Co-financed by the EU
DG-ECHO

URready40S
UNDERWATER ROBOTICS READY FOR OIL SPILLS

Outline

The project

Preparedness is the key to success to prevent detrimental consequences of oil spill, one of the strongest impacts of anthropogenic actions in the marine ecosystem, with costly economical, environmental and social consequences.

The project “Autonomous Underwater Vehicles Ready for Oil Spill (URready4OS)” was co-financed by the European Commission's Humanitarian Aid and Civil Protection Directorate General (DG-ECHO), which funds actions aimed at improving cross border civil protection and marine pollution cooperation, including regional cooperation, regarding preparedness for, direct response to and consequences reduction of natural and man-made disasters, including the consequences of chemical, biological, radiological and nuclear (CBRN) events under the Agreement ECHO/SUB/2013/661056.

Goals

The main goal of the project is to join forces to make available to European Civil Protection a fleet of autonomous underwater vehicles (AUVs), unmanned aerial vehicles (UAVs) and unmanned surface vehicles (USVs) with operational capability to intervene against oil spills in European Seas using new cooperative multivehicle robotic technologies.

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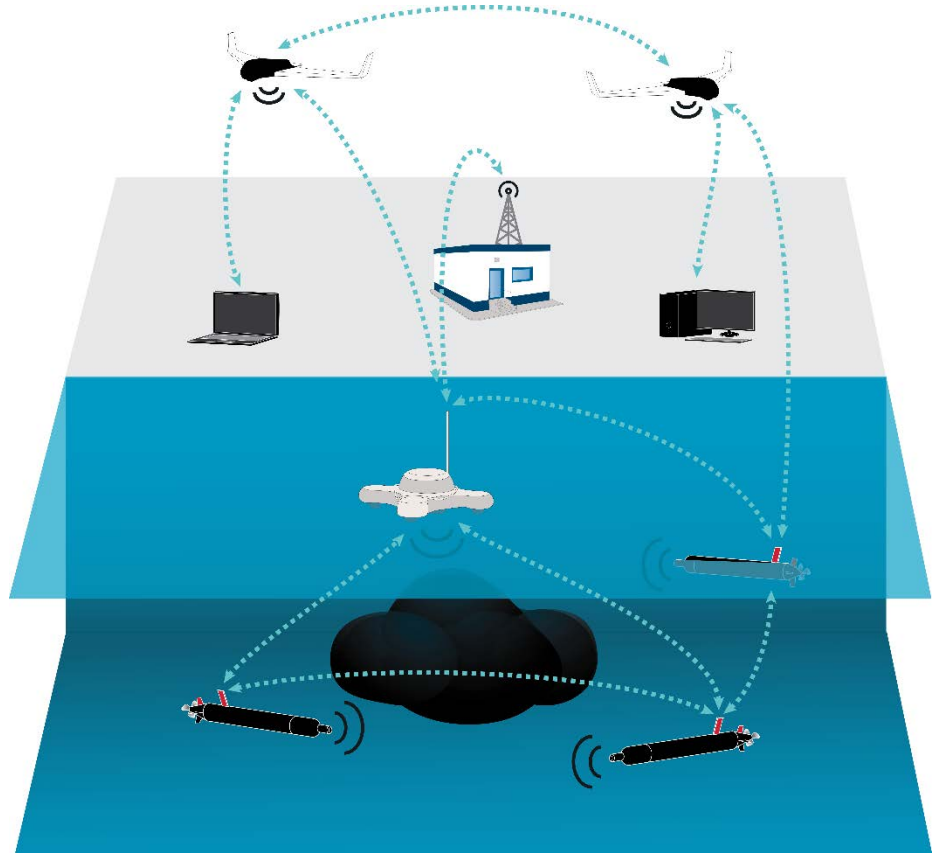
Concept

Surface oil is not the only effect of an oil spill. Underwater oil plumes can come from bottom leaks and from surface patches forming subsurface plumes. Recently brought into the public eye during the 2010 Deepwater Horizon accident, a horizontal plume of 35 Km long, 2 Km wide and 200 m thick at 1000 m depth was reported.



The multivehicle approach allows the use of relatively low-cost standard acoustic communications and oil in-water sensors, with novel advanced algorithms to get the most out these devices. The distributed intelligence of the networked devices across the spill is able to reveal a highly accurate and dynamic image of the spill. Ultimately, this cooperative multivehicle robotic technology allows a cheap, flexible, expandable, precise and rapid decision support system against oil spills.

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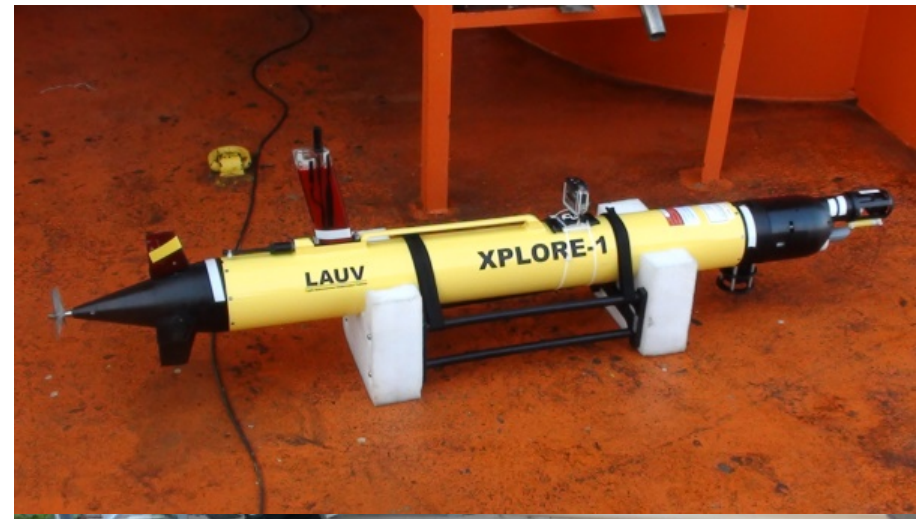
Fleet

Underwater vehicles (AUV)

Two kinds of AUVs were used during this project to measure oil in-water: The LAUV and the IVER2.

The Light Autonomous Underwater Vehicle (LAUV) is manufactured by OceanScan MST, targeted at innovative standalone or networked operations for cost-effective oceanographic, hydrographic and security and surveillance surveys. Based on a modular design, the platform is built to be robust and reliable.

The IVER2 AUV is a small man-portable AUV manufactured by Ocean Server Technology, Inc. With a proven track record over thousands of missions, it is ideal for imaging and environmental surveys, including research, development, and OEM based applications. The IVER2 design allows for the integration of new sensors and capabilities.



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Fleet Surface vehicle (USV)

The PlaDyPos is an autonomous surface vehicle that moves at water surface to work as a communication gateway with the underwater vehicles. This capability enables direct supervision with the underwater vehicle in mission critical scenarios.

This vehicle, developed and manufactured by the Laboratory for Underwater Systems and Technologies (LABUST) - University of Zagreb - equipped with an underwater modem and a differential GPS, can follow the AUVs underwater and retrieve their recorded data via acoustic modem.

Aerial vehicle (UAV)

The UAVs allow communication between the USV and/or surfaced AUVs with the central station (ground- or ship-based) at distances longer than 1 km.

In this project the X8 UAV, a low-cost Components Off-The-Shelf (COTS) vehicle, adapted at the Laboratório de Sistemas e Tecnologia Subaquática LSTS (University of Porto) was used. It can also be quickly launched for low altitude reconnaissance scenarios with live HD video feed.

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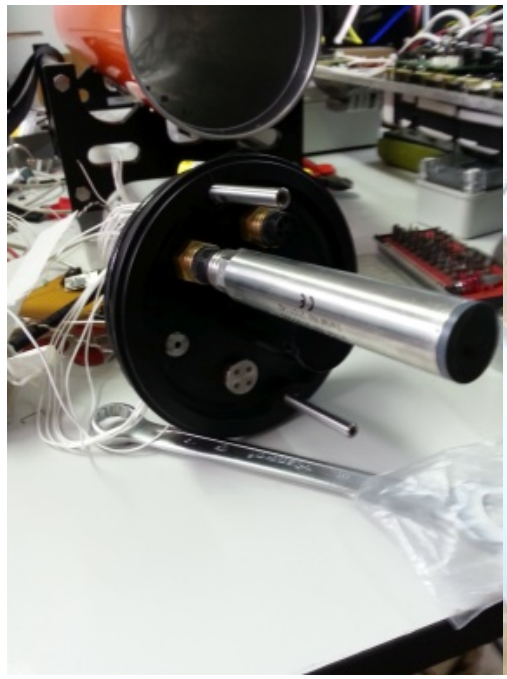
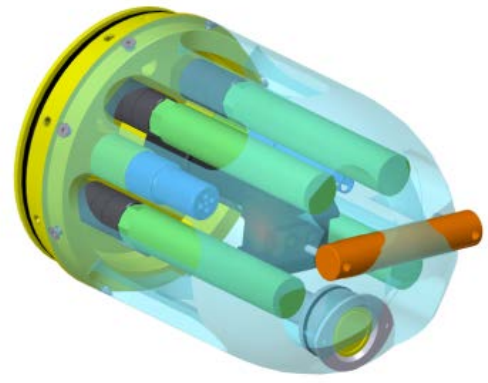
Measuring oil in-water

Oil in water, either crude or refined, can be measured by fluorescence techniques. Illuminating the water at a wavelength, an oil component fluoresces (at another wavelength), and this signal is sensed by the probe.

Probes Integration

Different underwater vehicles and oil sensors were integrated in the vehicles. Probes are able to detect also Rhodamine WT, a fluorescent, innocuous and non-toxic red dye widely used for research performing experiments in water.





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NEPTUS: Open Source Command and Control Software

The operators at the ground or ship station continuously receive the position from each vehicle - aerial, surface and underwater - and the AUV oil sensor data. Each vehicle uses different communication protocols that are integrated in the command and control software NEPTUS, developed at LSTS (University of Porto) (http://lsts.pt/toolchain/neptus).

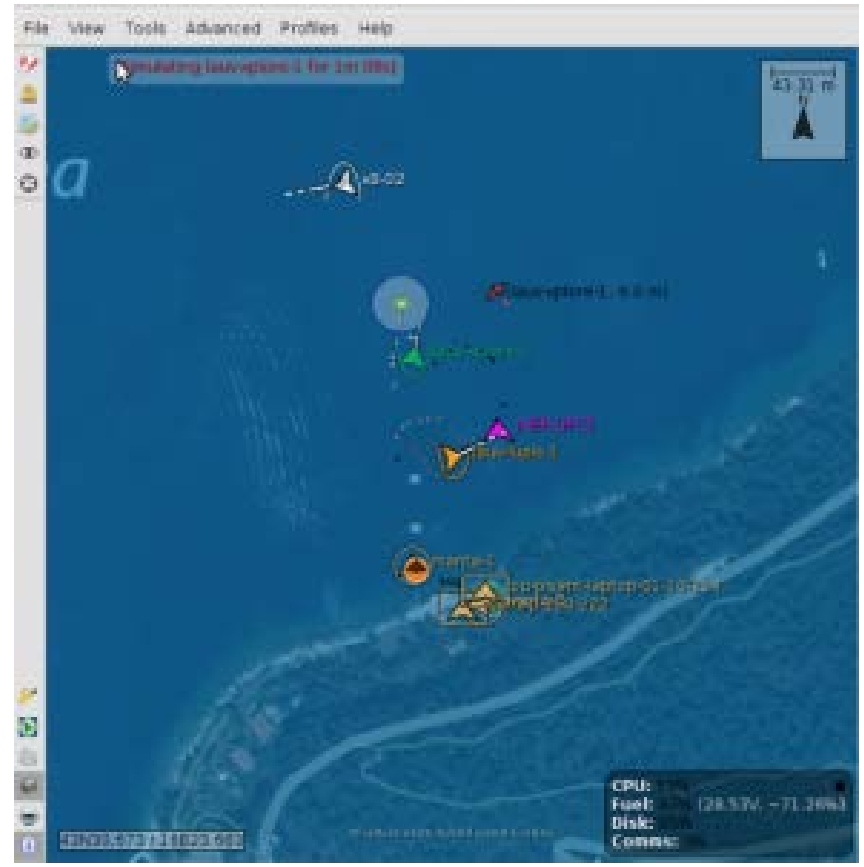
This open source software has, among many others, the following capabilities :

- Planning and missions execution. Within this project the software was upgraded to plan missions for both the LAUV and IVER AUVs.

- Shows the positions of all the vehicles during the operations on the screen.

- Receives and shows the recorded subsurface data in near real-time, either for underwater or surfaced AUVs.

- Shows the oil-tracking model outputs on the screen to help re-plan the vehicles' missions.



neptus

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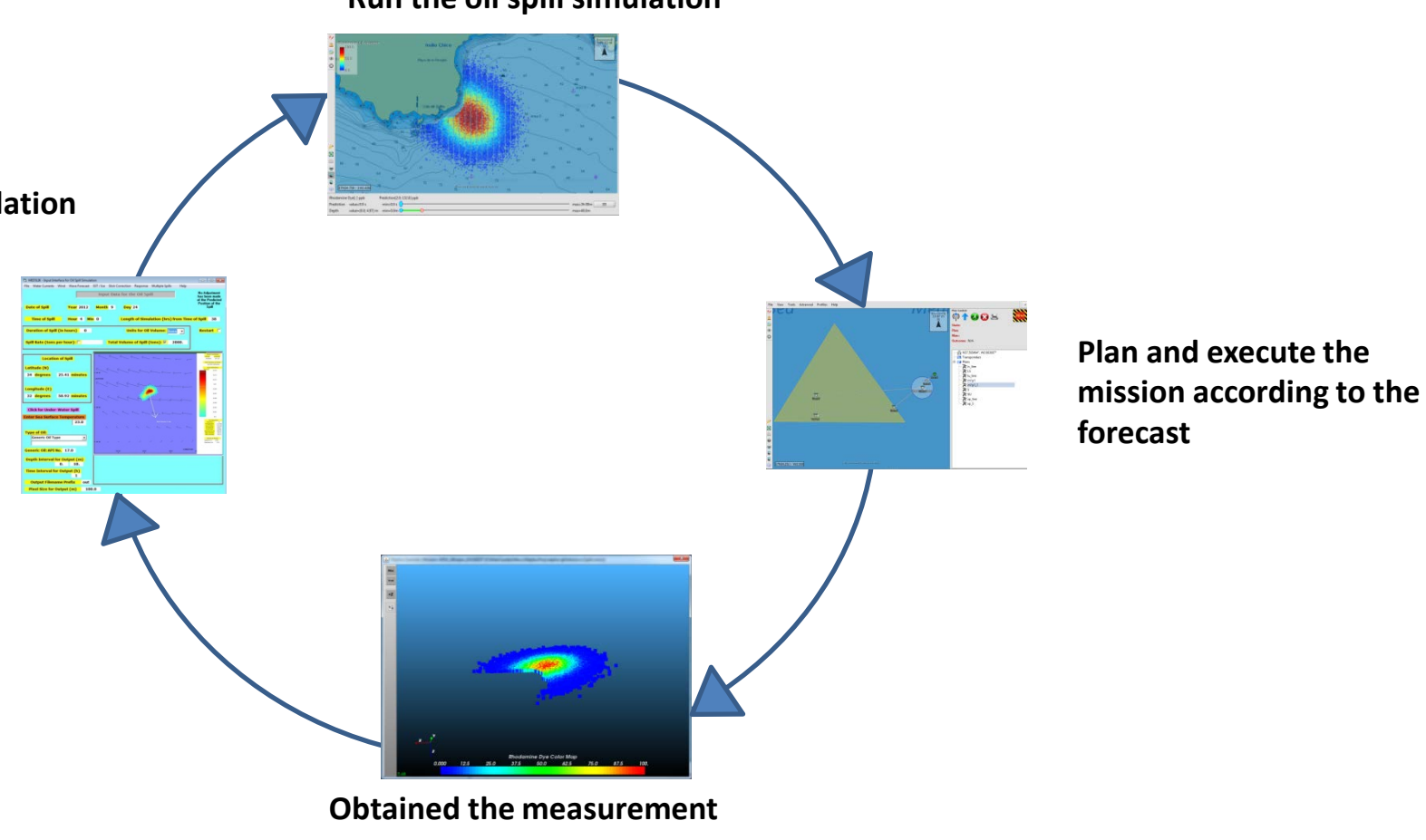
MEDSLIK: Open Source Oil-tracking Model

MEDSLIK is an oil spill and trajectory 3D model that predicts the transport, fate and weathering of oil spills and the movement of floating objects in the Sea. It is currently used in the Mediterranean, the Black and the Baltic seas (http://medslikii.bo.ingv.it/).

The first vehicles' mission design is based on MEDSLIK's forecasted trajectories. The data collected by the AUVs are then assimilated by MEDSLIK again to produce a new forecast. This feedback loop between model and vehicles allows for a better prediction of the spill trajectory underwater to fine tune the spill extent.



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OPERATIONS:

Two experiments were performed during this project, the first as a preliminary operation exercise to test oil in-water probes integration and communications, the second as a demonstrative experiment to prove the concept and capabilities under a simulated oil spill.

PRELIMINARY EXPERIMENT

Where	Split, Croatia
When	September 22nd to October 1st, 2014
Goals	- Test probes integration. - Test vehicles' communication. - Test capabilities of the command and control software NEPTUS. - Deploy several vehicles at a time using Rhodamine WT simulating a spill.
Achievements	- Detect a plume of Rhodamine WT simulating an oil spill under the water. - Receive data in near real time while the vehicles were underwater. -Synchronize all the vehicles with the onboard computer. -Draw the obtained data in NEPTUS knowing the position of each vehicle.

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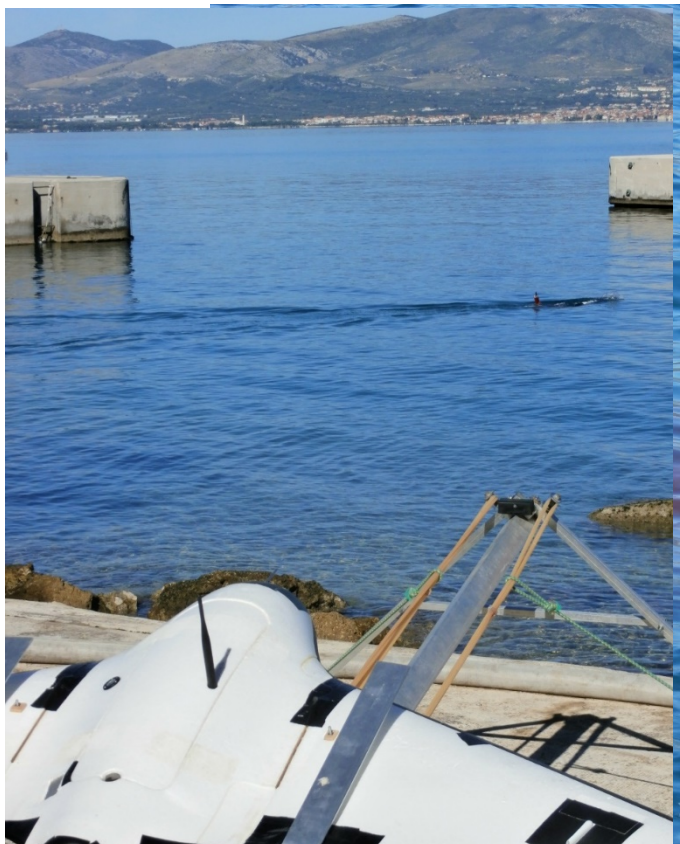

OPERATIONS: PRELIMINARY EXPERIMENT

The biggest challenge goal during the first experiment was to test successfully all the communication path, allowing the data exchange among systems involved and the full integration on the command and control software NEPTUS.

Two types of communication were applied: one to transmit data files from the AUV/USV to the UAV and the UAV to the base station by a secure Wi-Fi connection; and another one to exchange the vehicles' (AUV/USV/UAV) control commands and position with the base station. Two types of protocols (integrated in NEPTUS) were used for the last one: NMEA 0183 (*National Marine Electronics Association*) used to communicate with the IVER2 and IMC (Inter-Module Communication Protocol) for the others. Communication interfaces include Wi-Fi, acoustic modems, satellite and GPS/GPRS.

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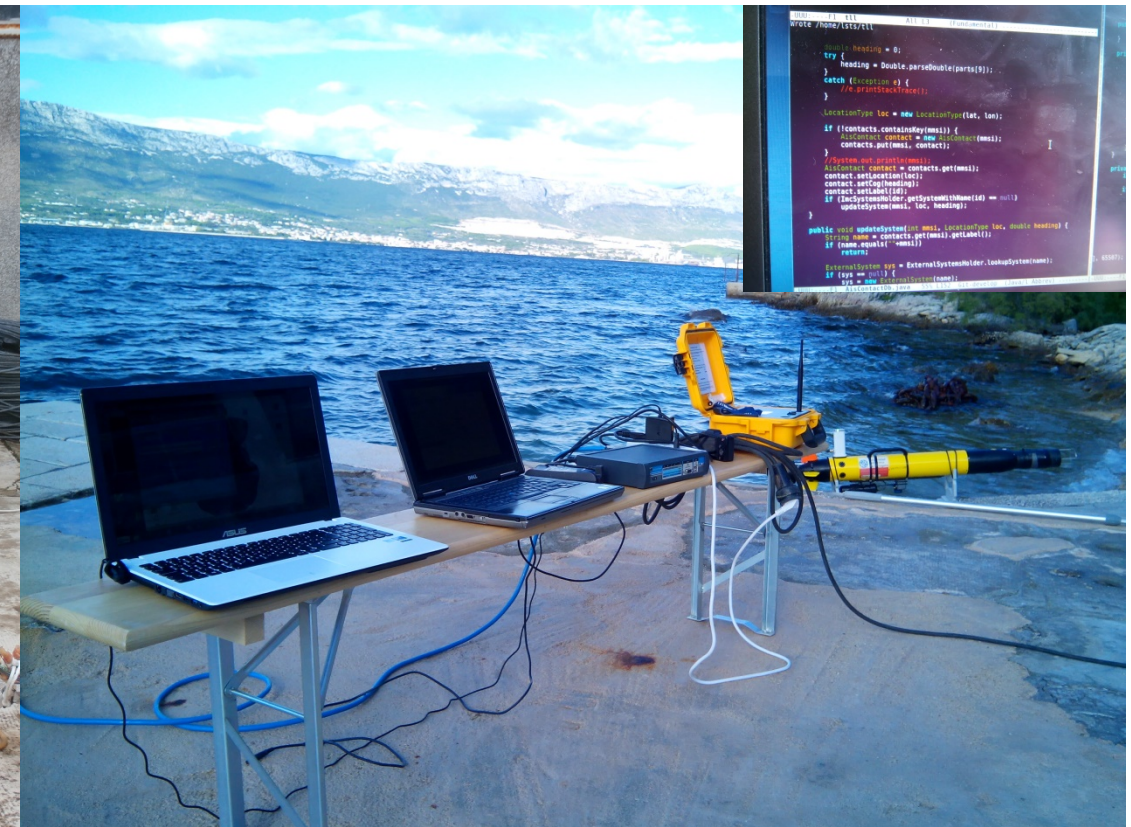

OPERATIONS:

DEMONSTRATIVE EXPERIMENT

Where	On Board of the Spanish Maritime Safety Agency sea tug “Clara Campoamor” in waters off Cartagena, Spain.
When	22nd to 26th of June 2015
Goals	- Coordinate and plan missions in a near-real time scenario using Rhodamine WT to simulate an underwater oil spill. - Show the capabilities acquired to international experts from authorities, industry, business and government sector.
Achievements	The project’s fleet of vehicles demonstrated the ability to locate a spill, determine its size, and predict its movement.

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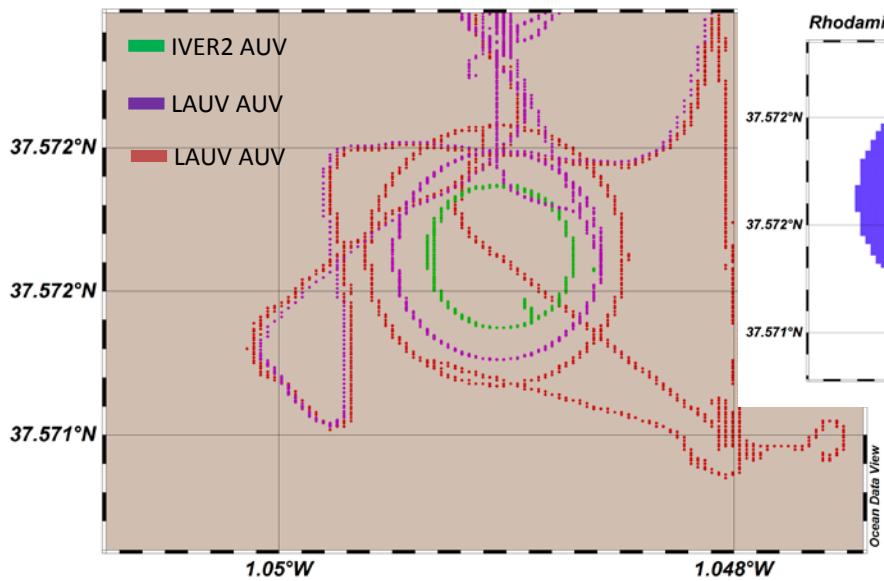
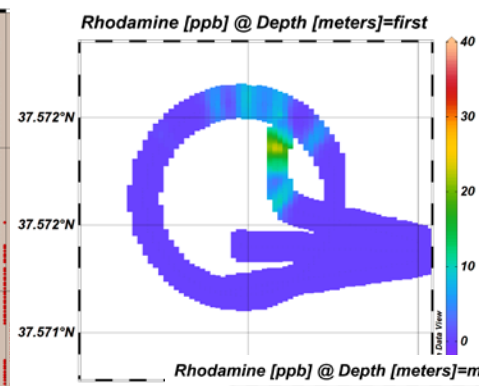
OPERATIONS: DEMONSTRATIVE EXPERIMENT

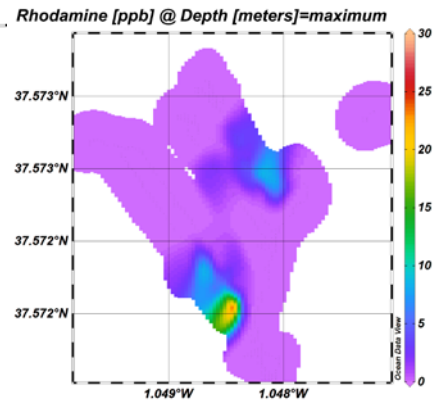
During the experiment, two oil spill simulations with Rhodamine WT were successfully performed. The fleet of vehicles (aerial, surface and underwater), the command and control software NEPTUS and oil tracking model MEDSLIK were successfully operated synchronously to detect and monitor the simulated oil plumes.

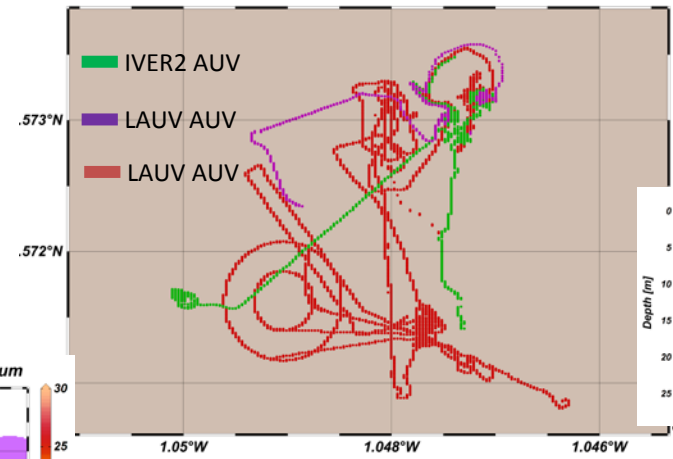
Firstly, a scenario was made to identify the direction of a spill originating from a known point. The AUVs were programmed to perform circles simultaneously at different depths around the given coordinates. With this kind of mission the AUVs detected the propagation direction of the spill.

Secondly, once the direction of the spill was identified, the vehicles were instructed to cross the plume perpendicularly following straight lines at different depths. By doing so, the extent of the plume was monitored.

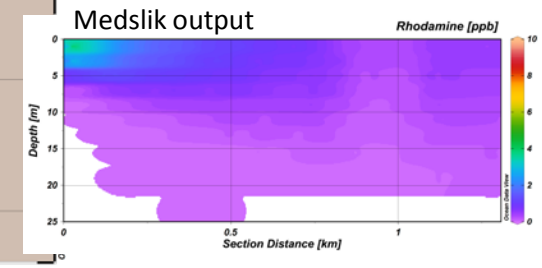


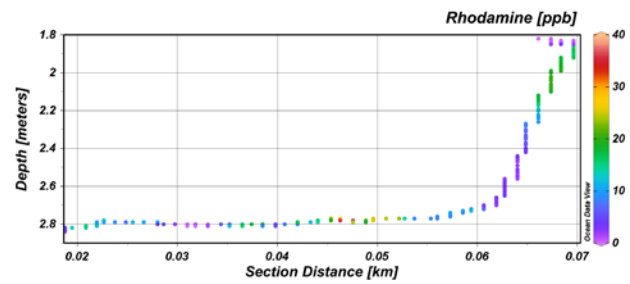


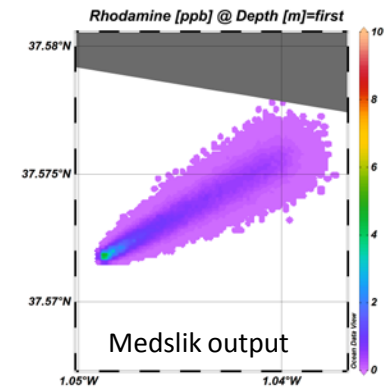




Medslik output







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Protocols, guide and experiences to operate the fleet

The description of the whole system, including hardware and software, with the operation's protocols are compiled in a white paper. It shows the advantages and limitations of this emergent technology, with case studies and concept of operations. The goal of this publication is to provide operators and decision makers with a comprehensive guide to consider how the fleet of cooperative vehicles operates and the conditions under which autonomous vehicles can be a tool to better fight against oil spills.

The URready4OS white paper contains a short review of the main available tools currently used in the prevention of the harmful consequences of the oil spill followed by a discussion of the advantages and disadvantages using multivehicle robotic operations. The description of the system elements with the pre-requisites for operation are included. The protocols of communication between agents are also described together with the NEPTUS command and control and MEDSLIK tracking oil model. Finally, several theoretical case studies and the results obtained during the project's experiments are provided. The publication is accessible at http://www.upct.es/urready4os/?page_id=964.

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Achievements

The project's concept has been successfully proven with the performed experiments. The system expands the currently existing capabilities to detect and monitor in-water oil by using a fleet of autonomous robotic vehicles.

Future

We are currently working to increase the capabilities of the fleet by:

- Contacting new entities that own vehicles to increase the number of assets.
- Performing new field exercises that allow the fleet to be ready for an eventual oil spill.
- To transfer the acquired knowledge to Maritime Safety Agencies.

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Communication

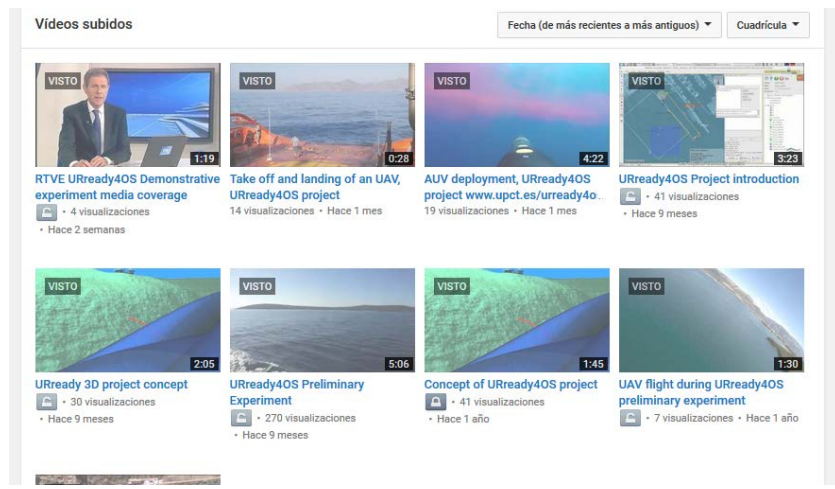
The project's website keeps visitors updated with partnership description, means involved, events (experiments and conferences, media appearances, activities and videos). Downloadable material produced is available on the website.

One brochure and three bulletins, also downloadable, were produced and printed to show the project's evolution in technical meetings and conferences.

Social networking has been performed also through Twitter, giving all those interested another way to be updated on the project.

http://www.upct.es/urready4os

The project has raised high expectations as shown in the media coverage, with appearances on Radio, TV, printed and online sources as well as invitations to exhibit the project in international conferences - such as the 5th European Civil Protection Forum 2015 (Brussels), InterSpill 2015 (Amsterdam), or pt-PROTECMA (Madrid) 2015. Activities and goals of the project have been published as videos on the webpage and the YouTube project channel. More than 680 video plays were requested by the time the project ended.



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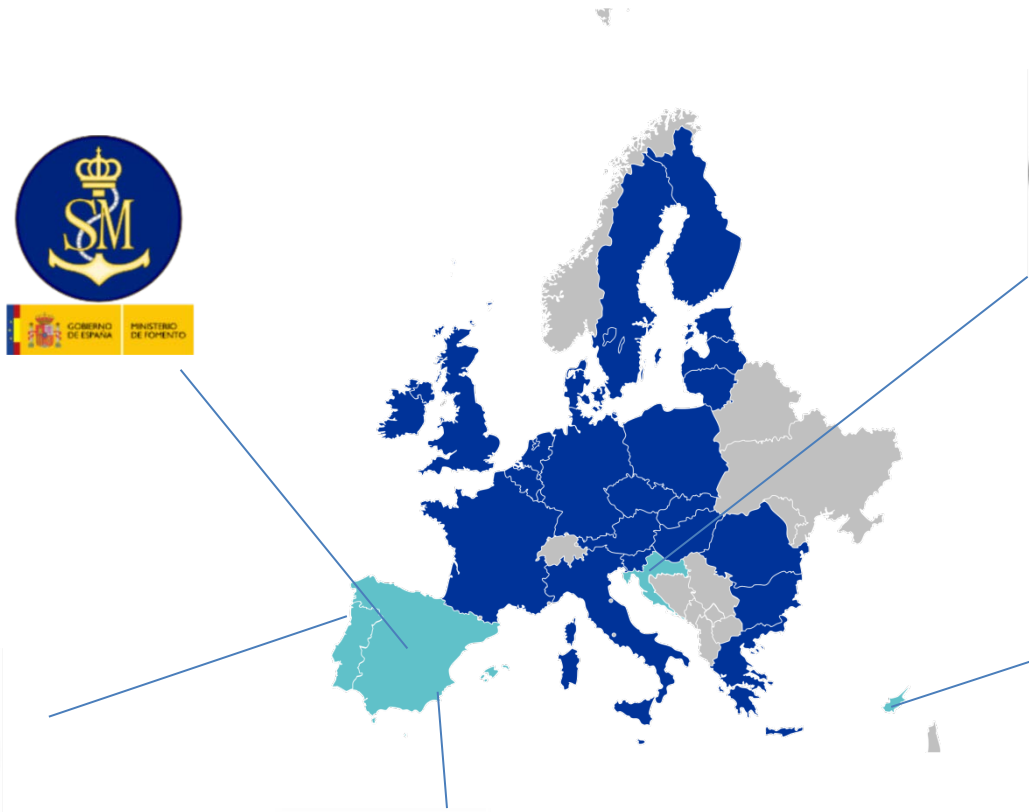
Partnership

Directorate-General Humanitarian Aid and Civil Protection – ECHO/A5
2013 CALL FOR PROPOSAL PREVENTION AND PREPAREDNESS

Start: January/2014
Duration: 24 months

Co-financed by the EU

Spanish Maritime Safety Agency (SPAIN)



University of Zagreb (CROATIA)

Universidade do Porto (PORTUGAL)

Oceanography Center University of Cyprus (CYPRUS)

Universidad Politécnica de Cartagena (SPAIN)

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http://www.upct.es/urready4os Coordination contact: Javier Gilabert javier.gilabert@upct.es +34968325669

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Directorate-General Humanitarian Aid and Civil Protection – ECHO/A5

2013 CALL FOR PROPOSAL PREVENTION AND PREPAREDNESS

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