two Autonomous Underwater Vehicles (AUVs), one sea bottom station (SBS), and one unmanned surface vehicle (USV), which are operated from a research ship, or where required from a land station, using the principles of swarm intelligence. The most prominent unique feature of the SMIS-fleet is its applicability as intelligent team system for large deep sea areas in water depths up to 6.000 m.

The Adaptive Autonomous Ocean Sampling Networks (AAOSN) is a British technology competition where several ideas to develop new technology solutions for coordinating a suite of marine autonomous systems have been submitted.

TECNALIA participated in R5-COP Project. Reconfigurable ROS-based Resilient Reasoning Robotic Cooperating Systems. http://www.r5-cop.eu/en/ (02/2014 - 01/2017) (ARTEMIS-JU Call 2013). R5-COP focused on agile manufacturing paradigms and specifically on modular robotic systems. Based on existing and newly developed methods for a formal modeling of hardware and soft-ware

components, R5-COP supports model-based design, engineering, validation, and fast commissioning. Using existing interface and middleware standards R5-COP facilitates integration of components from various suppliers. Planning algorithms experience from R5-COP is useful for SWARMs.

Other interesting projects identified and analysed by TECNALIA and WP3 partners when defining the SWARMs architecture (see D3.1) were:

- TRIDENT (http://www.irs.uji.es/trident/). This FP7 project proposed a methodology for multipurpose underwater intervention tasks with diverse potential applications like underwater archaeology, oceanography and offshore industries. Interesting topics for SWARMs are: methods used for seabed mapping and gathering of optical and / or acoustic data from the seafloor; reliable acoustic underwater communications and precise Ultra Short Base Line positioning.

- MORPH (http://morph-project.eu/project/about.html). MORPH (Marine robotic systems of self-organizing, logically linked physical nodes) project (FP 7, 2012-2016) advances the novel concept of an underwater robotic system composed of a number of spatially separated mobile robot-modules, carrying complementary resources. Instead of being physically coupled, the modules are connected via communication links that rely on the flow of information among them, i.e. inter-module interactions are enabled by underwater communication networks at distant and close ranges and supported by visual perception at very close range. This project is of special interest for SWARMs WP5 communications.

- SUNRISE (http://fp7-sunrise.eu): Building the Internet of Underwater Things. SUNRISE addresses FIRE objectives by combining technology with novel paradigms in new, open experimental facilities, integrating physical systems with software development into the Internet of Underwater Things. Interesting topics for SWARMs are: federated underwater communication networks; a software-defined open-architecture modem and protocol stack for open collaborative developments; sensing and monitoring on the underwater world.

- T-REX (http://wiki.ros.org/trex_executive). The aim of T-REX is having a middleware architecture able to take actions whenever the underwater vehicles where it is installed are confronted with changing conditions in their surrounding environments. This architecture works under a paradigm called sense-plan-act, as it is expected to make reaction plans according to what has been sensed in the surrounding environments.

Regarding publish/subscribe communication middlewares used for AUVs using low bandwidth modems, the following systems were analysed:

- SEAWARE is a publish-subscribe middleware [1] used in multi-vehicle net- worked systems composed of autonomous and semi-autonomous vehicles and systems. Seaware provides a high level interface to network communications and may be deployed with a combination of heterogeneous components within a dynamic network. Seaware supports the RTPS (Real Time Publish Subscribe) protocol, underwater acoustic modems and other forms of network

transport. This paper gives an overview of Seaware's implementation and its application to multi-vehicle networked systems.

- IS-MOOS (Intervehicle Secure MOOS) is an extension of MOOS (Mission Oriented Operating Suite). MOOS is a publish/subscribe system [2] for inter-process communication (IPC), which supports dynamic, asynchronous, many-to-many distributed communication. Its basic functioning, usual in all pub/sub systems, relies on a dispatcher, which is responsible for routing messages from publishers to subscribers. Messages are routed based on their topics, which is an information descriptor contained in the messages themselves. Subscribers have to declare their interests in specific topics by issuing subscriptions to the dispatcher, while publishers send their messages to the dispatcher. In the case of MOOS the dispatcher is represented by a central database (MOOSDB).

ACCIONA has participated in many project related to SWARMS, such as:

- LEANWIND (FP7).
  A short summary of this project has been presented by PLOCAN in previous paragraphs, so now it will only be said that the ACCIONA's role within the LEANWIND project is the leadership of the work package related with the gravity foundations (deployment, construction and decommissioning). In addition ACCIONA is also participating in the work packages related to logistics, systems integration, demonstration and validation, business model and, dissemination and exploitation of results.

- SEAMAR (INNTERCONECTA ANDALUCIA 2012).
  The main objective of this project is to develop advanced technologies for supporting structures of offshore wind turbines oriented to mass production so as to lay the groundwork regarding logistics requirements, installation and maintenance of future offshore wind farms, demonstrating the technical feasibility and economic of this offshore technology and thus placing Andalusia as the main national leader in the offshore wind sector. SEAMAR project is focused in non-robotic solutions but with the developments of SWARMs, the conclusions reached in SEAMAR could be improved.

- DEMOGRAVI3 (H2020).
  The project aims to demonstrate an innovative gravity-based foundation for offshore wind turbines designed for water depths between 35 m and 60 m. The competitiveness of the offshore wind business is strongly related to substructures and offshore logistics.

4. Cooperation plan

For the first version of this deliverable (D9.10), a set of activities identified by the partners in order to enhance the cooperation of SWARMs project with other interesting projects and stakeholders was included in this section. For each activity, a responsible and the involved partners were included, along with a short description and the expected results.

For this second version, the results of the aforementioned activities are included. In addition, the set of activities was modified from the previous version (including new activities and removing those which were not able to be completed by partners). For tracking issues, the activity ID remains as in the first version.

4.1. Proposed activities

ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
3	Demonstrations workshop	ACCIONA	All partners	May 2018	May 2018	Madrid / Bilbao	ACCIONA Technological Centre /University of Bilbao
Description							
	Sharing Results Between ECSEL JU Projects (MANTIS – SWARMs) on Cyber Physical Systems.						
Involved Stakeholders							
	MANTIS and SWARMs partners						
Expected Results							
	Share bandwidth use optimisation strategies between MANTIS and SWARMs projects.						
Indicators							
	Internal Meeting: attendants SWARMs: 8; MANTIS: 7 Bilbao's Meeting: attendants SWARMs: 2; MANTIS: 2 Contact: MANTIS Project Coordinator: Urko Zurutuza <uzurutuza@mondragon.edu> Project impacts (media, social, etc.): http://www.acciona-construccion.com/pressroom/news/2018/june/acciona-construction-develops-new-digital-tools-industrial-maintenance-maritime-operations/						
Comments							
	Two meetings between the projects MANTIS and SWARMs have been held. First, we organized an internal meeting (MANTIS – SWARMs) in the Technology & Innovation Division ACCIONA's facilities and then was held another meeting with the MANTIS Project Coordinator in the University of Mondragon in Bilbao. 						

ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
4	Critical Infrastructures Alignment	HIB	HIB	M12	M12	Online	Online
Description							
The successful FP7 project ARGOS (http://www.argos-project.eu/) which participated in the Security Programme of FP7 is looking for a continuation of the activities via a new proposal to be submitted in summer of 2016 (deadline is August 25th). The project revolves around the idea of increasing Critical Infrastructure protection by using augmented sensor networks to gather extra intelligence that can be used by operators to increase their situational awareness. This includes, for example, aerial drones. The proposal is being elaborated at the writing of this document.							
Involved Stakeholders							
HIB were participating in ARGOS, as well as Thales (a different branch than in SWARMs). HIB would be leading the effort in introducing results from SWARMs in the project (mainly the data model and the DDS communications implementation for constricted environments).							
Expected Results							
Technologies from SWARMs reused in another project and possibly on a different domain.							
Indicators							
The number of technology items from SWARMs reused in the resulting proposal.							
Comments							
N/A							

ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
5	OCEAN BUSINESS	PLOCAN	All interested partners	04/04/17	06/04/17	Southampton	National Oceanography Centre
Description							
PLOCAN has booked a stand in the well-known Ocean Business event for the SWARMS project. It is an industry oriented event that enables face to face interaction between the most important companies in the marine and maritime industry, final users and customers. It will provide SWARMS the chance to show the results achieved so far and attract the attention of the worldwide attendants. We have also booked a training session where we can give further details about the project course and results.							
Involved Stakeholders							
Most of the Marine and maritime technology companies, end users, universities, research centres							
Expected Results							
Well known industry companies and SMEs interested in the SWARMs project results. Project results dissemination.							
Indicators							
Number of companies contacted: over 10 Project impacts (media, social, etc.): Link to the new online, 8 retweets, over 25 attendants to the parallel session							
Comments							
The fair was quite successful for the SWARMs project, all the brochures, bags, stickers, etc. were distributed and the stand was busy all the time. A parallel event was also organized where the preliminary results of the project were presented. It was also a success with the event room fully crowded as can be seen in the pictures.							


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ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
6	Local Networking B2B	PLOCAN	All interested partners	29/09/16	29/09/16	Canary Is.	PLOCAN

Description

In the scope with the Early Trials PLOCAN is organizing a Local Networking B2B in order to foster the interaction of local SMEs and marine business companies with the partners of SWARMS.

Involved Stakeholders

Local companies related to the marine and maritime business and SWARMS partners.

Expected Results

Companies and SMEs interested in the SWARMs project results.
Companies-partners interaction.
Project results dissemination.

Indicators

Future collaboration between companies and partners.

Comments

The event brought 11 local SMES to the Early Trials event in order to interact with the different companies from the SWARMS consortium. The event was a success for both the partners and the SMES.

ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
7	Oceanology International	PLOCAN	All interested partners	13/03/18	15/03/18	London	

Description

The objective is to book a stand in the Oceanology International event that will be held in London in 2018. It offers a worldwide forum where industry, academia and government share knowledge and connect with the marine science and ocean technology communities. It will provide SWARMS the chance to show the results achieved during the project and find possible interesting stakeholders for the project outcomes among the attendants. We have also booked a training session where we can give further details about the project course and results.

Involved Stakeholders

Most of the Marine and maritime technology companies, end users, research centres

Expected Results

Well known industry companies and SMEs interested in the SWARMs project results.
Project results dissemination.

Indicators

Number of companies contacted: over 15
Project impacts (media, social, etc.): Link to the online new. 11 retweets.

Comments

The presence of SWARMS in one of the biggest fairs of the marine and maritime sector, has been a key success in order to promote the latest project results made in the last year of the project. The stand was very well located and, like in the Ocean Business fair, the project had a big impact.

ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
8	ICHSA 2017: Conference on algorithms	TECNALIA	Applicable to WP3 and WP6 partners	22/02/17	24/02/17	Bilbao	

Description

ICHSA 2017: 3rd International Conference on the Harmony Search Algorithm. The 2017 edition of this international event will span beyond the development, design and applications of naive, variants, and hybrid methods of the Harmony Search Algorithm: prospective authors are encouraged to present their latest achievements around Computational Intelligence, with particular emphasis on innovative bio-inspired optimization methods (Evolutionary Computation, Swarm Intelligence) and their applicability to exploratory data analysis, predictive modelling and optimization.

Involved Stakeholders

End users, universities, research centres

Expected Results

Spread the results of mission and vehicle planning algorithms among other interested actors

Indicators

Number of visits to the project website (during and after 1 month from the conference). See below.

Comments

The conference took place in February 2017. After the conference there was a mild peak tendency in SWARMs total pageloads.

Weekly Stats Report	6-12/02	13-19/02	20-26/02	27-05/03	6-12/03	13-19/03	20-26/03
Pageloads	208	251	183	269	186	306	278
Unique Visits	113	112	72	112	95	134	113
First Time Visits	52	64	54	57	53	84	72
Returning Visits	61	48	18	55	42	50	41

ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
9	DDS Middleware press release	TECNALIA	WP3 partners	Dec/16	Dec/16	Bilbao	
Description							
WP3 partners will cooperate with Twin Oaks in issuing a joint press release about the semantic middleware based on Twin Oaks Core DX DDS Solution.							
Involved Stakeholders							
AUV providers, middleware companies, End users, universities, research centres							
Expected Results							
Spread the results of WP3 semantic middleware based on DDS among other interested actors							
Indicators							
Number of visits to the project website and contacts (after 6 months)							
Comments							
The DDS based semantic middleware and the project results were disseminated through: • Twin Oaks Computing website and December Newsletter, 30 Nov. 2016 • SWARMs Article at Hamersham website: Making Underwater Robots Communicate - SWARMS Early Trials a Success, 16 Dec. 2016. Hamersham is CoreDX distributor in Europe • Twin Oaks Computing presentation at AUVSI XPONENTIAL 2017, Dallas, USA, 08 - 11 May 2017, conference related to unmanned vehicles • Twin Oaks Computing free webinar IoT Evolution World's "Ensuring Security in the Age of the Connected Device", introducing SWARMs as a practical example.							

ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
10	Planning and replanning best practices	TECNALIA	Applicable to WP3 and WP6 partners	June/17	June/17	Bilbao	
Description							
TECNALIA plans to apply in SWARMs, best practices learnt from developing planning and replanning algorithms in R5-COP project. As R5-COP project started on February 2014, in SWARMs we want to benefit from the experience gained in this first year in order to speed up the development of our algorithms and minimize the time losses that derivate from wrong initial assumptions or lack of considerations when starting to work on the real use cases. In addition, SWARMs project wants to share with R5-COP the restrictions found concerning underwater environments.							
Involved Stakeholders							
R5-COP and SWARMs partners							
Expected Results							
Sharing of best practices among both consortiums							
Indicators							
N/A							
Comments							
A best practices document regarding planning problems was shared.							

ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
12	Local Networking	UAVR	ITAV, GSLDA	Q4 2016	Q2 2018	Aveiro and Porto	
Description							
Pursue interaction based on initiated contacts with several local and national entities, such as LSTS (Underwater Systems and Technology Laboratory of FEUP – University of Porto), which is very active in underwater autonomous systems, as well as participates in relevant European projects, e.g. FP7-SUNRISE. Also, InovaRia (http://www.inova-ria.pt/en), which is a B2B innovation network centred mainly on Onshore and Offshore activities. Multiple discussions and particular close interaction with LSTS and OceanScan (spin-off company) occurred mostly at the end of the considered period, in Porto, during SWARMs dedicated integration meeting near Porto, at UPTec, with respective testing at sea (harbour), as well as in the final demonstrations of the project in Norway.							
Involved Stakeholders							
Onshore and Offshore Industry/SMEs, e.g. OceanScan; Other R&D entities, such as FEUP, IST or INESC-TEC.							
Expected Results							
Promotion of SWARMs and its results; Development of new opportunities through joint cooperation.							
Indicators							
Joint activities (up-to 12 months after), e.g. organization of joint workshops, and participation in relevant (national or European) project proposals (e.g. P2020, PENTA, ITEA, H2020, etc.). One tacit example of such joint activities that were initiated are the early discussions on the preparation of a national (or eventually European) project proposal involving heterogeneous/hybrid robotic vehicles, together with UP's LSTS.							

ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
13	Scientific technical events	UPM / ITAV	All	Q1 2018	Q2 2018	Limerick, Ireland; Madrid, Spain	EMRA 2018, OMAE 2018
Description							
Joint organization of a scientific technical conference and of a workshop, involving entities from other European and International projects. The preparation of these two scientific dissemination events, also with the aim of stimulating synergies with other potential entities and organizations, occurred mostly in the first half of 2018, with some previous alignment with the respective main venues and respective organizations.							
Involved Stakeholders							
Industry and SMEs, and also Academic and R&D entities, whose core business and focus is directly related to SWARMs topics, or also participating in relevant R&D projects, namely addressing higher TRLs.							
Expected Results							
Promotion of SWARMs and other relevant projects, as well as their results, in a higher impact or broader format.							
Indicators							
Number of (external) participants (around 40), and established contacts (up-to 3 months after). , e.g. Edin Omerdic, from University of Limerick Mobile & Marine Robotics Research Centre, and Jon Mikkelsen, from the Naval Architecture and Marine Engineering team at University of British Columbia.							
Comments							
 							

ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
14	Integrated exploitation of results	ITAV / ECA	All, namely industrial partners	Q1 2018	Q3 2018	N/A	N/A
Description							
Companies and other entities participating in SWARMs and in other relevant projects can consider and evaluate concerted approaches towards the exploitation of the respective project results, namely by developing further elaborated value chains and integrating each participant core contribution. Such potential integrated value chain would be important towards achieving broader results exploitation, with increased dimension and scope, leading to bigger impact in the industry sector, and also in the scientific and research community. Moreover, such kind of coordinated approach can help better exploit the ongoing work by adding further strength and international visibility to the project in order to eventually have some subsequent relevant influence in standardization activities and respective entities.							
Involved Stakeholders							
Industry, SMEs, and R&D entities participating in SWARMs or in other relevant projects, initiating or participating in relevant business development, as well as relevant standardization bodies.							
Expected Results							
Further effective exploitation of results coming out from SWARMs and from other relevant projects, in concerted higher impact approaches, towards further potentiating joint business, and influencing standardization as well.							
Indicators							
Number of common envisaged approaches or strategies to exploit projects' results jointly, up-to 12 months after SWARMs terminus. Potential joint approaches have been included in SWARMs deliverables D9.8 and D9.12.							
Comments							
Aligned with SWARMs deliverable D9.8 and associated SWARMs task 9.2.							

ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
15	UUV Simulator Demonstration	BOSCH	N/A	13/12/2017	15/12/2017	Sidney (Australia)	N/A
Description							
Workshop on the usage of the UUV Simulation environment for Gazebo developed in the scope of the SWARMs project. Tutorials should include the configuration of new vehicles and scenarios, the setup of a new mission and interfacing with sensors and actuators.							
Involved Stakeholders							
Participants and interested people in projects on maritime robotics: Marine and maritime technology companies, end users, research centres							
Expected Results							
Promotion of SWARMs and its results, especially the UUV simulator							
Indicators							
Number of cloners of the UUV simulator package on Github							
Comments							
Unique downloads end of 2017 where around 20-30 per 2 weeks (Github evaluates two week periods). Within the first half of 2018, unique cloners rose to 70-100 per two weeks.							

ID	Activity name	Responsible	Participation of other partners	Start Date	End date	City	Venue
16	CPSwarm Extended Stakeholders Group	UPM/ITAV	N/A	N/A	N/A	N/A	N/A
Description							
UPM and ITAV were invited to join the Extended Stakeholders Group (ESG) for CPSwarm EU-funded project.							
Involved Stakeholders							
Companies and research organization working in the area of robots autonomy and cooperation.							
Expected Results							
Networking and knowledge sharing among stakeholders in the area.							
Indicators							
Number of group meetings (1 year after). Until mid-July 2018, UPM and ITAV participated in one CPSwarm ESG meeting (1st Extended Stakeholders Group (ESG) Online Meeting, held on April 16th 9:30 CET), where the goals of the ESG and the respective members were presented and early discussions have been initiated, led by Claudio Pastrone, from the Istituto Superiore Mario Boella (ISMB), in Italy, and René Reiners, from the Fraunhofer Institute for Applied Information Technology (FIT), in Germany.							
Comments							
N/A							

4.2. Conferences and workshops

- UPM participated in the workshops on EU-funded Marine Robotics and Applications EMRA 2017 (Girona, Spain) and EMRA 2018 (Limerick, Irland) presenting the results and achievements of SWARMs project.
- UPM organized the conference “SWARMs Conference on Novel Solutions for Underwater Vehicles in Autonomous Sea Operations” co-located with EMRA 2018 on June, 11th 2018 at Centre for Robotics and Intelligent Systems- CRIS, University of Limerick, Ireland.
- UPM organized the symposium “Advanced Underwater Vehicles and Design Technology Workshop” within the 37th International Conference on Ocean, Offshore & Arctic Engineering, where other SWARMs partners presented the achievements of the project. The conferenced took place in Madrid (Spain).
- The 10th International Federation of Automatic Control (IFAC) **Conference on Control Applications in Marine Systems** (CAMS 2016) took place in Trondheim, Norway, from **September 13-16, 2016**. The conference provided an excellent opportunity for the presentation and discussion of research results and development in the areas of control applications for surface & underwater vessels, floating & sub-sea structures, and other marine systems.
- PLOCAN presented preliminary SWARMS results Martech Nov, 2016. http://www.upc.edu/cdsarti/martech/

- PLOCAN held a stand at the **Ocean Business** in April 2017 in Southampton, UK (http://www.oceanbusiness.com/) for the SWARMs project. The Ocean Business is one of the biggest events related to ocean technology held in Europe and worldwide stakeholders will be present.
- PLOCAN held a stand on the next **Oceanology International** (http://www.oceanologyinternational.com/) event that will take place in London in 2018.
- In the scope with the Early Trials PLOCAN organized a Local Networking B2B in order to foster the interaction of local SMEs and marine business companies with the partners of SWARMS.
- PLOCAN presented SWARMS at the European Geosciences Union General Assembly (EGU) 2017.
- PLOCAN presented SWARMS at the Ocean Science Meeting in Portland, USA, February 2017. https://osm.agu.org/2018/
- PLOCAN presented SWARMS at Jornadas Enginheria Hidrográfica in Jun 2018. http://www.hidrografico.pt/jornadas2018.php
- PLOCAN presented SWARMS at EMRA in Jun 2018. http://swarms.eu/conference.html
- TECNALIA organized the 3rd International Conference on the Harmony Search Algorithm that took place in Bilbao in February 2017. Harmony Search Algorithm is used in the high level planner at the MMT.
- TECNALIA presented the SWARMs architecture in the Ocean Business in April 2017 in Southampton, UK (http://www.oceanbusiness.com/).
- TECNALIA presented the work done in WP4 in IEEE Oceans'17 conference held in Aberdeen (UK) from the 19th to the 22nd June 2017.
- TECNALIA will present its plume detection algorithm in EngOpt 2018 conference that will take place in September 2018 in Lisbon (Portugal). This conference is an International Conference on Engineering Optimization (http://engopt2018.tecnico.ulisboa.pt/).
- ITAV participated in EMRA 2017, in Girona, Spain, in May 2017.
- ITAV showcased its work on RLNC at the 37th International Conference on Ocean, Offshore and Arctic Engineering (OMAE 2018), in Madrid, Spain, in June 2018, represented by UAVR.
- UAVR participated in the 6th International Conference on Image Processing Theory, Tools and Applications (IPTA 2016), in Oulu, Finland, in December 2016
- UAVR also participated in OCEANS 2017 (Europe) MTS & IEEE/OES OCEANS Conference & Exhibition (Europe), where they presented SWARMs work carried out with the support from several partners, including ITAV, in Aberdeen, Scotland, in June 2017.
- UAVR participated in 2017 IEEE Jordan Conference on Applied Electrical Engineering and Computing Technologies (AEECT 2017).
- UAVR participated in the 37th International Conference on Ocean, Offshore and Arctic Engineering (OMAE 2018), in Madrid, Spain, in June 2018, also presenting work developed by ITAV.
- ACCIONA supported PLOCAN in the Oceanology International event held in London. March 2018.
- HIB participate in "V Congreso Nacional de I+D en Defensa y Seguridad" on 22, 23 and 24 November 2017, in Murcia, Spain, where it was presented the ontology used in SWARMs.

- HIB participate in the the 37th International Conference on Ocean, Offshore and Arctic Engineering (OMAE 2018). June 2018, Madrid Spain, where it was presented the results from WP3.

4.3. EU meetings and brokerages

UPM has participated in ECSEL and H2020 meetings and brokerages where relevant topics related with SWARMs project were presented. The goal was to extend the results obtained within this project by participating in new project proposals.

HI Iberia participated in events which were attended by the FI-WARE community such as the continuing event to ICT 2015 (in which HI Iberia and other SWARMs partners participated and met). In these events, we arranged discussions with the FI-WARE representatives to discuss potential connections to SWARMs.

HI Iberia also participated to the Artemis and ECSEL meetings (such as the past Artemis/ECSEL brokerage event held during 2016 and 2017. In these events, in addition to new proposals, activities with the past ARTEMIS projects such as VARIES and PaPP (mentioned in previous sections) are conducted. The action plan was to discuss potential collaborations and reuses of technology with these representatives in the events.

PLOCAN has participated in as many EU meetings and brokerage events related to the SWARMs project as possible. PLOCAN is always looking for synergies and collaborations with partners involved in the maritime and marine field, marine autonomous vehicles and oceanic observation. In order to consolidate these collaborations we periodically attend to the main related events. Some of these have been the one organized by PLOCAN in parallel with the Early Trials with local SMEs, the EGO 2017 conference that took place in Southampton, the 2016 MARTECH conference that was held in October in Barcelona, the 2017 Ocean Business, the 2018 Oceanology, the 2018 Jornadas Enginheria Hidrográfica in Lisbon, EMRA ’18 in Limerick and Oceans Science Meeting ‘18 conference.

TECNALIA participated in several meetings where new proposals were presented and collaborations with other partners were consolidated: the ECSEL Brokerage Event 2017 (January), ICT Proposers’ Day 2017 (November), the European Big Data Value Forum 2017 (November) and ARTEMIS Brokerage Event 2018 (February). TECNALIA also attended The Internet of Things Week 2017 in Geneva and The Internet of Things Week 2018 in Bilbao to join industry and academia representatives from around the world and share synergies.

ITAV participated in multiple relevant brokerage events held in 2017 and 2018, organized by European Industry associations, such as ARTEMIS-IA Brokerage Event, ECSEL JU Brokerage Event and AENEAS/PENTA events, where many potential relevant collaborations have been initiated or strengthened, namely in the CPS, IoT and Security domains.

ITAV participated in European Forum for Electronic Components and Systems (EFECS), in Brussels, Belgium, in December 2017, representing SWARMs at a local stand/booth together with UAVR. In this venue it was possible to establish a solid collaborative connection with H2020-CPSwarm project, which will continue at least one more year after SWARMs terminus. ITAV has been invited and integrated into this project's Extended Stakeholders Group (ESG) in order to provide our practical perspective in discussions to assess the good evolution of the project.

UAVR participated, together with ITAV and GSLDA, in a national brokerage event, FCT Event - Border External Security: "Data fusion for maritime security applications", where it was possible to establish multiple contacts for future collaborations, namely on topics already initiated or further developed within SWARMs.

4.4. Joint dissemination with relevant industrial stakeholders

The semantic middleware developed in WP3 is based on DDS standard. Therefore, TECNALIA, UPM and HIB have held telephone calls and audio meetings with the 3 main DDS solution providers, i.e.:

- Twin Oaks Core DX DDS:
  - Nina Tucker, Vice President at Twin Oaks Computing, Inc.
  - Marilyn Davison, Market Development, EMEA (Europe Middle East Africa) at Twin Oaks Computing, Inc.
  - Nick Pridham of Hamersham LtD. He is based in UK and partners with Twin Oaks to expand client support throughout Europe.
- PrismTech OpenSplice:
  - Vincent Rolin. He is based in France and is responsible for commercial-related duties.
  - Ramzi Karoui, the technically proficient person to address technical questions.
- eProsima (supplier of RTI solutions in Spain)
  - Jaime Martin Losa, CEO eProsima.

In addition, a joint dissemination activity has been carried out between SWARMs Project and Twin Oaks to share the project's results based on DDS technology among **industrial partners**. These results were communicated through their newsletter and website, through Hamersham website who is CoreDX distributor in Europe, in conferences related to unmanned vehicles like AUVSI XPONENTIAL and through their free webinars:

- IoT Evolution World's "Ensuring Security in the Age of the Connected Device" webinar, introducing SWARMs as a practical example, 27 March 2018
- AUVSI XPONENTIAL 2017, Dallas, USA, 08 - 11 May 2017
- SWARMs Article at Hamersham website: Making Underwater Robots Communicate - SWARMS Early Trials a Success, 16 Dec. 2016
- Twin Oaks Computing December Newsletter, 30 Nov. 2016

4.5. New project proposals

The projects ARGOS and SAMi2 identified by **HI Iberia** in the section 3 finished in December 2015 and both are currently seeking opportunities for continuation of the activities in European R&D Calls open in 2016. These and SWARMs could cross-benefit in the following manners:

- SAMi2 continuation could benefit from reusing components and approaches of the SWARMs data model, specifically fuzziness in ontologies. Current approach in SAMi2 is to use traditional (crisp) ontologies but the results generated by the system (e.g. inferences of a particular safety event happening gathered from the comments of people in Social Media) are by definition guesses that can be better treated with fuzzy reasoning. Thus, we will monitor the activity in SWARMs and where possible reference it in any new proposal. Since the plan is to continue HI Iberia leading this R&D effort the action plan is simply to cross-pollinate in-house the developments.
- ARGOS continuation, which is likely as the project got an 'Excellent' qualification in the final review, intends to keep the focus on Critical Infrastructures. PLOCAN is an excellent candidate due to its centrality in Spanish R&D plans and easy access through SWARMs. Action plan is to initiate this contact as the proposal develops.
- AFarCloud proposal, HIB participated in the preparation of this project, that has been accepted and shares common background with SWARMs regarding the architecture and the semantic modules.

As mentioned before, **PLOCAN** has already identified a potential collaboration with the ongoing project HERAKLES. The main objective of this project is to follow the UNDERWORLD project line, re-evaluating the electromagnetic communications in underwater sensor networks in order to create an operative Underwater Wireless Sensor Networks.

PLOCAN has also submitted the proposal BathyDrone leaded by GEOMAR which objective is to achieve a step-change in bathymetric survey technology, increasing endurance from weeks to months using swarms of ASVs. This proposal is fully aligned with SWARMs objectives and achievements. The outcomes of this project will have a major impact in sectors such as geological and habitat mapping of the seafloor as well as environmental monitoring and exploration in fields such as oil & gas, offshore wind farms, submarine telecom cables and mining.

UPM has leaded a new project proposal funded within the last ECSEL-JU call: AFarCloud. The main objective of the AFarCloud project proposal is to provide a framework able to promote precision farming solutions by using not only new robotics platforms but also incorporating legacy systems already deployed in the farms. This project proposal is comprised of 60 organizations from 14 European countries, and it includes industrial companies (large and SMEs), as well as academic partners (research organisations and universities).

ITAV, ACCIONA and **HI Iberia** participated in the preparation of a European full project proposal, AFarCloud (coordinated by **UPM**), submitted in late Q3 2017, which has been selected for funding. AFarCloud shares some common relevant background with SWARMs, namely regarding CPS and

autonomous robotic vehicles. Other project proposals are also being initiated, including further collaboration with some SWARMs partners, also in relevant topics.

TECNALIA participated in the preparation of AFarCloud proposal which shares common background with SWARMs especially with regard to the coordination architecture and the planning algorithms. Besides, TECNALIA is planning to participate in a proposal for DT-ICT-08-2019 call which will also share common background with SWARMs and AFarCloud.

ACCIONA is part of the consortium of a project proposal that aims to commercialise VortexScan, a modular robotic platform equipped with advanced Non Destructive Testing (NDT) capabilities for the inspection of large vertical concrete walls of hydropower dams, bridges and concrete caissons. The operation of this system is fully automated eliminating the need for scaffolding and rope access for getting access to the concrete surface.

4.6. Standardization

As part of Task 9.2 within this WP, a comprehensive analysis regarding the standardization outcomes relevant to SWARMs project was performed, as presented in D9.9. Within this task (9.3), the aim is to use the results of D9.9 to identify the most relevant outcomes to be shared among other interested stakeholders. Although that deliverable is closed in line with this (M12), some preliminary process has been identified, as presented below.

One of the main challenges in SWARMs is to manage interaction between vehicles in underwater scenarios where communications involve the transmission of information using acoustic techniques. Acoustic communications are governed by 3 factors: limited bandwidth due to modems restrictions, time-varying multipath propagation and low speed of sound underwater. Together, these factors result in communication channel of poor quality and high latency.

The semantic middleware developed in WP3 provides the needed mechanisms to handle low-latency and real-time QoS compliant with the Data Distribution Service (DDS) standard in order to guarantee interoperability among robotic vehicles.

WP3 partners have cooperated with Twin Oaks, one of the 3 main leading vendors of DDS solutions. The purpose was to foster the use of DDS and the communication protocol defined in task 2.7 as the interoperability standard for underwater communications among robotic vehicles. SWARMs was put as example by Twin Oaks of the first known case using DDS technology in underwater environments.

The UUV simulator is available as open source package on GitHub. We currently have around 35 – 50 unique cloners per week. The UUV simulator is currently in discussion to get the simulator for the next DARPA underwater robotics challenges, which means that the simulator would get a standard for simulation of underwater robots.

Finally, ITAV (as member in ETSI and C-ITU) will try, eventually jointly with other entities and organizations, to take influence in such standardization bodies, and other relevant committees and industry fora, exploiting SWARMs major relevant outcomes.

5. References

[1]. Eduardo R. B. Marques;· Gil M. Gonçalves; · João B. Sousa; "*Seaware: A Publish/Subscribe Communications Middleware for Networked Vehicle Systems*". https://www.rti.com/docs/UPorto-Seaware.pdf

[2]. Andrea Caiti; Vincenzo Calabro; Gianluca Dini; Angelica Lo Duca; Andrea Munaf; "*MOOS Middleware and Node Adaptivity in Underwater Sensor Networks: Results from the UAN11 Sea Trial*". Proceedings of the 11th European Conference on Underwater Acoustics.