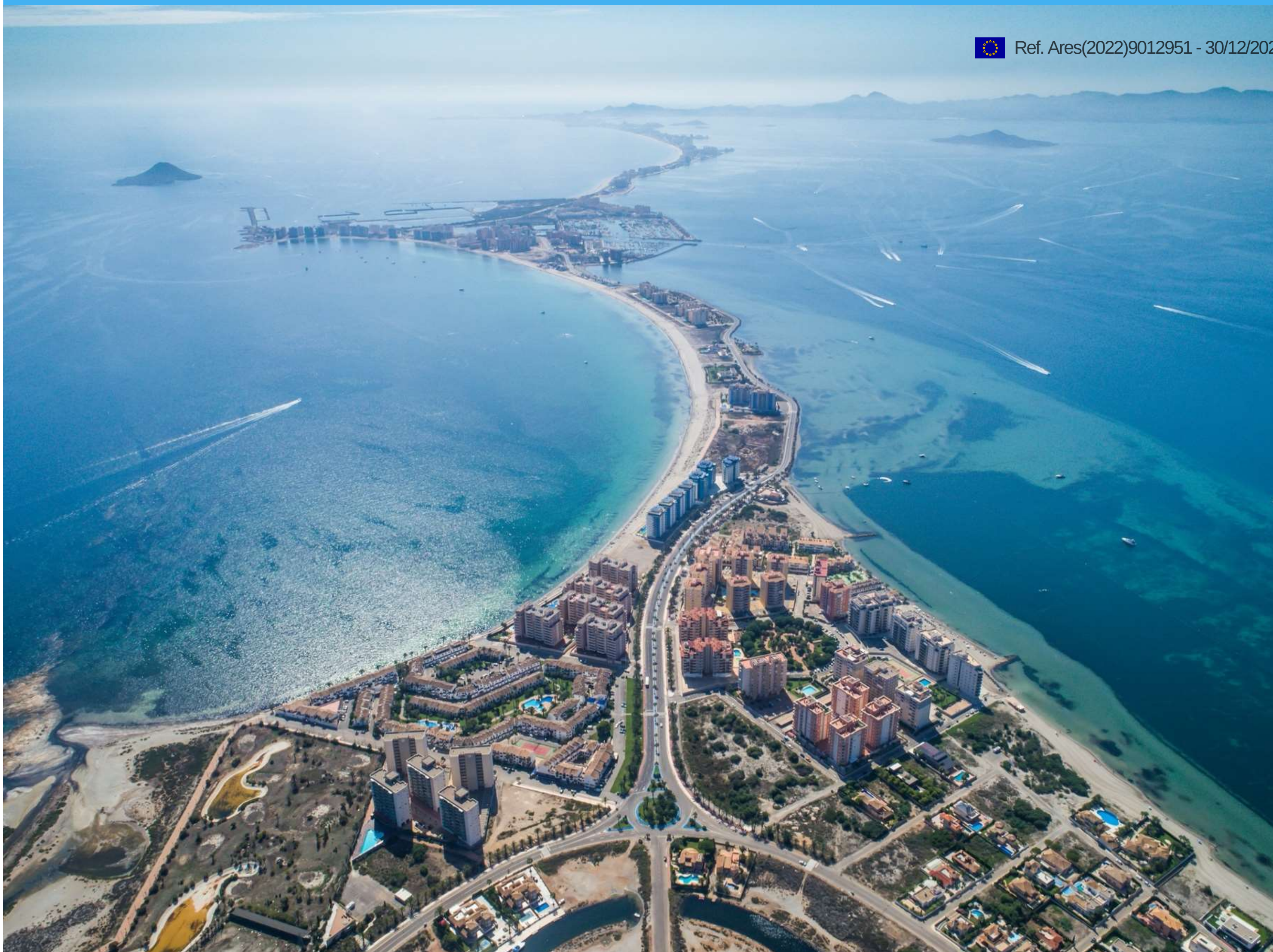

SMARTLAGOON

# DELIVERABLE 7.6

## A Blueprint for European Environmental Intelligence

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101017861.

SMARTLAGOON

# *Innovative modelling approaches for predicting Socio-environMentAl evolution in highly anthRopized coasTal LAGOONs*

## Deliverable 7.6

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# Abstract

SMARTLAGOON Project benefits from the financial support of the Horizon 2020 programme of the European Union within the framework of an Innovation Action. The progress of the project activities as well as the key results are documented by the members of the SMARTLAGOON consortium in a series of deliverables released throughout the project duration (48 months).

The present deliverable D7.6 is the second version of the "Blueprint for a full-fledged system for environmental intelligence" according to the inter-project Collaboration Agreement between the FET projects (see Annex). The deliverable is jointly prepared by the projects funded under the H2020 FET Environmental Intelligence call: I-Seed, SMARTLAGOON, WatchPlant, RAMONES and Re-SET.



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# Introduction

This document is the second iteration of a collaborative Blueprint for European Environmental Intelligence and is produced jointly by five projects of the Horizon2020 Future and Emerging Technologies (FET), called Environmental Intelligence: I-Seed, RAMONES, ReSET, SMARTLAGOON and WATCHPLANT.

Environmental Intelligence gathers key innovative scientific and technological components needed to better address environmental challenges in Europe and beyond. Specifically, the purpose of environmental intelligence is to improve environmental sustainability through policy or management endowing nature with technology. In the first blueprint the challenges and the solutions were identified by all the project involved in this action, which means a multidisciplinary approach addressing these challenges. This may be communicated as a set of problems, questions, or proposals for investment or management for which information is required using innovation as a tool. Specifically, when these problems will be solved, Europe could benefit from information currently under-sampled or a new combination of parameters or analysis of existing information in case of remote areas together with appropriate measurement technology. Thus, the challenges detected by Environmental Intelligence group are covered under these topics by the projects: Hardware; Software; Networks; People, Training and Engagement, and Policy.

- **Hardware**. This represents the computing, the communication and the data collection hardware that provides, processes, and communicates the derived intelligence. It also includes the physical "body" of the technology and system used to collect certain data: the body of a robot and its physical components (sensors, actuators, batteries/energy suppliers). The EI challenge should always be addressed with green technologies to reduce the environmental footprint of the ICT itself. For example, the use of biodegradable or zero-impact materials and alternative sources of energy.
- **Software**. It involves the code running on data collection, data processing and communication infrastructure that forms part of the environmentally intelligent system.
- **Networks**. This represents the soft networks of people, institutions, and stakeholders, as well as the hard networks for data collection, data processing and communication of outcomes.
- **People, training, and engagement**. This represents the people involved in the collection, processing, and analysis of data (including model results), as well as those impacted by the environmental problem, asking the questions, assessing the proposed solutions, and implementing investments, policies or regulations.
- **Policy**. It covers the policy context and policy levers available to facilitate change given intelligence on what needs to be done, but also the demand for evidence and effectiveness assessment that in-turn creates the need for environmental intelligence.

In addition to these topics in distant disciplines, Environmental Intelligence needs multidisciplinary approaches and a clearly integrative methodology to move environmental research in a more solution (rather than problem identification) focused direction. It is a logical extension of recent developments in data science, coupled with the increased need for high-quality, question-focused evidence to support sustainability interventions in unsustainable systems.

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Finally, considering the joint multidisciplinary efforts to contribute to social good in terms of Environmental Intelligence, technical challenges in Environmental Intelligence identified in the first blueprint will be updated in this version. Additionally, it would be beneficial to consider, firstly the need of society and secondly the capability of the target markets to incorporate new products and services. Thus, the Environmental Intelligence Consortium exposes the challenge of advancing the TRL of innovation in this direction. In this sense, this document addresses the preliminary identification of new market opportunities available or created due to the innovative technology efforts in the projects, challenges in founding start-ups to make the tech available to higher TRL level, if not yet mature and basic disseminating and exploiting innovations actions to develop in this field.

# Technical challenges in Environmental Intelligence. Year 2 FET projects developments

In this section, the main topics addressed by the Environmental Intelligence group have been review from the first blueprint 2021. Specifically, the challenges and advances in each topic carried out by the projects under a multidisciplinary approach have been updated.

## Key information

### *I-Seed*

The EU FET Proactive Environmental Intelligence project "I-Seed" targets towards the development of a radically simplified and environmentally friendly approach for analysing and monitoring topsoil and air. Specifically, I-Seed aims at developing a new generation of self-deployable, zero-impact and/or biodegradable soft miniaturized robots, inspired by the morphology and dispersion abilities of plant seeds, able to perform a low-cost, environmentally responsible, and in-situ detection. I-Seed robots are conceived as unique in their movement abilities because inspired by passive mechanisms and materials of natural seeds, as well as in their environmentally friendly design because made of biodegradable components. Sensing is based on a chemical transduction mechanism in a stimulus-responsive sensor material with fluorescence-based optical readout, which can be read via one or more drones equipped with fluorescent LiDAR technology and software able to perform a real-time georeferencing of data.

Following the definition of the I-Seed environmental scenarios and field validation strategy, a series of scientific and technical activities for the design and development of the I-Seed components have been performed. Specifically, a focused study of plant seed materials and biomechanics has been carried out to define useful specifications for the modelling and the design of artificial systems in terms of multi-functional materials, their structural properties, and morphological adaptation. We have started parallel activities on the mathematical modelling of movements of natural and artificial seeds, on the design and development of the artificial seeds and sensing units, on the active laser-


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induced fluorescence system on the drone, as well as on their geo-referencing software and smart flight controller.

### RAMONES

The EU FET Proactive Environmental Intelligence project RAMONES (Radioactivity Monitoring in Ocean Ecosystems) aims to offer new and efficient solutions for in situ, continuous, long-term monitoring of radioactivity in harsh subsea environments. A new generation of submarine radiation-sensing instruments, assisted by state-of-the-art robotic technology (SoA) and artificial intelligence (AI) will be developed towards understanding radiation related risks near and far from coastal areas, while providing data towards shaping new policies and guidelines for environmental sustainability, economic growth and human health.
The main ambition behind RAMONES is to lay a radical new path to close the existing marine radioactivity under-sampling gap and foster new interdisciplinary research in threatened natural deep-sea ecosystems. RAMONES invests a significant effort to provide tools for long-term, rapid deployments, propose new AI-driven and supported methodologies, and offer scaled-up solutions to researchers, policy makers and communities. RAMONES combines SoA equipment from various disciplines and advanced modelling in fine synergy and designs new and effective approaches for the marine environment to provide efficient response to natural and man-made hazards, shaping future policies for the global population.
In the first year of the project, the RAMONES team initiated the design of the prototype instruments to be developed together with the required technologies to assist them, investing time on preparing the required infrastructure, software and hardware. This part of the work has been extended to the second year of the project, while additional progress has been made for all tasks involved, including validations of instruments and field testing. The project continues with realization of the task objectives according to its timeline.

### ReSET

The EC H2020 ReSET project (Restarting Economy in Support of Environment through Technology), brings together environmental scientists, social scientists, informatics specialists and stakeholders from five European countries to develop state-of-the-art green investment policy support systems. These combine the best available earth observation, crowdsourced and field-monitored data with sophisticated spatial policy support systems for biophysical and social processes. Harnessing combined machine and human intelligence, we seek to understand best-bet options for 'build back better' investments that maximise environmental, economic and employment benefits of green investments. We focus on both urban and rural green investments throughout Europe including those addressing air pollution, flood, drought, heatwave, noise, and light pollution.
In the first year we have developed a range of new, low-cost IoT sensors, improved our FreeStation //Smart: a system for gathering and processing data from these systems, deployed sensors at a series of demonstration sites where stakeholders are in need of environmental intelligence and begun the process of further developing and integrating our spatial policy support systems that will link


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with these data streams to provide actionable evidence to inform investment, policy, and regulation.

### *SMARTLAGOON*

The overall objective of SMARTLAGOON is to develop cross-cutting and green technology for modelling and predicting socio-environmental processes across different temporal and spatial scales. This will be achieved through a digital twin strategy that allows researchers, stakeholders and policymakers to collect data in a more cost-effective way, and to create more precise models and predictions to support better decision making. As a case study, this project uses the Mar Menor lagoon (Murcia, Spain), an ecosystem that supports a great variety of human activities encompassing tourism, agriculture, fishing and mining, that have led to its deterioration.
An important novelty of the SMARTLAGOON approach relies on the holistic view of coastal lagoon ecosystems. Developing a data-centric technology solution will provide real-time monitoring and forecasting of socio-environmental trade-offs in these ecosystems, aimed at helping policymakers in their decision-making. It will also enable an increase in people's awareness of these trade-offs, which will benefit the understanding and enforcement of applicable legislation (e.g. EU Water Framework Directive (2000/60/EC), EU Floods Directive (2007/60/EC), RD 2/2019, December, 26th, Integral Protection of the Mar Menor).
In this second year, SMARTLAGOON has focused on the digitisation of the most relevant variables of the Mar Menor lagoon and its catchment area. Firstly, an exhaustive analysis of the scientific literature and current legislation in the socio-economic context of the Mar Menor has been carried out in order to identify the most relevant variables for monitoring both the catchment area and the lagoon. These variables are involved in different BMPs that have been identified as a very relevant to be simulated by our digital twin. Secondly, the first oceanographic buoy has been deployed in the Mar Menor to measure different water quality parameters such as Conductivity, Chlorophyll-a, Turbidity, Oxygen, Water Temperature to mention a few. Thirdly, the first artificial vision algorithms have been designed to estimate the quality and quantity of surface water draining into the Mar Menor through the ephemeral streams present in its basin. Three cameras have been deployed in different strategic locations to measure the flow that is generated naturally at these points in order to calibrate the different models. Finally, the first physical base models of the basin, lake and basin-lake have been developed, which will be improved in the coming years.

### *WATCHPLANT*

WatchPlant project proposes a novel approach of developing a biohybrid system technology for in-situ, self-powered monitoring, which allows plants to wear a net of sensors, AI components and technological interfaces, resulting in the creation of “smart biohybrid organisms” for environmental monitoring. Therefore, the main goal is to develop, deploy, and perform an experimental validation of this new biohybrid system technology to address the in situ monitoring of environmental context focused on pollution, together with living plants, primarily in urban scenarios using undersampled

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parameters in plants, multiparametric data collection and interpretation together with air quality as a study case, in order to establish a relation to human health.

Currently, there are a lot of monitoring approaches and sensors already developed to obtain information about the environment. However, which is the key parameter for each application and context is still a challenge in ecophysiology, even more so when the phenomena are due to multifactorial causes. For this reason, access to new valuable information based on undersampled parameters is one of the goals for sensing but always coupled with an understanding of the data and to correlate them with the environmental problem understanding. To this aim, environmental models are very useful and will be one of the targets of the WatchPlant project in the upcoming years to obtain a better understanding of the environment. Is not only about measuring but deciding what to measure while understanding the obtained data properly.

In this second year, we have developed the separate components of the biohybrid system for tracing the indicators in the plant that correlates with environmental changes identified during the first year. Experimental data from those separate components is being collected and analysed to ensure the reliability and robustness of the devices. Each component provides information about the plant status which could not be informative enough in an out-of-context situation (that is, separately from the others component information). Nonetheless, the integration of all of the components provides the information to obtain a more realistic picture of the plant status, and as it was mentioned previously, to correlate it to environmental changes and, as final connection, to human health but also to any other application. The following year, we will be working on this integration to achieve the autonomous biohybrid sensor system.

# Hardware Challenges

### *I-Seed*

One of the first challenges was to define the methodology to translate the biological principles of some selected plant seeds and their dispersal strategies in the design and fabrication of environmentally responsive seed-like soft robots made of multi-functional biodegradable materials. With the I-Seed objective to perform measurements in both air above soil and topsoil, two groups of natural seeds have been identified and analysed to extract biological specifications for the artificial systems: (1) self-burying seeds able to passively penetrate into the soil fractures. Crawling and burying occur thanks to the seed awn unit, which has hygroscopic characteristics and responds to variations of external humidity by changing its configuration; (2) flying seeds - which use their morphology and structural features to be carried by the wind and dispersed over great distances. We have systematically collected, for the first time together, the morphological, structural, biomechanical and aerodynamic information from selected plant seeds relevant to take inspiration for the engineering design of soft robots, and discussed potential future developments in the field across material science, plant biology, robotics and embodied intelligence (Mazzolai et al., 2021). Motion and dispersion of the seeds can be obtained by using the natural combination of sensing and actuation through material computation, with which is possible to obtain a passive mobility (with no need of


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any internal energy source), exploiting their morphology, structure, and biomechanics/aerodynamics.

Starting from the identified biological principles, the second challenge focused on building artificial seed-like robots with biodegradable/environmentally-friendly materials able to provide structural support and dynamically respond to several environmental stimuli. With this in mind, we have already fabricated a first version of self-burying robots made with biodegradable polycaprolactone materials using different manufacturing techniques (i.e. two-photon lithography, bioprinting, electrospinning) (Fiorello et al., 2022) (Cecchini et al.)].

### *RAMONES*

RAMONES has faced several challenges with hardware in the second year of implementation. Some have already been confronted successfully, while for others the consortium is working hard to provide solutions. We summarize the challenges in the following points:

- **Challenge: global supply chain disruption**. The COVID19-related lockdowns have resulted in increasing insecurity and disruption of the global supply chains, esp. those related to industries manufacturing critical components for sensors and assistive electronic components. **Solutions**: In some cases, we have secured needed equipment from local suppliers with available stock or decided over equally or better alternatives available, while in some limited cases, we have experienced delays in delivery, which we coped with minor changes in our schedule of development and testing.
- **Challenge: Power supply and autonomy**. The harsh and remote conditions existing in the depths of the ocean require careful design and preparation of the power supply to ensure long operation of the instruments. **Solutions**: The benthic lab is a challenging part in terms of power supply, where batteries will be installed. Detailed design and optimization of the instruments housings, the power connections, the onboard computing demand, the transmission of data and more have been undertaken successfully. Further optimization will take place as the project proceeds in its timeline and field testing will provide feedback on power demands and operation.
- **Challenge: Sensors integration on mobile robotic gliders**. The integration of radiation sensors on the autonomous underwater gliders which will roam the ocean waters is challenging in many respects. The provision of power, signal connectivity to the sensors, but also the AI-based decision making of the gliders based on the radioactivity levels recorded in real time by the integrated CZT sensors are not straightforward tasks. Sufficient statistics are required, and such, optimization of the sensors placement on the gliders and proper choice of the size, shape and material of the housings is critical. **Solutions**: In the second year The RAMONES team have provided various hardware solutions to ensure optimization of the operation at the hardware level via alternative designs. In addition, multiple scenarios involving different types of materials and geometries for the encapsulated sensors have been explored to avoid loss of sensitivity in the online measurements of radioactivity in the marine environment.


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### *ReSET*

In the second year of the project, ReSET has focused on the following additional hardware challenges:

- **Challenge: the need for battery monitoring**. Some of the microprocessors that we are working with have no on board battery monitoring. This means it is challenging to understand the performance of the monitoring solution under different sensor configurations and solar power environments. Solution: we have built a battery monitoring solution into all of our PCBs, the standard Nano sized PCB and the new Zepto and Femto, smaller sized units
- **Challenge: supply insecurity**. As a resolution of COVID related lockdowns and recovery there is a global shortage of silicon and many IoT providers have low or no stock or are having to reconfigure their systems to work with supply secure silicon. Solution: we have had to adapt PCBs in line with the changes made by IoT microprocessor providers and have also expanded our range of supported devices from Particle only top Particle, Arduino and Raspberry Pi in order to cope with these challenges.

### *SMARTLAGOON*

To date SMARTLAGOON is addressing the following hardware challenges:

- **Challenge: Designing Edge computing systems to reduce energy consumption**. Machine vision algorithms developed for flow estimation are computationally expensive. Currently, they are executed following a cloud computing approach that involves continuously sending the information for further processing. However, we are in ephemeral stream environments where no water flows 95% of the time. Processing in this way is energy inefficient and can therefore be optimised by designing a system that reduces this sending of data to the cloud.

### *WATCHPLANT*

To date WatchPlant is addressing the following hardware challenges:

- **Challenge: Plant perturbation and adaptation to the biohybrid sensor system. Solution: analysis of the lifetime of the biohybrid sensor and design strategies to overcome the natural plant mechanisms for adaptation/perturbation**. Living organisms tend to adapt to perturbation in their environment. The biohybrid system includes sensor nodes and electronics that, in the first place, could become a potential perturbation for the plant, changing its natural dynamics. Moreover, in the long term, it could adapt, forming a separate environment for the sensors. In either of the cases, the reliability of the data with the biohybrid system could be compromised. Therefore, it is a challenge to develop hardware methods that ensure the quality of the phytosensing measurements in any of those situations.
- **Challenge: Enhancing the hardware of the energy-efficient PhytoNodes**. The challenge here is to utilize the limited computing capabilities of the sensor nodes without increasing energy consumption. Installing extra RAM and flash on the PhytoNodes using an extension board


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could be a proper approach toward this goal. The increased memory will enable the nodes to run more complex machine-learned models and algorithms.

## Software Challenges

### *I-Seed*

Sensing in artificial seeds is obtained via transduction-based sensor materials, which challenge to advance in-situ sensing technology based on chemical transduction mechanisms. This goes beyond the current sensor network by using materials that react to environmental parameters, such as temperature or humidity, or to certain chemical analytes by changing optical properties. The reading of the signal is based on optical signalling and fluorescence by LiDAR (Light Detection and Ranging) technology. The challenge focuses on the design and development of a multi-wavelength fluorescence LiDAR system capable of detecting several excitations in one observation. This will extend the presented laser-induced fluorescence principle as evaluated for vegetation to other materials being part of the I-Seeds.
LiDAR data post-processing and drone flight controller are necessary to design and implement a "smart" flight controller based on deep learning architecture, with a software able to read and process in real-time the data stream and a desktop software to do post-processing and export.

### *RAMONES*

RAMONES has faced several challenges with software in the second year of implementation. Some have already been confronted successfully, while for others the consortium is working hard to provide optimal solutions. We summarize the challenges in the following points:

- **Challenge: Software for sensor data handling, preprocessing, storing**. RAMONES is developing various prototype instruments, which require appropriate software to acquire and manage the data recorded. The different technologies necessitates the development of software which will connect all sensors running in parallel to the onboard computers seamlessly, offering preprocessing capabilities, low-power footprint and onboard storage, where needed. **Solutions**: API or SDKs have been requested and acquired from the manufacturers of individual modules, where available. Custom solutions and harmonic synergies among different software platforms have been developed where needed.
- **Challenge: Software for self-awareness and coordinated navigation**. Limited power and reduced weight constraints impose severe constraints on the design. On one hand, the navigation system must be designed taking advantage of only a few sensors. On the other hand, the navigation suite is a key system of any autonomous vehicle since it is responsible for supplying the state of the vehicle, which usually comprises, at least, the position, attitude, and linear and angular velocities. These quantities are not only necessary for control purposes but also for geolocalization, which is of paramount importance in this project. **Solutions**: in the second year of RAMONES, the newly developed control algorithms are devised


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considering the available computational power and very limited actuation capabilities. The envisioned cooperative navigation system for the AUGs will take advantage of the flexibility offered by the USBL positioning systems installed on-board all vehicles and will switch between different modes of operation, depending on the conditions of operation (position vs. range measurements) and energy constraints (periodic sampling vs. on-demand position/range requests). The ASC will provide inertial references through communication and simple kinematic/dynamic models will be considered for the AUGs, for dead-reckoning purposes, possibly considering the presence of inertial sensors installed on-board the AUGs. Self-driven or event-driven control techniques will be employed to balance the estimation error covariance and the energy consumption.

- **Challenge: Information system software**. RAMONES introduced novel communication and response channels to engage key socio-political stakeholders, as required by the rise of new technologies and capabilities that need to be considered in future environmental assessments and management plans. With monitoring, a strategy of information and data access will be developed at regular intervals from medium (daily, weekly) to low (monthly to annually) frequencies, in addition to near-real-time data transfer if required. The envisioned scenarios are affected by the monitoring autonomy and operation capabilities of the final systems deployed, as well as the location and demand. **Solutions**: All scenarios are considered in a flexible and adjustable software platform which is currently under development. The prototype Information System is designed to provide critical assessment of the risks based on (near-)real-time data transmitted by the operating instruments in the marine environments. Various layers of validated data and specifications driven by international regulatory bodies are implemented in the core of the software.

### *ReSET*

Additional challenges that had to be addressed in the second year of ReSET have included:

- **Challenge: management and maintenance of large deployments of sensors**. Several of the ReSET demo sites have deployments in excess of 20 dataloggers with multiple sensors on each. Maintenance needs to occur with a clear knowledge of any data collection issues. **Solution: clustering loggers**. We have developed logger clustering techniques in order to display and manage large deployments as a unit so that battery levels and other troubleshooting information can be seen across many loggers.
- **Challenge: communication of results**. For large deployments it is important that live and periodic data updates and changes to logger configuration are available without having to update web pages over many deployments. **Solution: we have developed automated visualisation pages** that provide summary maps, charts and tables for clusters of sensors associated with demo sites. These pages are produced by the FreeStation data management platform so no manual updating of them is needed as new data becomes available and sensor/logger configurations change.


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### *SMARTLAGOON*

To date SMARTLAGOON is addressing the following software challenges:

- **Challenge: End-to-End communication system for data visualization and model training**. **Solution**: Once the data has been captured, at the software level, the challenges of sending this data in near-real time to the cloud for further analysis and visualisation are posed. In addition, this data must be analysed, sanitised and connected with the models developed to make short-, medium- and long-term predictions.
- **Challenge: Clearly define the outputs of the digital twin of the Mar Menor**. **Solution**: The concept of the digital twin is applied in SMARTLAGOON to the socio-environmental intersections of an ecosystem such as the Mar Menor. These interactions are innumerable and growing in the future, making it difficult to establish a static model. Therefore, it must be established, dynamically, which interactions are most relevant to the context of the Mar Menor, in order to be able in the future to determine and/or amplify new relevant information that our digital twin should produce.
- **Challenge: Social impact measurements in real time**. **Solution**: In order to measure the social impact of the economic and environmental context of our digital twin, it is essential to know people's opinions in real time. We are designing a social monitoring tool to identify people's main concerns on social networks and to be able to respond to this in real time.

### *WATCHPLANT*

To date WatchPlant is addressing the following software challenges:

- **Challenge: Integration of the information provided by the components and decision-making**. **Solution**: To design a software based on adaptive and explorative algorithms capable of learning specific behaviours and detecting specific disorders in the living organisms due to environmental perturbations.
- **Challenge: Developing simple yet efficient algorithms for the PhytoNodes**. The challenge involves to train/develop fewer complex models while maintaining acceptable performance. **Solution**: Classification, prediction, and compression are examples of tasks that need to run on the PhytoNodes for stimuli classification while keeping energy consumption to a minimum for sustainability.
- **Challenge: Efficiently utilizing PhytoNodes hardware and saving energy**. The challenge here is to perform dynamic duty cycling those changes based on the available renewable energy. For example, during the day, the availability of solar energy allows increasing duty cycling or performing more communication. During evenings, duty cycles could be decreased to save energy.

## Network Challenges


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### *I-Seed*

The collection of environmental data and their analysis target the filling of geographical gaps to improve ongoing monitoring networks in areas where no monitoring infrastructures are available with low investment and management costs. I-Seed scenario challenges to increase the spatial resolution of monitoring points/sites developing a low-cost technology allowing to execute continuous field campaigns in contaminated sites/emission regions to cross-check the effectiveness of remediation measures adopted to restore ecosystems quality.

### *RAMONES*

The prototype instruments of RAMONES are designed to perform in situ, long-term monitoring of radioactivity levels in the marine environment and offer imaging capabilities in locations where harsh conditions exist. The intercommunication of the mobile robotic vehicles (gliders), the static benthic laboratory and the autonomous surface vehicle will be handled by state-of-the-art USBL models. The demand to have a low power footprint in transmitting and receiving data at the best possible communication rates has a central role in RAMONES. In addition, the coordinated navigation of the gliders, based on the AI-driven software developed, requires high-level control and SoA network algorithms to achieve the envisioned scenarios of operation. In the second year of the project, RAMONES has already developed a large portion of the required network capabilities, installed critical infrastructure and worked towards final implementation and testing in the field.

### *ReSET*

No additional network related challenges had to be addressed in the second year of ReSET.

### *SMARTLAGOON*

To date SMARTLAGOON is addressing the following network challenges:

- **Challenge: Development of low-power, long-range communication systems in remote environments**. The deployed oceanographic buoy is located about 12 km off the coast. SMARTLAGOON has developed a LoRa-based communication system to connect the oceanographic buoy with the Spanish Institute of Oceanography (IEO) in Murcia, located on the shore of the Mar Menor. In this way, the processes of collecting and sending data through this protocol are being optimised. In addition, a Mesh-based protocol is being designed to scale the protocol with multiple devices and allow greater coverage range.

### *WATCHPLANT*

To date WatchPlant is addressing the following network challenges:

- **Challenge: Communication range and energy.** Ideally, sensor nodes on natural plants should be distributed over a whole city. Establishing a distributed network (e.g., multi-hop) requires


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communication ranges of about up to a kilometre. Depending on different optional radio communication protocols (e.g., GSM, LoRA, WLAN, Bluetooth), long communication ranges come at the cost of potentially high energy consumption. Due to physical constraints, communication range correlates with energy consumption. At the same time, environmental constraints require small, lightweight sensor nodes with minimal energy footprints confronted also with difficult energy harvesting situations. Hence, the challenge is to compromise between communication range and minimal energy consumption.

- **Challenge: Robust and efficient data routing.** Given we may aim for a high number of small, inexpensive sensor nodes, the system should be considered an open system with (unreliable) nodes coming and going. In addition, mobile sensor nodes may be used, too (e.g., smartphones). This requires a robust, decentralised, and possibly adaptive routing scheme that can deal with dynamic neighbourhoods on different timescales (from seconds to months). Similarly, routing needs to be efficient to minimise energy consumption. The close proximity to seasonal plants (e.g., trees losing leaves in winter) may also change link quality over periods of weeks and months.
- **Challenge: Duty cycling and task allocation.** In general, we try to bring energy consumption to a minimum. Here, the challenge would be to perform dynamic duty cycling that changes based on the measurement frequency necessity and to allocate specific tasks to nodes at relevant areas. For example, during the day, a higher measurement frequency might be necessary to obtain more precise predictions due to increased external noise and plant activity. Lower measurement frequency in calmer conditions (e.g., at night) would help reduce energy consumption. The network here should perform location-based duty cycle adjustment and task allocation based on surrounding environmental activity.
- **Challenge: Distributed connectivity control.** It is well-known that the rate of data propagation within the network correlates with its degree of connectivity. However, increasing the number of links between nodes can lead to deteriorated control and increased energy and computation costs. Similar to adaptive duty cycling, the challenge is to ensure desired communication performance while minimising energy consumption. Additionally, the effects that extrinsic and intrinsic disturbances have on the system performance must be considered when deploying a network in real-world scenarios. To address this challenge, we have developed a method for distributed topology control through algebraic connectivity measures. The algebraic connectivity is estimated locally with a trust-based consensus algorithm and links are dynamically added or removed to maintain desired connectivity.

## People, training and engagement Challenges

### *I-Seed*

During the second year, I-Seed has focused on the following major challenges:


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- Communication. Raising awareness of the I-Seed project mission, challenges and results using social media (Twitter: https://twitter.com/iSeed_project), project website (https://iseedproject.eu/), press releases at national and international level, addressing popular newspapers, magazines, participation in radio and TV programs, in fairs, and organisation of "scientific café".
- Dissemination. Dissemination of project results towards the scientific community and industrial representatives via scientific publication in peer-reviewed journals and international conferences; flyers, posters, presentations; organisation of special tracks, workshops, special sessions to present results and technologies in national and international conferences
- Environmental sustainability and community building. Leverage the cross-disciplinary connection of the community of biorobotics and environmental science to support the evaluation of the effectiveness of measures undertaken in the implementation of environmental policies; and to promote eco-innovation initiatives through citizens' involvement for raising awareness on critical environmental issues.
- Training. Use of master classes, dedicated workshops, scientific tours, and summer schools, with the goal of educating a new generation of roboticists, material scientists, biologists and environmental scientists with the multi-disciplinary expertise for the creation of new environmentally-friendly technologies for the environment.
- Exploitation. Use of presentations of I-Seeds prototypes, in their different phases, and meetings with potential customers and stakeholders

### *RAMONES*

The people, training and engagement challenges in the second year of RAMONES can be summarized in the following list:

- **Communication challenges:** Raising and expanding awareness of the RAMONES objectives, work and vision. The social media channels (Facebook, twitter, instagram, youtube, LinkedIn) and the project website (https://www.ramones-project.eu) have been the main vessels to communicate our work over the course of two years, showcase developed technologies and present our cause to a wider environment. To that end, the press (online and printed) has also provided the means to reach a large audience.
- **Dissemination challenges**: In the second year, several peer-reviewed publications, conference papers, reports and announcements at international and national conferences have been produced by the RAMONES consortium. The RAMONES partners have participated in Trade Fairs, Workshops, Panels and Special Tracks/Sessions where the Environmental Intelligence concept has been promoted to research audiences, as well as a wider field of stakeholders. The main challenge was to overcome the first-year COVID-19 effects, where personal presence at events was limited.
- **Training challenges**: Similar to the main challenge in dissemination, in the second year of RAMONES, a main effort was centered around providing in-person training to a new generation of scientists and engineers across various disciplines. To that end, several existing synergies with relevant projects (with a signed MoU or not) have been exploited. Workshop


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events, dedicated masterclasses and webinars have communicated key technologies of the future, as pursued by RAMONES.

- **Challenges in Environmental sustainability and community building**: The cross-disciplinary connection of the community of radioactivity, marine robotics and engineering, information technology, geosciences, risk information technologies and policy shaping has been leveraged in the second year to promote innovation initiatives through citizens' involvement for raising awareness on critical environmental issues and support the central ideas behind teh Environmental Intelligence Initiative.

### *ReSET*

Additional challenges that had to be addressed in the second year of ReSET have included:

- **Challenge: The need to simplify our offering**. The tools that we provide are many (FreeStation, //Smart:, Co$tingNature, WaterWorld, Metronamica, ReSETMap, ReSET toolkit). **Solution: careful communication and training**. We have had to ensure that each is communicated simply and effectively to the relevant audiences through the ReSET website h2020reset.eu and the website and user documentation or training associated with the individual tools. We have developed demo-specific web pages and stakeholder-group specific documentation, for example for teachers through our EduStation materials.

### *SMARTLAGOON*

To date SMARTLAGOON is addressing the following People, training and engagement challenges:

- **Challenge: Disseminating new findings and involving stakeholders potentially interested and able to benefit from them is not an easy task. Solution**: Raise awareness through communication activities and direct engagement through co-design and co-creation. We have begun awareness raising of the SMARTLAGOON project using social media #SMARTLAGOON @SMARTLAGOON, web www.smartlagoon.eu, participation at events, and presentation at conferences. Moreover, we organized workshops and meetings with stakeholders to make them aware of what we can provide and to understand their needs, capacities and priorities, and eventually, co-design and co-create our solutions with them.
- **Challenge: Gathering the support of the different stakeholders involved in the environmental problems of the Mar Menor is the greatest social challenge of the project. Solution**: Maintain a clear communication strategy based on the scientific documents generated as a consequence of the tasks carried out during the project. The clear politicisation of the social problem derived from the environmental crisis of the Mar Menor has led to a very tense working climate in which SMARTLAGOON has to keep out of the political interests of the different stakeholders. This neutral position must be based on a clear communication of the scientific documents of the project.

### *WATCHPLANT*


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To date Watchplant has focused on the following people challenges:

- **Challenge: Available and accessible data for citizens / Enabling citizens to interact with the sensor network**. One of the main motivations for Environmental Intelligence research is to provide people with tools for better and more meaningful environmental data. To increase their engagement, the interaction with the citizens should start already at the data collection level at the hardware and software level but also a step further. Specifically, the challenge is to determine simple and effective methods for the rapid distribution of key environmental parameters to the public, as well as encourage participation in collecting, processing, and distributing data within the sensor network using smartphones or wearable devices. Solution: People's awareness, real-time data collected by the biohybrid system will be uploaded to the web page to enable free and open access to data for citizens. On the other hand, participation in events, and presentation at conferences is another action carried out during the whole project to spread the environmental intelligence topic.

## Policy Challenges

### *I-Seed*

To date I-Seed has focused on the following policy challenge:

- **Challenge: Policy makers and implementing agencies**. An important component of dissemination and outreach strategy of I-Seed is the involvement of international convention secretariat and expert groups supporting the policy implementation at national, EU and UN levels (i.e., UNEP, UNIDO, UNITAR), considering that I-Seed project could help to face challenges related to UN Sustainable Goals (i.e. 13 - Climate Action; 15- Life on Land). The evaluation of the effectiveness of measures undertaken by governments to achieve the objectives of an environmental policy depends primarily on the availability of monitoring data that may show the improvement of environmental quality over time. To leverage the ongoing monitoring programs with low-cost monitoring technologies would allow nations to promote nationwide monitoring programs and be an active part of the policy implementation.

### *RAMONES*

No additional policy related challenges than those highlighted in the first volume of this document have had to be addressed in the second year of RAMONES. This is expected to change in the next iteration, as RAMONES develops and test its prototype technologies which will provide data-driven assessments and define a firm framework of policies for radioactivity in the marine environment.

### *ReSET*

No additional policy related challenges than those highlighted in the first iteration of this document have had to be addressed in year 2 of ReSET.


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### *SMARTLAGOON*

To date, SMARTLAGOON has focused on the following policy challenges:

- **Challenge: Legislation updating through collaboration with regional and national administrations**. In recent years, both the regional and national governments have published various regulations specifically related to the Mar Menor coastal lagoon. These regulations include a broad list of measures that are not prioritized among them. The digital twin to be developed in the project will allow the quantification of the effectiveness of the differ-ent measures and the stakeholders will be informed for the possible updating of the cur-rent regulations.

### *WATCHPLANT*

No additional Policy related challenges had to be addressed in the second year of Watchplant project.

# Basic science and technology facing innovation. Challenges in Environmental Intelligence

Environmental Intelligence faces the challenge to unify multidisciplinary innovation in the fields previously exposed in the direction of benefit social good. This is supposed to be easily translated into an interest in investment from target companies in the related fields. Thus, Environmental Intelligence objective is focused on multiply the impact of the proposed solutions and prepare the transition towards medium-range TRL developments, together with preparing the ground for future industrial and commercial uptake, to fully achieve the expected impact. In this section, the needs of society have been identified for each field and linked to associated technology and target markets. Additionally, challenges in founding start-ups from low TRL technology or in context in which there is not a market developed yet will be pointed in this section.

## Market Opportunities

### *I-Seed*

The market opportunities for I-Seed technologies are being defined thanks to a continue discussion with environmental scientists and innovators.
Reduced environmental footprint for environmental ICT: Made of biodegradable materials and with no need for internal power supply, I-Seed robotic systems are conceived to avoid the dispersal of


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new e-waste and no-need of retrieval actions for the devices themselves. New multi-functional materials and fabrication processes will be investigated and implemented for the development of the I-Seed series, paving the way for a new generation of environmentally benign technologies.
Availability of reliable data and models at multiple levels of granularity for environmental policy-making: The proposed I-Seed technology would provide three key contributions to the current monitoring capabilities that would represent an advantage for the implementation of environmental policies at any geographical scale, which include: (i) the possibility of filling geographical gaps to improve ongoing monitoring networks in areas where no monitoring infrastructures are available, with low investment and management costs; (ii) the increasing of the spatial resolution of monitoring points/sites with a technology that is cost-effective, robust over time, remotely controlled, and that allows monitoring our selected parameters in the top soil, and air above the top soil (air-top soil interface). This is crucial information for reducing the range of uncertainty in numerical atmospheric modelling evaluation aimed to assess spatial patterns of contaminants' concentrations and exchange fluxes over terrestrial receptors with changing emission regimes and meteorological conditions; and (iii) the development of a low cost technology that would allow to execute continuous field campaigns in contaminated sites/emission regions to cross-check the effectiveness of remediation measures adopted to restore ecosystems quality.

### *RAMONES*

RAMONES is a low-TRL project aiming to develop completely new technologies and develop innovative approaches across various scientific disciplines. As such, the market opportunities in the second year of the project are still rather dim and placed in a horizon beyond the end of the project. However, several actions have been undertaken during the second year to ensure that the innovative potential of RAMONES technologies will remain high and the market opportunities will be consolidated as the project progresses through its timeline. The RAMONES consortium envisions a high applicability of the developed technologies: novel sensors, increased mobility in the marine environment, advanced marine robotics and AI algorithms, innovative marine engineering, high scalability, groundbreaking approaches in Risk Information Systems and more. To that end, market opportunities have already been explored and discussed among the consortium members, as well as potential stakeholders, the RAMONES advisory board, and EU officials and experts.
Given the high innovation potential RAMONES has been invited to participate in a dedicated Innovation Bootcamp under the aegis of the EU, in which members of the consortium have had the opportunity to receive training on how to facilitate the passage from low-TRL (pathfinder) to a high-TRL status at the end of the project and beyond. The Bootcamp has provided unique opportunities to understand the pathway to market availability of the prototype instruments and technologies of RAMONES. Despite the rather immature state of RAMONES for market availability, the challenge to increase its market exploitation in the future has been strongly confronted with useful experience gained by the members of the consortium.


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### *ReSET*

Our key societal challenge is that huge investment in urban and rural restoration of nature will be made in the next decade to avoid existential challenges associated with (a) increasing exposure to floods, droughts, heatwaves, wildfire (b) the mass extinction of biodiversity and (c) the collapse of nature's contributions to people which underpin food, energy, water and financial security. These investments require evidence to ensure that they are effective, cost-effective and socially just, but there is a lack of supply of integrated knowledge systems for:

a) Effectiveness assessment to learn from already-made land management and restoration investments.
b) Strategic spatial planning of what restoration investments to make where, for low-cost, socially-just and environmentally sustainable outcomes.

Current approaches are often without social dimension, fragmented, time-consuming, lacking evidence base, difficult and not solution-focused. ReSET's environmental intelligence brings together advanced remote sensing, sophisticated spatial modelling and low-cost, in-situ, IoT sensing to provide locally specific evidence for green investment. We have world-leading environmental and socio-econ modelling (Co$tingNature, Metronamica); prototype sensors and sensor networks (FreeStation); excellent understanding of environmental policy and regulatory landscape, decision support needs and metrics for environment, economy, employment and leading work on multi-stakeholder processes (CNR, ICA, RIKS).

We consider the market for our technology to include all public and private sector investors and planners that will have obligations to invest in nature to ensure:carbon net-zero by 2050 (or earlier); nature positive (by 2030) and management of climate and nature-related risk in their portfolios. This systemic transformation of business models and practice towards sustainability will be the greatest challenge most public and private sector organisations have ever faced. The ESG consulting market will more than triple this decade, to support this transformation & investment.

Producing a sustainable business model for such as broad range of technologies as ours is challenging but could include:

a) Consultancy: use the improvements made to our technologies under ReSET to expand the existing consultancy market of the 3 SMEs in the project
b) Platform economy: Build systems for use by other environmental consultants, under affiliate licence, including some Freemium.
c) End user software licensing: for well understood environmental investment scenarios, market direct to end-users eg company ESG departments, urban and rural green investors, planners and implementers.

By the end of ReSET our tools will vary from TRL 2/3 for those newly developed in ReSET to TRL 5/6 for those existing tools improved under ReSET. Investment will be needed to achieve a transition from TRLS 2/3 and 5/6 to TRL 8/9 and thus to grow societal impact by entering new markets. This investment would be put to professionalising the software and systems. This would enable us to go beyond ReSET, towards an investment-ready proposition, supporting a socially-just, multistakeholder, nature-positive transition for sustainability.

SMARTLAGOON
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## SMARTLAGOON

SMARTLAGOON is one of the the first attempts to develop a digital twin strategy to improve the policy making process in complex socio-environmental systems such as coastal lagoons. The TRL 3-8 applications developed can lay the foundation for the SMEs in the consortium and other stakeholders in the sector to continue the product development and exploit the tools for other cases beyond the project's lifetime. Although not included in the budget at the beginning of the project, we plan to seek additional funds for market opportunity studies.

## WATCHPLANT

The main goal of WatchPlant is to develop, to deploy and to perform an experimental validation of new biohybrid system technology to address the in-situ and remote monitoring of environmental context together with living plants in order to establish a relation to human health. The goal is to create a remote sensing tool for decentralized analysis of environmental status which will provide different stakeholders with a powerful tool for decision-making in real-time based on the real status of the environment. This is in line with the trend of decentralized monitoring but it will need to overcome some barriers that private sectors such as agriculture and the production of sensors industries will pose in the sense of limited resource uses, time-consuming and costly methods or materials, and also energy efficiency systems to be well accepted for the target markets or to be profitable enough for new companies generation.

***Table 1.*** *Environmental Intelligence contributions to target markets in the key fields*

| Field | Availabe technology | Non-availabe technology | | Target market | Target segment | Actor |
|---|---|---|---|---|---|---|
| | | New product, service, process | IIPR | | | |
| Key information | Spatial decision support models | ReSET Investment Toolkit | varies | Consultants, green investors, sustainability departments | Consultants, green investors | ReSET |
| | | | | | | RAMONES |
| | Distributed and optical measurement of air/soil parameters | Biodegradable/biocompatible fluorescent robots sensitive to environmental parameters. | Patents; licenses; industrial know-how | Green investors. Public institution, private companies | Farmers and producers/ Sensors manufacturers companies | I-Seed |
| | On-demand data of socio-environmental interactions. | Mar Menor's digital twin | varies | Public institutions | Policy-makes | SMARTLAGOON |
| | On-demand measurements of physical and chemical parameters. | Sensors development for under-sampled chemical parameters. Ecophysiology to understand obtained data in a combined manner | Patent/ Industrial and Commercial Secrecy | Private companies | Farmers and producers/ Sensors manufacturers companies | WATCH-PLANT |

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| | | | | | | |
|---|---|---|---|---|---|---|
| Hardware challenges | Spatial distribution of the I-Seed robots and reading of the fluorescent signals by UAV/LIDAR technology | Biodegradable/biocompatible I-Seed robots dispersible by wind and humidity changes. Fluorescent materials sensitive to environmental parameters (e.g., Temperature, Humidity, $CO_2$ and Hg). LIDAR on board of UAVs for fluorescence stimulation and reading. | Patents; licenses; industrial know-how | Green investors. Public institution, private companies | Farmers and producers/ Sensors manufacturers companies UAV producers. | I-Seed |
| | | | | | | RAMONES |
| | Battery monitoring | New on PCB battery monitoring | varies | FreeStation users | | ReSET |
| | Low-power and ubiquitous measuring systems | Edge computing artificial vision device to measuring flows | varies | Public institutions | River basin agencies | SMARTLAGOON |
| | Non-combined sensors and clean energy harvesting strategies | Miniaturised, integration of a net of physical and chemical sensors and power supply | Patent/ Industrial and Commercial Secrecy | Private companies | Farmers and producers/ Sensors manufacturers companies | WATCHPLANT |
| Software challenges | Management and maintenance of large deployments | Software for data analysis and data-driven flight control | varies | Users of FreeStation | Farmers and producers. UAV producers | I-Seed |
| | Communication of results | | varies | users fo FreeStation and ReSET-IT | | RAMONES |
| | Management and maintenance of large deployments | | varies | Users of FreeStation | Consultants, teachers, scientists | ReSET |
| | Social impact measurements | Social sensing tool to measure people's concern in real time | varies | Public and private institutions | Local, Regional and national governments, Medium-big companies | SMARTLAGOON |
| | | | | | | WATCHPLANT |
| Network challenges | Distribution models, environmental data management and validation | Data architectures, Data calibration and validation | Patents | Green investors. Public institution | Sensors manufacturers companies, Farmers and producers, UAV producers | I-Seed |
| | | | | | | RAMONES |
| | No additional | | | | | ReSET |
| | Low power and long range communication protocols in rural areas | LoRa-based Mesh protocol | varies | Private companies | IoT-based companies | SMARTLAGOON |
| | | Minimise energy consumption | | Private companies | Sensors manufacturers companies | WATCHPLANT |

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# Dissemination and exploitation

## *I-Seed*

The consortium has presented the project at several international conferences and public events in the fields of robotics (e.g. the 2021 and 2022 IEEE International Conference on Soft Robotics "RoboSoft"; the 2021 International Workshop on Embodied Intelligence; the 2022 IEEE International Conference on Robotics and Automation "ICRA"), material science (e.g. the 2022 Material Research Society "MRS" Spring Meeting), and environmental science (e.g. the 2022 World Biodiversity Forum). Training sessions for students and young researchers have been included in the 2021 International Winter School on Smart Materials for Soft Robotics; in the 2021 Lecture Series of AI of the KIT Center Information, Systems, Technologies; in the 2022 Soft Robotics Winter School and Symposium of the University of Delft, just to mention a few.
Particularly relevant during this year, was the contribution and sponsorship of I-Seed to the organization of the 2022 IEEE International Conference on Soft Robotics "RoboSoft" under the theme "Soft Robots for the Planet". Plenary talks, workshops, conference papers, posters sessions and Science Café events, discussed scientific and technological advancements for the development of soft robots with low environmental impact and the ability to safeguard the earth, improve healthcare, and increase the quality of life. Presentations and panel discussions demonstrated that scientists and engineers are more and more questioning themselves about the impact of technologies on the environment and, at the same time, how they may contribute to help with pollution, climate change and future well-being of our Planet. With the promotion of the I-Seed vision, the Robosoft 2022 Conference was an important demonstration of a growing interest in this theme.
Thus, during the first two years, I-Seed has participated in a series of Environmental Intelligence kick-off meetings and in a series of meetings organized by the European Innovation Council project managers around the topic of Environmental Intelligence.
Two special tracks on Environmental Intelligence have been organized at the ACM GoodIT conference in 2021 and 2022, to which I-Seed has contributed with a position paper and a talk.

## *RAMONES*

In the second year, the RAMONES consortium has been very active in various dissemination and exploitation actions, building upon the momentum of the first year of the project. RAMONES have (co-)organized special sessions in conferences, authored focused deliverables on dissemination, exploitation, outreach and public awareness, organized dedicated webinars and workshops, cooperated with relevant projects (such as NEANIAS and SANTORY) to highlight key environmental issues and exhibit the solutions offered by our novel and innovative technologies. RAMONES have invested significant time and effort to advance the concept of Environmental Intelligence via multiple channels to reach a large audience, both scientific and general, communicate key results of the first two years to relevant stakeholders and increase public and citizen awareness and participation to the main objectives of RAMONES.


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Among other things, RAMONES issues a newsletter twice a year, circulates press releases and updates continuously the RAMONES blog and social media with all actions of the consortium. The interested reader may refer to the website of the project for a full list of activities of RAMONES (https://www.ramones-project.eu/category/news).

### *ReSET*

Dissemination of ReSET activities and results is taking place throughout the project but will increase over time as more of our outputs and results become available. Dissemination between the FET projects has included on time delivery of D6.2 (led by KCL) and D6.3. D6.4 was changed from a summer school to a range of engagement events because of COVID challenges. ReSET Project exploitation planning has been delivered as D6.1 and D6.5 and has guided our dissemination, collaboration and exploitation strategy. We have developed the www.h2020reset.eu website to outline the aims, activities and progress of the project. The site contains a link to all our public outputs and details of what we are doing and where we are working. The outputs page is most used followed by where we are working and what we are doing. The website has, to date, attracted >1000 unique users from 92 cities in 19 countries, mostly in Europe. Our social media presence is largely on Twitter (@h2020ReSET). Though we have relatively few followers on this new account, members of our team have thousands of followers between us so engagement with some of our Twitter-based dissemination is significant. Top @h2020ReSET tweets range from 5900 impressions to 3600 for tweets focused on our FreeStation deployments to 1700 impressions for our Groundswell dissemination events with farmers to 1600 impressions for some of our EduStation focused work. Overall ReSET-related tweets earned an average of 7K impressions per month in 2021 and 8K impressions per month in 2022. ReSET has participated in two special tracks on Environmental Intelligence have been organised at the ACM GoodIT conference in 2021 and 2022, both of which have resulted in publications: (Mulligan et al., 2021) and (Douglas et al., 2022).

### *SMARTLAGOON*

Members of the SMARTLAGOON consortium have organised again this year the special track on Environmental Intelligence where SMARTLAGOON and the other projects from the environmental intelligence call are meeting and presenting the results of their projects in the framework of the ACM GoodIT conference. Furthermore, the progress of the project has been disseminated not only in high impact scientific journals (López-Ballesteros et al., 2023; Cecilia et al., 2023) but also in different media such as television, newspapers and radio.

### *WATCHPLANT*

WatchPlant currently focuses the efforts of public dissemination on the Internet (on the website of the research centre itself (ITE as coordinator and partners) and the WatchPlant project website) and social media, scientific publications have also been made (Hamann, et al., 2021), (García-Carmona, et al. 2021), (Kernbach, 2022), Kermbach et al., 2022) and (Griparic et al., 2022).


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Additionally, and in order to reach the general public, WatchPlant attends different events in regional companies' clusters, workshops, networking events, universities and national media and radio in the countries of the partners involved. It is a main goal of the Watchplant project to empower social citizens with new valuable information about the environment and provide society with new tools for environmental monitoring. Thus, the main goal of dissemination activities in the projects lead the road of awareness to the public of the new advances in monitoring advances applied for environment surveillance. To increase people's awareness of those new environmental intelligence advances, WatchPlant is using social media (LinkedIn: WatchPlant EU Project, Twitter: @WatchplantP, web: https://watchplantproject.eu).

Regarding exploitation, a distinction is made between the generation of new projects or articles in scientific journals thanks to the knowledge acquired during this project, and the licence of the potential patent that we hope to obtain with the results obtained for the sensor manufacturing industry.

# Overall Conclusions

Environmental intelligence is a challenging endeavour since it brings together a range of disciplines in very action- and product- focused research and development. This is especially so at times of supply-chain uncertainty and rapid technological development. The wide range of environmental intelligence projects funded by the H2020 FET call have several challenges in common, relating to hardware; software; networks; people, training and engagement and policy contexts. These have been addressed in different ways by the projects as best suits their specific objectives but with the same vision for environmental intelligence profit.

In this challenging context, the common trends are focused on the good use of resources whether it is energy, materials or data aligned with sustainability. Environmental Intelligence tools are pushing their efforts to look for more efficient energy systems by software developments, but also new technologies based on enzymatic biofuel cells adapted for plants, or passive mechanism for autonomous sensor using bio-inspired shapes together with biodegradable materials. Thus, the challenges bring together advanced remote sensing, sophisticated spatial modelling and low-cost, in-situ, IoT sensing to provide locally specific evidence for green investment.

On the other hand, in line with energy-saving it is to develop cost efficient methods to contribute to interesting solutions for the markets, society, to benefit the social good. In this sense, in the era of data where there is a lot of information available, it is essential to focus on obtaining the key information about environmental phenomena. In this context new tools to monitor key under-sampled parameters or combine existing data to obtain understandable and useful information is a must to provide comprehensive information from the data and a usable roadmap for the users. It is essential not only to obtain information about the process but correlate it with the environmental process to act in the proper way.

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This fact is also essential to contribute to cost-effective solutions since, the good use of available data impact in the good use of resources in the new topic of environmental Intelligence, which trigger the use of technology by nature itself so humans could benefit from this information to fight common challenges.

Additionally, the global climate change and all the effects it is causing, on our Planet and on the living beings that inhabit it, are becoming more noticeable. For this reason, it is necessary to have tools that allow us to carry out measurements in real time, so that they can support the most appropriate decision-making in the shortest time to stop the process and mitigate its effects. Thus, it is important to provide new tools for remote sensing considering possible issues in the field such as broken links, long-range data transmission, or interoperability. It constitutes a step forward in access to information providing users with new tools to be aware of the environment they inhabit, and control certain environments, especially in remote areas.

This document represents and update on the December 2021 A Blueprint for European Environmental Intelligence and will be further updated in December 2023.

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SMARTLAGOON

**End of Deliverable 7.6**

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