

1. Publishable summary



Automatic Oil spill Recognition and Geopositioning integrated in a Marine Monitoring Network

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The concept of the ARGOMARINE proposal is the monitoring of the marine traffic due to carriers and commercial ships through environmental sensitive sea areas. This monitoring will be realized by means of sophisticated electronic, geopositioning, and telematic tools connected through a high speed network along with data transmission through suitable data links. Data from different sources will be collected in an independent and remote fashion and sent to a main acquisition and elaboration central unit. Motivation and scope of the Argomarine project is the safe detection, notification and interventions on vessels in emergency situation and the protection of sea and insular environment, endangered by heavy and continuous activities, mainly due to intensive ship traffic, generating a consistent pollution risk. The envisaged goal is connected to the necessity of precise and punctual pollution control in areas and shores which are, for instance, of particular naturalistic value, and/or are exposed to risk of accidental or even intentional contamination due to their vicinity to industrial or highly densely populated settlements, or crossed by a heavy ship traffic. All the data and the information obtained will be merged and elaborated in a Marine Information System (MIS), i.e. an information system where remote sensing data, field experiment results and estimates from simulation models will be integrated, and tools for data storage and retrieval, data manipulation and analysis, as well as for presentation, will be available through a common interface.

ARGOMARINE: a Project overview

Ship traffic through Mediterranean basin daily consists of 2,000 ferries, 1,500 freight ships and 2,000 commercial crafts, 300 of them are tankers (20% of the world amount of oil sea traffic), carrying more than 350M oil tons per year (8M barrel per day). The scope of the proposed ARGOMARINE Project is to develop and test an integrated system for monitoring of the marine traffic and pollution events due to carriers/commercial ships as well as recreational boats through environmental-sensitive sea areas.

This monitoring will be implemented by means of electronic, geopositioning, and tools for transmitting ship navigation data through a high speed communication network. Environmental data from different sensors (SAR, hyperspectral sensor, thermal sensors, electronic noses, acoustic sensors) on satellites, aircraft, vessels, in situ anchored buoys and AUVs will be collected in test areas, and sent by telemetric links to a central server where all the data are integrated by use of web mapping technology. Accident modelling and post-accident intervention simulation tools for impact prediction will be implemented and tested through field experiments. To monitor marine pollution, data from both satellite and airborne remote sensors and in situ sensors on vessels and buoys will be used to derive information about water quality and spread of hydrocarbons/oil slicks over large areas. Vessel and airborne support will be provided by Italian Coast Guard and Foresters Corps. Other data will come from electronic nose technology, which is being shown as effective to monitor oil/hydrocarbons leakage in marine water. The final sensor device will be scale-reduced and hosted on an autonomous buoy. An electronic control will supervise the performance and the activation of the sensor device.

At the same time, tracking of sea ship traffic will be accomplished by ARGOMARINE technology. The system will act as an intelligent transponder through either satellite platforms or ground-based stations. External data such as weather station data, weather operational models and large scale hydrodynamic and wave models will be gathered from the external providers. Local implementations of high resolution mathematical models will be developed for the study sites. The modelling system will include a 3D hydrodynamic model a wave model and an oil spill model. The modelling system will be run in pre-operational mode, downscaling the solutions of existing global/Mediterranean operational models.

All the data and the information obtained will be merged and elaborated in a Marine Information System (MIS), i.e. an information system where remote sensing data, field experiment results and estimates from simulation models can be integrated, and tools for data storage and retrieval, data manipulation and analysis, as well as for presentation, are available

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ARGOMARINE: the expected results and the breakdown

The work plan is organized in eleven scientific and technological Workpackages, including dissemination and exploitation and of the results, and project management, which outline the methodology and the evolution of the project considering both its functional and architectural aspects. The WP articulation will be the following:

- **WP1 (SAR imaging and analysis)** will be dedicated to imaging, and analysis by using SAR (Synthetic Aperture Radar). Long term SAR data will come from satellite-hosted platforms. Meanwhile, new methods will be implemented and tested for detection of oil spills and classification of surface phenomena in multipolarisation high-resolution SAR images.

Two study areas were defined: the Tuscan Archipelago National Park and the National Maritime Park of Zakynthos. An automatic image download from the ESA SAR rolling archive for both the demonstration areas has been set up. The computation of wind and currents has been set up for ASAR Wide Swath Mode (WSM) images downloaded from the ESA Rolling Archive from the two test areas in Italy and Greece. SUMO software was used as the main vessel detection tool in a semi-automatic mode, proved to be an efficient software tool for satellite imagery vessel detection. 696 vessels in total, have been detected in the area of the acquired imagery and 194 of them are contained in both of the target areas. The image analysis (both raw and processed) has been performed, from the SAR imaging subsystem towards the MIS Service Unit, and its interface.

WP2 (Hyperspectral-Thermal Analysis) will concern hyperspectral and thermal infrared image analysis, utilizing in-situ spectroradiometer measurements, airborne hyperspectral and thermal images as well as satellite images. Airborne sensors will be operated and hosted on mobile platforms (helicopter/airplane/vessel). Appropriate methodology and algorithms will be developed for oil spill type and thickness detection. Hyperspectral and thermal analysis will be supported by in-situ measurements. The methodology will be tested and evaluated through project test activities. Up to this point, two sets of laboratory experiments were implemented. Experiments include measurement of the spectral signature and temperature at various time points and thicknesses for different oil types. Moreover, algorithms for detecting oil spills in the seawater have been implemented. The installation of the CASI-550 (Compact Airborne Spectrographic Imager) sensor on flying means (helicopters) of the Italian National Corps of Foresters is under course in order to perform the first instrument test, whose goal is to understand compatibility between the CASI-550 instrument and AB412 helicopters to be used in some of the field campaigns.

WP3 (Electronic Nose) will be devoted to the application of Electronic Nose technology to the monitoring of oil/hydrocarbons spills in marine environment. E-nose technology will be adapted to this specific goal, and the sensor will be engineered to be remotely controlled, hosted both on an autonomous buoy and aboard of a AUV. A sensor head has been tested to a number of different types of oils distributed in sea water. Synthesis of these materials has begun to produce new types of sensors. The results indicated it was perfectly possible to discriminate between seawater and seawater plus oil. A quantity of polyterthiophene has been synthesized and 3 different types of semiconducting polymer sensors based on this monomer have been manufactured. At the same time, commercial micro-metal oxide sensors (MOS sensors) have been tested and compared against ST's conducting polymers in seawater/oil combinations. Then, silver nanoparticle-based sensors have been sought. Their responses to sump oil in water are much higher and the processed data separation is also greater, indicating these sensor types are good candidate for oil detection. The first design for the electronic control system has been produced and the first PCBs realized. A remote controlled floating test rig has been developed to aid water sampling and E-nose system development. This test rig (FATCAT) is a miniature catamaran approximately 1m square capable of carrying 10-15kg of test equipment within 50-75 meters off shore in calm waters for 1 hour.

Initial testing were performed during Summer 2010 on the Mediterranean Sea and successfully concluded.

WP4 (Underwater Monitoring Technologies) will be dedicated to the development of underwater monitoring technologies, which will be used for both preventive action to detect possible unauthorized access to a sensitive protected area (i.e., a marine park), and environmental monitoring and post-accident action to detect and localize oil spillage in a confined area by using AUVs. The proposed system for underwater passive acoustic monitoring developed consists of two identical bottom-moored platforms connected to shore via two electro-optical cables which provide DC power to the underwater units and high speed optical links to the shore equipment. Each platform hosts a 4 hydrophones broadband array in equilateral tetrahedral configuration. The bread-boarding and prototyping activity of all the critical units has been completed and the electrical/electronic drafts have been updated according to the test results. An overall investigation of the problem has been conducted from a theoretical point of view. After the definition and model of realistic at-sea scenarios, a study of the State of the Art (SoA) has brought to the quantification of expected ship-radiated noise levels, bandwidths and overall signature model of different classes of vessels (big, slow ships vs. small fast boats, in particular). Investigations on expected background noise level and statistical characteristics (power spectral density and probability density function) have been conducted. Under favorable geometry (relatively flat bottom) and environmental (seabed sediment, sea state and ambient

noise) conditions a big ship is expected to be detected up to 5-6 km of range and a small boat upto about 2 km. Acoustic noise was recorded during a sea trial conducted by NURC in September 2010 by a single hydrophone located close to the seabed in very shallow waters in the coastal area of the Isle of Pianosa, in the National Park of the Tuscan Archipelago, Italy. Tests on eFOLAGA AUV hybrid vehicle have been performed in order to define relevant characteristics of the vehicle respect to the e-nose sensor installation. A software has been developed to compute optimum sampling designs with AUVs and moorings to have the best environmental characterization in a region affected by an oil spill. Specifically, the software computes the trajectories of one or a fleet of vehicles to obtain the maximum information contain of the environment when the data is merged with observations from moorings.

In the **WP5 (Mathematical Modelling)** a mathematical modelling system will be setup and applied to the study sites. The system will be linked to external operational forecast data products already available for the Mediterranean Sea. Such a modelling will be strictly linked with MIS and its Decision Support System. In the first half of activity, a local system of nested 3D hydrodynamic models for the study sites was implemented. Additionally a review of the known oceanographic characteristics of the region was performed and the results obtained with the model were interpreted in the light of these characteristics. A wave model for the study site was implemented too. The development of a multi-mesh Lagrangian transport algorithm was realized and an oil transport model was implemented for the study site. Several hypothetical oil spills accidents were simulated using these scenarios, with the oil module being forced both by waves and hydrodynamics. Additionally an interface is being developed to operate the modelling system in operational mode.

Through the **WP6 (The ARGO-Geomatrix Platform and the integrated communication system)** the ARGO-Geomatrix platform will be developed. The purpose will be to set up and realize a telecommunication infrastructure able to: 1) guarantee efficient transport of general purpose information through means of propagation, 2) give full support to several communication devices, high level protocols, and 3) give full and accurate information about the position of each operator (either prepared specialists or casual user) in the End-User (PNAT and NMPZ partners) context (environment). The activity in this first 18 months was related to the definition of an environmental decision support within the specific marine areas along with possible scenarios for oil-spill detection. Data communication standards were analysed and described, to be used for real time surveillance of large marine areas and merged to the analysis on the communication and data protocols to be used by the different partners. Communication and data protocols used by the different partners were analysed and defined looking forward the MIS integration. The ARGO-Geomatrix tool has been developed i.e. a mathematical inferential model that should optimise all the monitoring instrumental and communication efforts united to the localization of the risks involving oil spill pollution events. Meanwhile, specific efforts were dedicated to the volunteer activity by providing tem with a "White Box" and a new C#-based smartphone applet to send georeferenced warning signal to the MIS. The internal and external communication system has been designed according to the data flow control model for the distributed computing devices and the marine areas selected for the case study. A survey on communication and data protocols used by each beneficiary has been carried out, and the collected data were analysed. Functional requirements of ICS and MIS interfacing have been tested in relation with the logistics of each study sites.

In **WP7 (The Marine Information System)** the implementation of an integrated Marine Information System (MIS) will be approached. Obtained heterogeneous information spatially and temporally distributed, will be merged and elaborated through an information system where remote sensing data, field experiment results, and estimates from simulation models can be integrated, and tools for data storage and retrieval, data manipulation and analysis, as well as for presentation, are available through a common interface. The activity carried out in this first phase has concerned with de design of the Marine Information System architecture: requirements and strategies have been studied to achieve to a seamless integration of all the subsystems included in the ARGOMARINE global system. Data models and standards have been investigated for defining communication and interfacing policies. All the requirements, analysis and preliminary tests on available tools and technologies have been put together and mapped onto the ARGOMARINE Project global requirements. Dedicated protocols have been modelled and agreed in order to ensure communication consistency and quality. All various existing GIS databases were examined. Solutions for retrieving, parsing, and storing data have been studied. First static data (coastal relief maps and marine depth) based on digital maps of the marine test areas have been retrieved, collected and elaborated. The MIS architecture regarding the Environmental Decision Support System has been defined and interfaces dedicated to the acquisition, management and interaction of the external data incoming to the MIS has been designed and modelled.

- In **WP8 (Test and Field Validation)**, test activity will be carried out. Both static and dynamic data will be collected. Tests of the various sensor platforms will be performed during the overall length of the ARGOMARINE Project. During the first phase of the project the test activity will be carried out in an independent fashion by each group involved, in order to evaluate their analytical characteristics, while, during 3rd year, a final test exercise will be carried out on the overall system, in real operational situations. Bathymetric, coastline and AIS data has been acquired for the target areas of Tuscany Archipelago and the National Maritime Park of Zakynthos and a preliminary analysis of the static geo-referenced data has been performed. Data will be collected in the field validation and, eventually, made available to the entire ARGOMARINE platform through MIS.

Dissemination and exploitation of project results will be faced in the **WP9 (Dissemination and Exploitation of Project Results)**: specific actions will be set up, along with a workshop and a media-broadcast campaign, in order to promote the achievements of ARGOMARINE. Multiple disseminating actions will be carried out at local, national and international level. Results of the project will be disseminated through different channels. The activity carried out in the first half of the project's life has produced about 10 press releases at local and national scale and about 60 press news have been produced. Contacts with broadcast networks were taken at both Regional and National (with special reference to Italy and Portugal) level; a video clip was prepared for the Italian RAI TV National Network and broadcasted. Regional/National networks have released 12 TV news spots, interviews and reports on ARGOMARINE. Radio Networks have interviewed project Partners two times. Moreover a video presentation describing the ARGOMARINE project has been realized with the collaboration of external professionals. Video production was concluded and broadcasted. The clip has been realized in both Italian and English. The length is about 3 min. An extended version of the video (20 min.) is in progress, to be delivered at the end of the project. A YouTube ARGOMARINE Channel has been activated, containing with all the video clips available and launched about the project. The project was also presented at several general events, Science Festivals, National exhibitions. A dissemination activity toward scientific community and connections with other EU-supported initiatives was also carried out by presenting the project at international Conferences and other events. A promotional web site (www.argomarine.eu) was setup for dissemination purposes. It has been designed to provide wide dissemination of the results, public deliverables, papers and information about the project,

- **Project Management** is described in the **WP10** and **WP11** and will aim at a cost-effective development of technical and scientific activities, preventing and overcoming critical situations from both technical, and financial/administrative points of view, and finally ensuring the respect of all obligations of the consortium regarding procedures and deadlines. Technical management of ARGOMARINE has been dealt with frequent informal contacts and official Steering Committee meetings, and a Quality Assurance Plan (QAP) was implemented for all the documents to be produced in the Project. A mailing list for internal communication was created among the partners of ARGOMARINE project, managed and updated regularly by the Coordinator.

The impact of the ARGOMARINE Project can be summarised as follows:

Strategic Impact: ARGOMARINE project, not only contribute towards the realization of this described vision, but does it according to the processes, recommendations and guidelines of the FP7 programme. The underlying motivation which eventually led to the proposed R&D work for realizing the ARGOMARINE vision is clearly reflected in the following futuristic environmental conservation scenarios:

- Fishery, both looking towards the safeguard of the fishery economy, and the fisher traffic in coastal and off-shore environmental sensitive areas, with fall-out on the pollution control.

- Tourism, is in the sense of safeguard of the economy by means of early warning alerts in events which may negatively influence the marketing perception of the tourist, as a consequence of pollution events

- Wildlife protection against pollution accidents

Technologies for the safeguard and for preventive analysis in protected areas: effects of the projects will be also on a higher quality remote environmental conservation, and resource savings by reducing costly in site surveillances, and late interventions. The ARGOMARINE platform integration will grant access to the system at any time from anywhere, and moreover it will extend the concept of in site surveillance to that of remote mobile surveillance, by allowing the monitoring of the surveillance area status even away of the operative central. The concept of ubiquitous computing is extended both in data acquisition and in data distribution.

Coordinating and operational activities for efficient crisis support management against marine pollution and post-accident monitoring: the environmental services provided by the ARGOMARINE project will provide a holistic solution for the early detection and management of disaster causing polluting events.

Integration of underwater robotics, advance sensing systems for sea protection, and water monitoring and management of heterogeneous information in a Decision Support System for marine environment safeguard and marine pollution prevention: the services provided by the ARGOMARINE platform environmental decision support and the knowledge base system will be able to process the available information and to provide useful information to the personnel responsible for the intervention about the status of their polluting accident and risks and the evolution of the events.

Advanced sensing and bio-chemical systems for water monitoring, protection of biodiversity and for combating marine pollution: the pollutants revealed are mainly oils and chemicals, but in the future the system permits the integration of any type of sensors for any types of parameters, giving the possibility to integrate any new methods and technologies.

Methodologies, models and simulations tools for prompt assistance, organization and interventions in marine protected areas and liaisons with international operators for marine and submarine interventions: the ARGOMARINE project aims to help in the strengthening of the EU leadership in the Environmental Conservation Systems' industry.