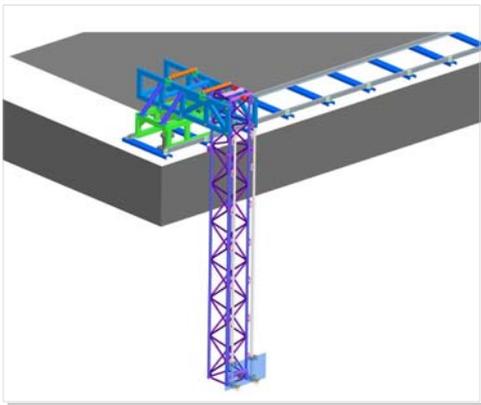


## NURC “On Track” for New Test Facility

NURC’s new rail-based test facility for sonar equipment is nearing completion and is expected to undergo its acceptance tests this summer. This facility, called the Linear Motion System, includes a rail line that runs along the waterfront at NURC’s La Spezia facility. On the rail line is a carriage with an arm that extends into the water. Attached to the end of the arm is sonar equipment or other equipment that requires testing. This type of test facility will let scientists test sonar systems and other types of oceanographic equipment in an at-sea environment that is highly controllable and known.

For example, detailed data can be gathered about specific underwater objects, such as mine shapes, which can improve our ability to find and classify them.



*This design plan shows the Linear Motion System, a new rail-based test facility at the Centre.*

The carriage is constructed of aluminium, making it lightweight and durable. An additional feature of the system is that it can be disassembled and removed when not in use.



*The carriage and side-arm under construction. This photo shows the underside of the carriage (upper left) and the side-arm that will extend into the water (bottom right).*

## SAUC-E Competition Returns

Ten teams from the UK, France, Germany and Spain will converge at the Centre from 4–10 July to compete for this year’s Student Autonomous Underwater Vehicle Challenge—

Europe (SAUC-E). Each team has designed and built an AUV that they will use to complete a mission in a realistic environment at NURC’s salt water harbour. SAUC-E



*Participant from SAUC-E 2010 launching the team’s AUV in NURC’s harbour.*

encourages students to think about underwater technology and related applications while fostering innovation and technology. It also encourages young engineers and scientists to consider careers in the field.

SAUC-E 2011 is the second consecutive competition hosted by NURC, who will host SAUC-E again in 2012. According to NURC’s Director, “We want to be involved in providing students with the opportunity to experience firsthand the challenges of underwater technologies, and to nurture interest in this area of research”. For more information, see [www.sauc-europe.org](http://www.sauc-europe.org).

### SAUC-E 2011 Teams

- University of Girona (2010 Champions)
- Heriot-Watt University (2010 2nd Place)
- ENSTA Bretagne (2010 3rd Place)
- DFKI Bremen
- University of Southampton/University of Birmingham
- University of West England
- University of Luebeck
- Cambridge University
- ESIEA, Paris – Aquatis Team
- ESIEA, Paris – Ryujin

## Working Toward an End-to-End Mine Countermeasures System: ARISE'11

Current mine countermeasures (MCM) operations are usually characterized by the three distinct phases: search-classify-map, reacquire-identify, and neutralize. Although autonomous systems are starting to be used in the first two phases, a large human operator component remains, and neutralization, or disposal, operations are especially dependent on the supervision of human operators. The extension of machine intelligence (autonomy) technologies into mine countermeasures operations has the potential to significantly shorten the tactical timeline for these operations, as well as remove personnel from the minefield. Of critical importance to the effectiveness of autonomous systems for mine countermeasures missions is the ability to classify objects of interest and to localize the objects so that they can be avoided or dealt with in a neutralization phase. These abilities become more important for concepts where multiple, specialized systems operate in teams and where information from one system must be passed to another for a follow-on phase of the operation.



*MUSCLE AUV in transit to start of mission.*

The NURC project *An Autonomous Naval MCM System* aims at investigating novel autonomous approaches to mine countermeasures, in other words an end-to-end system including mine search and disposal that will significantly lower danger to navy personnel. To investigate these novel approaches, NURC is using readily available equipment and is collaborating with relevant research teams from the NATO nations.

The main scientific NURC trial for autonomous mine search in 2011 was conducted from 3 May through 1 June off the coast of Liguria and was called the Autonomous Reactive Intelligence Sea Experiment 2011 (ARISE'11). The primary objective of the trial was to significantly move forward with machine intelligence development using the MUSCLE autonomous underwater vehicle (AUV) equipped with an interferometric synthetic aperture sonar (InSAS).

During the trial, machine intelligence was demonstrated by the completion of several missions over an artificial minefield. The basis for true autonomy has now been established, and NURC will continue to implement more advanced machine intelligence methods based on *in situ* information of environment and contacts detected.

The trial was also used to demonstrate off-line automatic target recognition (ATR) methods, implemented by NURC scientists and foreseen to be ported to the AUV to further enhance machine intelligence. The ATR was demonstrated successfully and results were shared with the Italian Navy as part of the NATO exercise ITMINEX, which NURC participated in. NURC further contributed to the NATO exercise with a Percentage Clearance trial evaluation (MCM performance evaluation) and AUV surveys with both the MUSCLE and Remus. It was shown that, owing to improved battery technology, MUSCLE reliably covered an area of almost 10 km<sup>2</sup> a day, after which contact information was automatically generated during the night and made available the next day.

In addition to capturing sonar images of a large number of mine shapes and man-made objects, sonar images of two shipwrecks in the sea-trial area were captured. This resulted in photo-like SAS images and also provided valuable data for further developments of automated interferometry used to produce 3D sonar images.



*A sonar image captured using the MUSCLE AUV of the shipwreck Vittoria, a tugboat that sank in 1944. Interferometric SAS data from four perpendicular directions were collected for this image.*

## ARGOMARINE Phase I Complete

The first phase of the European project ARGOMARINE (Automatic Oil Spill Recognition and Geopositioning integrated in a Marine Monitoring Network) came to an end on 6 May at NURC in La Spezia, with the successful completion of the first at-sea test. ARGOMARINE is a 3-year project intended to develop new technologies capable of constantly monitoring our seas and giving a real-time alert for oil spills. This project is funded by the European Union's 7th Framework Programme for Research and Technology Development.

As part of the project's Mid-Term Steering Committee meeting, scientists from the nine project partners conducted a joint experiment of the instruments developed to date. The instruments tested included hearing sensors and autonomous vehicles. These instruments will act in synergy with satellites, radar stations and sophisticated computer systems.

In the next phase of the project, the system will be enhanced with new sensors that are able to "sniff" and catalogue emissions coming from an oil spill. These sensors will be installed on floats and autonomous underwater vehicles.

## NURC hosts CIESM

On 12 April, NURC hosted members of the Mediterranean Science Commission (CIESM). The meeting was chaired by Dr. Frederick Briand, CIESM Director General and welcome remarks came from by Dr. Dirk Tielbuerger, Director of NURC.

Participants included experts from Institut Pasteur de Tunisia; Ministère de l'Enseignement Supérieur et de la Recherche (France); Romanimata SCRL (Italy); Stazione Zoologica Anton Dohrn (Italy), IEEP (U.S.), University of Oxford (UK), and CNRS (France).



## NURC Presents at Recent Conferences

NURC scientists and engineers presented seven papers at the IEEE Oceans Conference in Santander, Spain, 6-9 June. At this conference, Dr. Edoardo Bovio (NURC) gave the keynote speech "Autonomous Persistent Surveillance of the Ocean for Civilian and Military Applications." Another 14 papers were presented by NURC staff at the 4th Underwater Acoustic Measurements conference that was held at the island of Kos, Greece, 20-24 June.

## Real Deal Workshop

NURC hosted the Real Deal experiment team for an analyst workshop, 7-8 April. The goal of the workshop was to help experiment participants finalize the contents of Real Deal reports. The Real Deal experiment, conducted last October, tested optical and acoustic warning technologies. NURC contributed with its expertise in acoustic and laser devices, which was developed during several port and harbour protection trials. The experiment was a result of a NATO panel on "Capability Based Evaluation of Non-Lethal Weapons".

## Optical Processes Symposium

An Optical Processes Symposium (OPS) Workshop was held at NURC from March 29–31. The OPS Workshop was funded by ONR-Global (London, UK) and attended by both European and North American optical oceanographers, including 10 invited participants and 8 NURC scientists. The focus was on inverse and forward radiative transfer optical modelling and the deconvolution of optical signals into individual components. The coupling of optics and ecosystem-physical modelling is a 2012 customer-funded project.

## Reaching Out to the Local Community

NURC continues to be involved in local scientific activities for the public. In addition to participating in "Sea Future", the International Naval and Maritime Innovations Exhibition held in La Spezia on 13-15 October 2010, the Centre recently took part in *Un Mare di Scienza* ("A Sea of Science"), which offered lessons to students about marine science. In March, two classes from local schools attended lessons given by Dr. Walter Zimmer, scientist at NURC.

Furthermore, NURC participated in the *Festa della Marinaria* ("Marine Festival"), which was held in La Spezia, 16-19 June. The Centre was involved in the exhibition *Un Mare di Tecnologia* ("A Sea of Technology") and in two workshops.

## MED 2011 Papers Focus on Unmanned Vehicle Robotics

NURC presented two papers at the 19th Mediterranean Conference on Control and Automation (MED 2011), 20-23 June in Corfu, Greece.

*Modular USV and Payload Design for Advanced Capabilities in Marine Security Applications.* Caccia, M., Bibuli, M., Bruzzone, G., Djapic, V., Fioravanti, S., Grati, A.

*Sonar Aided Navigation and Control of Small UUVs.* Nad, Đ., Miškovic, N., Djapic, V., Vukic, Z.

The papers were presented in a special, invited session called Marine Systems - Results of the "Breaking the Surface 2010" Field Workshop. The workshop took place in Murter, Croatia.

### **Modular USV and Payload Design for Advanced Capabilities in Marine Security Applications**

This paper describes the collaborative effort between NURC and Italy's National Research Council-Institute of Intelligent Systems for Automation (CNR-ISSIA) to increase the functional autonomy of Unmanned Surface Vehicles (USVs). The assets used for this demonstration were CNR-ISSIA's catamaran-type USV, known as Charlie, with its autonomy software and NURC's payload module consisting of a sonar, pan-tilt unit, and the control software for both. The goal was to interface the two separate autonomy modules in order to manoeuvre the USV relative to a target of interest (in this demonstration a bottom target). Charlie's mission is to carry the payload while performing various behaviours to survey an area of interest. Whenever an interesting potential target is seen in the view of the forward-looking sonar, the payload software takes over control from Charlie's main vehicle computer, interrupts its pre-programmed behaviour, and sends the necessary messages so the USV adapts its track based on the target location.

### **Sonar Aided Navigation and Control of Small UUVs**

This paper addresses the problem of guiding a simple unmanned underwater vehicle (UUV) from a more capable, sonar-equipped platform, preferably an autonomous underwater or surface vessel (AxV). One application of this concept, considered in this article, is autonomous mine neutralization and disposal.

First, a sonar-equipped AxV acquires a possible target in the sonar image. Once the target location is known, an expendable UUV is released. The UUV position is determined from sonar imagery onboard the AxV. This minimal information is sent to the UUV via acoustic link so that it can converge towards the desired target. With this

approach, complex and expensive sensors are removed from the expendable vehicle, which now becomes a simple actuation system that carries the neutralization payload to detonate the target.

The paper advocates the potential of using collaborative autonomous vehicles in mine countermeasure scenarios. In the envisioned concept of operations, an autonomous surface vessel reacquires a target that looks like a mine using its imaging sonar. Then, an autonomous surface vessel guides a low-cost neutralization UUV carrying a payload to neutralize the target. Collaboration between the highly capable autonomous surface vessel and the less capable, low-cost mine neutralization UUV is viewed as an interesting research subject in the field of mine reacquisition and neutralization since it can potentially reduce the overall MCM mission timeline, keep personnel out of harm's way, and significantly lower the cost of mine countermeasures.



*An ASV carries a sonar-guided, expendable mine neutralization UUV.*

Although this research is in the domain of mine countermeasures, it is applicable to other problems where aided navigation between platforms is beneficial.

### **NURC**

#### **A NATO Research Centre**

Viale S. Bartolomeo 400  
19126 La Spezia, Italy  
Phone: +39 0187 527 1  
Fax: +39 0187 527 700  
E-mail: pao@nurc.nato.int

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