NURC

PARTNERING FOR MARITIME INNOVATION

NATO OTAN

2010 Research and Technology Highlights

July 2011

Contents

Message from the Director

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The Research and Technology Highlights 2010 provides an overview of special events and outcomes of the last year. More importantly, it reflects the ongoing work at NURC, a work that supports NATO commands and NATO nations in the maritime domain in order to resolve capability shortfalls that are visible now or that are foreseeable in future operations.

NURC 's continuing focus on the maritime domain is related to the ever-present and growing threats and challenges in the maritime domain. The Alliance Maritime Strategy points out that as "recent events have demonstrated, collective security is unattainable without the security of the seas."

All naval operations above and below the sea are severely affected by the maritime environment. Thus, sea-going capacities and capabilities, including the necessary research assets and engineering resources, are a mandatory prerequisite of research and technology in support of these operations. Conducting research and technology in a sea-going manner constitutes the basis for naval products that are robust, reliable, interoperable, and thereby leads to usable and affordable capabilities.

Our four pillars of research—antisubmarine warfare; mine countermeasures; environmental knowledge and operational effectiveness; and maritime security—not only comprise the portfolio of our work in support of NATO stakeholders and customers, these pillars are the relevant areas of research that will help ensure the security of the maritime environment.

Collaboration, networking, and outreach are cornerstones in NATO. NURC, and science and technology in general, are in the middle of these activities. Moreover, concepts of use and concepts of operation of cutting-edge technology, particularly in the maritime domain, are widely dependent on the insight gathered during the research and technology phases. NATO's general approach relies on the Defence Planning Process (including now science and technology), the Allied Command Transformation's capability development process, the navy-oriented Centres of Excellence in the nations, and NURC. This approach offers an outstanding opportunity to be prepared for and to shape the future superiority of NATO in all maritime challenges that will emerge.

NATO as a coalition of nations with the same values, such as freedom, democracy, independence, and prosperity for the people, has to ensure these values in a common approach. In the maritime domain, NURC guarantees a common understanding, a focus on relevant shortfalls, and a competitive and realistic way ahead with world-class science and technology. In this way NURC helps NATO achieve more security for all its members. Security in the nations could not be easily afforded with an individual approach.

Building a Relevant

The Centre's mission of supporting NATO military transformation requires flexibility to meet the changing demands of NATO and to provide long-term continuity in our research. To accomplish this balance, the Centre structures its work around disciplines. All work, whether it is entirely NATO funded or is funded by an outside customer, falls into one of these areas of research. The Centre's work is also built on a set of core competencies that cross all disciplines. The disciplines form the pillars in the Centre's structure and the core competencies are the foundation.

The pillars of our research

For 2010, the Centre's work was structured around four disciplines:

Antisubmarine warfare, a long-standing discipline at the Centre, is exploring the use of a network of underwater sensors to provide persistent surveillance in shallow waters. Two important elements of this work are the development of undersea communication networks and decision support tools to visually describe the network to an operator.

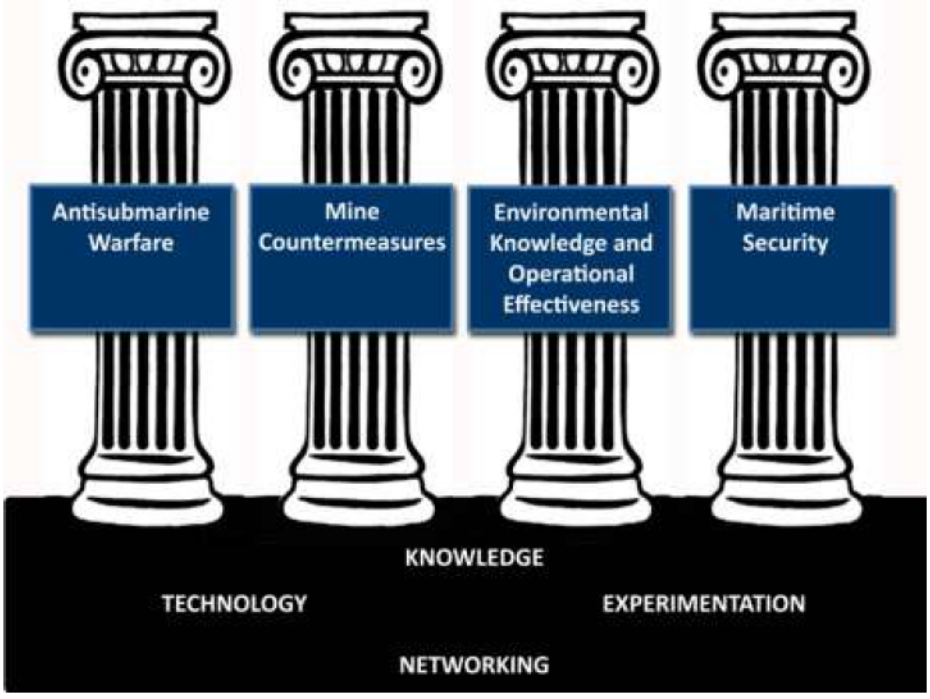
Mine countermeasures is proving the concept of an end-to-end system based entirely on autonomous maritime vehicles. In this system, both autonomous underwater and surface vehicles are being used to find, classify and dispose of underwater mines.

Environmental knowledge and operational effectiveness is applying basic oceanography to answer the questions: what do we know about the environment that the NATO navies operate in, how does it influence their operations, what level of uncertainty is there in this knowledge, and can we design tools that translate these uncertainties into operational risks?

Maritime security advances technologies and concepts for protection of our harbours, ports, and ships in transit. Because this is a relatively new field, the Centre is analyzing existing technologies and promoting collaboration through events such as the Second International Conference on Waterside Security 2010.

The foundation of our work

The core competencies at the Centre include:



Knowledge of ocean processes. Since its inception, NURC has brought together top scientists in the field of underwater acoustics to conduct basic and applied research on underwater surveillance, imaging, communication, navigation and other activities in the interior of the ocean. The computational and theoretical knowledge of NURC's scientific staff and the Centre's experimental facilities and at-sea testing capabilities have been an extraordinarily successful combination for over 50 years.

Research Programme

Technologies. To support the Centre's scientific research, technologies must be developed. This year's Research and Technology Highlights presents a number of those technologies. The Centre also supports NATO by developing operational concepts to translate the output of scientific data into useful tools for NATO personnel. For example, the Centre developed the Multistatic Tactical Planning Aid, software for viewing acoustic tracking data in 3D.

Experiments at sea. With world-class engineering facilities, a state-of-the-art research vessel and a location on the Gulf of La Spezia in Italy, the Centre is able to conduct research in the field year-round. The 93-meter NRV *Alliance* offers researchers at the Centre and our partners an opportunity to conduct acoustic tests on one of the quietest ships in the world. The Centre also has access to the Italian Navy's CRV *Leonardo*, which is an excellent platform for shorter, smaller-scale projects.

Networking and collaboration. The Centre is uniquely positioned to facilitate collaboration and knowledge sharing that is at the heart of NATO. Whether it is collaborating on joint projects, hosting conferences or offering short courses, the Centre brings together experts from academia, research institutes, military labs, industry, and NATO forces. The way the Centre is organized also promotes collaboration, bringing together the best and brightest scientific staff from the NATO nations on a rotational basis.

Measures of success

It was a productive year at the Centre, resulting in more than 43 publications, 24 sea trials/engineering tests and 264 days at-sea onboard the NRV *Alliance* or the CRV *Leonardo*. It was also the first of three years that the Centre has committed to hosting the SAUC-E competition (See "Fostering the Next Generation of Scientists and Engineers", p. 16), an effort that resulted in the Centre winning the J. Guy Reynolds Memorial/MAST Award at the MAST (Maritime Systems and Technology) 2010 Conference. Perhaps most importantly, this year brought new levels of collaboration with government, academia, and industry (see "Sample of 2010 Customer Projects"). Underlying these and other notable successes, which are covered in this report, is the ongoing advancement of science and technology in the service of NATO.

Sample of 2010 Customer Projects

- ARGOMARINE—Automatic Oil-Spill Recognition and Geopositioning Integrated in a Marine Monitoring Network
- SECTRONIC—Improved civilian maritime security in ports, on ships, and on maritime energy platforms
- Game and Learning Alliance—Serious games for security, safety and crisis management
- Marine radar wind retrieval
- Long-term monitoring of seafloor using MUSCLE AUV to detect changes in bathymetry
- Gliders for near-real time meteorological and oceanographic data collection
- Estimating winds from synthetic aperture radar under typhoon conditions
- Clean Sea—Environmental assessment using the Ocean Explorer (OEX) AUV
- AUVG—Gravimetric payload on OEX AUV
- Emulation of clutter scintillation in a tactical sonar trainer
- Research sensor autonomy and group intelligence for cooperative ASW
- Calibration and validation of the visible infrared imager radiometer suite

Reading the Ocean

Traditionally, marine radar has been used to assist in navigation and traffic control by scanning the ocean for ships and land. To find objects, marine radar measures the backscatter from the ocean surface, including objects on the surface. The backscatter from the ocean surface, called sea clutter, is normally treated as noise and suppressed to obtain better images of ships, land and other objects. A few years ago, scientists realized that the noise they were trying to suppress might contain useful information about conditions on the sea surface. For example, sea clutter is mainly caused by centimetre-scale surface roughness that is generated by local wind, so sea clutter can be used to measure surface wind. Furthermore, the centimetre-scale surface roughness is strongly modulated by larger scale features, such as waves and currents, which allow us to retrieve additional information of value to maritime operations. NURC scientists are working on extracting this additional information.

Analyzing the noise

Using the Surface Feature Monitoring System (SuFMoS), recently developed at the Centre, scientists are able to extract qualitative information on internal waves, currents, bathymetry and atmospheric features as well as quantitative information on wind speed and direction. This information is particularly valuable to commercial and military shipping operations, because it is available in real-time over a range large enough to provide an early warning system for potentially hazardous conditions.

Real-time monitoring of surface features within a range of up to 4 km around the vessel or platform is a unique feature of SuFMoS and a clear advantage it offers over traditional means of monitoring ocean conditions. For example, visual observation is limited to observing nearby surface features during the daylight, and satellite-based remote sensing has delays that make it unsuitable for predicting what's going to happen now to a ship or perhaps even a diver.

Creating a real-time view

In general, SuFMoS consists of a standard marine radar system, an analogue-to-digital convertor to convert the radar analogue images to digital images, and a standard PC. SuFMoS can be operated from moving vessels as well as ocean or coastal platforms. The radar scans the ocean surface over a range of 4 km with a resolution of approximately 7 metres. The raw radar scans are digitized by the analogue-to-digital convertor and transferred to a PC, where the data are saved, processed to obtain surface features and winds, and then turned into images that are displayed to the user in real-time. Processing involves integrating radar images over time (typically over 120 seconds), which removes the dominant feature of surface waves (Figure 1), and then applying a 2D filter to enhance surface features that are not normally visible. The types of surface features that can then be seen include currents, internal waves, bathymetry, atmospheric disturbances (such as a heavy rain storm), and oil spills (Figure 2).

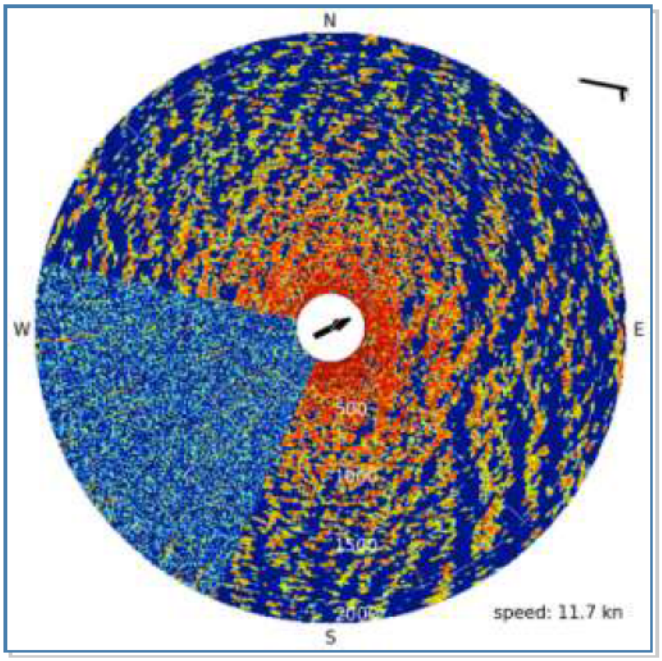


Figure 1: Raw marine radar images taken from on-board the RV Planet showing long and large waves propagating from the west.

with Marine Radar

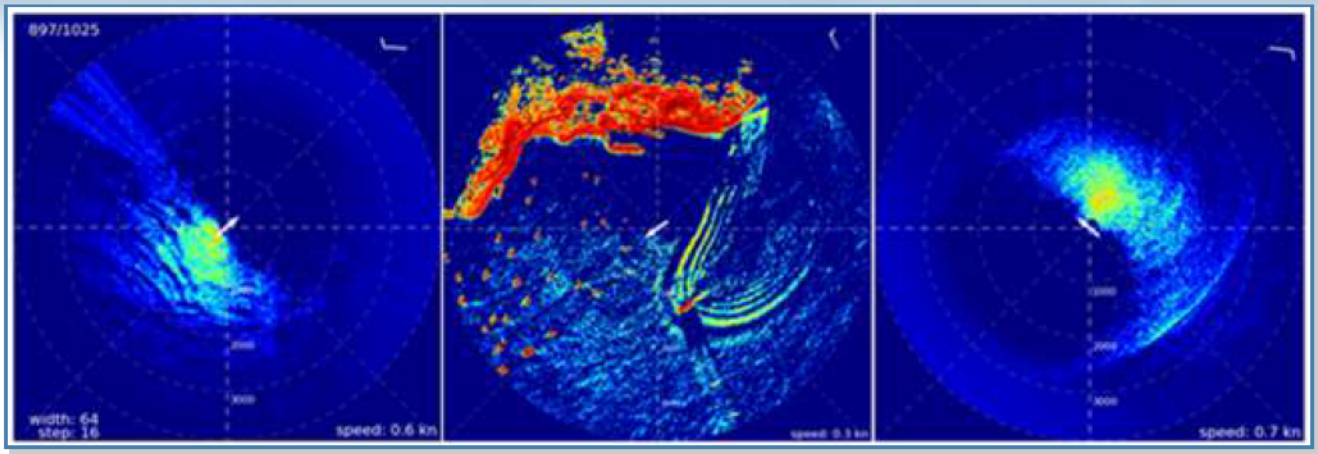


Figure 2: Ocean features extracted from marine radar image sequences using SuFMoS. The features depicted are, from left to right: bathymetry effects, ship-generated internal waves and an atmospheric front.

To distinguish between static features (e.g., bathymetry) and non-static features (e.g., internal waves), SuFMoS geolocates all radar data. Figure 3 shows a series of geolocated radar images that are taken from a moving vessel and have been integrated in time. As the ship moves, each radar image is geographically offset from the image before it, creating a timeline of integrated images along the track of the ship. The image sequence that is created could let a ship's crew know where their vessel is relative to a surface feature.

In addition to showing surface features, SuFMoS can be used to measure the surface wind direction and speed. The great advantage that radar offers over other wind sensors is that it is not affected by the motion and height of the sensor. Also, since the wind is determined from the roughness of the ocean surface far from the radar, the structure supporting the radar, such as a ship's mast, does not interfere with the measurement.

The next wave

Although adapting radar to "read the ocean" requires some off-the-shelf hardware modifications and software tools, the prevalence of radar makes it an excellent sensor for providing real-time monitoring of features on the ocean surface up to 4 km away. Initial investigations indicate that by analyzing the noise created by a radar image, you can extract not only wind direction and speed, but you can monitor other features, such as currents, internal waves, atmospheric disturbances, and oil spills. Future investigations will look at using SuFMoS with other radar setups to validate these initial findings on stationary platforms as well as moving platforms.

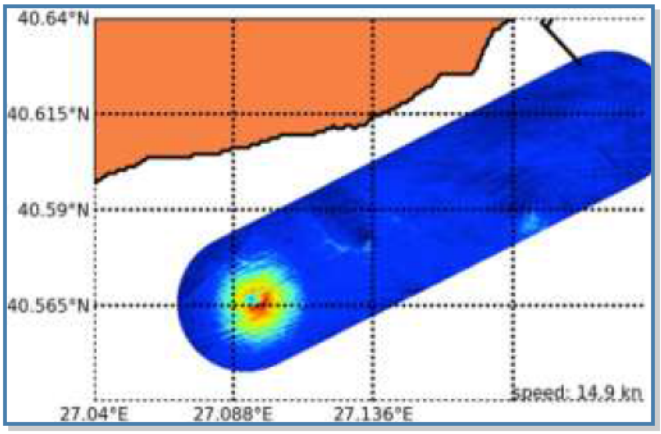


Figure 3: Geolocated radar images from onboard the RV Alliance. These integrated radar images were gathered over 25 minutes while the vessel travelled east to west.

[A longer version of this article, written by Dr. Jochen Horstmann *et al.*, appeared in "Defence Global", May 2011.]

A New NATO Fleet: A Better Solution

Historically, undersea surveillance or research has involved towing a sonar array behind a moving ship to detect objects of interest, such as submarines, or to gather data that help navy personnel understand the environment they operate in. The biggest drawback of this approach is that a thorough survey of an undersea area is time consuming, expensive, and not flexible to changes in the environment. Although the days of conducting traditional naval reconnaissance and oceanographic research are not over, NATO navies are looking for more cost-effective, persistent ways of monitoring the ocean. The solution may be a new NATO fleet of autonomous underwater vehicles (AUVs) and autonomous surface vehicles (ASVs).

NATO is looking for more cost-effective, persistent ways of monitoring the ocean.

Using autonomous vehicles for surveillance and data gathering purposes is not a new idea. Over the past 50 years, AUVs have been used for a variety of tasks, including gathering physical oceanographic data, finding mines, and mapping the seafloor. What is new is that NURC, and other research organizations, are using AUVs and ASVs for more sophisticated surveillance and research operations. Autonomous vehicles are now capable of towing small sonar arrays (see "Thin Arrays for Autonomous Vehicles"), carrying onboard software for real-time decision making, and communicating with other vehicles to share information and coordinate efforts. At NURC, autonomous vehicles are being used in all disciplines: mine countermeasures, antisubmarine warfare, port and harbour protection, and environmental knowledge and operational effectiveness.

Here are a few examples of the types of advancements made using these vehicles during 2010.

The **mine countermeasures** team made progress on an end-to-end system for finding, classifying and disposing of mines. Using the Centre's MUSCLE AUV with its state-of-the-art synthetic aperture sonar (SAS), a rich data set of images was collected to support research into multi-view data fusion, a technique that combines sonar images from multiple aspects to create a more complete image of the seafloor and objects on it. The team also tested a system where an ASV (Figure 1) is able to find a mine that has been previously located by an AUV. Then, the MOOS-IvP software (see "Promoting Collaboration through Open Source Software", p. 14) onboard the ASV guides an untethered ROV into position to detonate the mine.

Figure 1: The ASV used by the Centre in mine countermeasure experiments.

In 2010, the **antisubmarine warfare** team acquired and modified a second Ocean Explorer (AUV) (Figure 2) to investigate collaboration between autonomous vehicles. Towing a sonar array and carrying a communication system and on-board processing running the MOOS-IvP software, these AUVs can execute certain actions, known as behaviours, to respond to specific conditions. In a demonstration this year, one of the AUVs detected and tracked a

to Surveillance and Research

suspicious noise (generated by a research ship) and then turned on an active sonar array using underwater acoustic communications. Then, the second AUV tracked the target and optimized its path based on information obtained through its sensors.

Figure 2: Two OEX AUVs outfitted with towed arrays, on-board processing and communication systems.

NURC scientists are putting more sensors on the OEX AUV to gather oceanographic data that is useful for **environmental knowledge** of an area of interest. During a 2010 experiment, the OEX was deployed with a suite of sensors for several days in a range of environments, from clean to polluted. The effort was funded by *Ente Nazionale Idrocarburi* (ENI, Italy) as part of their "Clean Sea" initiative. In a separate initiative funded by the European Union's Seventh Framework Programme, a sensor that sniffs hydrocarbons is being added to an AUV to detect oil spills.

The new, emerging fleet of autonomous vehicles offers NATO a number of advantages over traditional surveillance and research techniques. The vehicles are small, so they are quickly deployed, making it easy to scale-up operations. The vehicles are relatively inexpensive, can cover a wide area and work well in shallow waters. Because AUVs operate below the surface, they are stealthy, and because autonomous vehicles are unmanned, they minimize danger to personnel. Ultimately, this new fleet will be able to operate with true autonomy, working together as a group of robots to detect problems within our oceans and in some cases solve them.

Thin Arrays for Autonomous Vehicles

Since 2007, NURC has been developing thin arrays that are light enough to be towed by AUVs. In 2010, the Centre developed two new arrays (see photo). TRIBENS is 31 mm in diameter and has a triplet of hydrophones that are configured in such a way that an object's position can be precisely determined. (Hydrophones in a line are unable to discern whether an object is to the left or the right.) Slim BENS, with a diameter of only 18 mm, was developed to be towed by the smallest AUVs currently on the market. In addition to reducing drag, this array was also designed to have low energy demands. For example, a traditional NURC array consumes 9.5 W, while the slim BENS draws only 0.7 W.

The two thin arrays developed at the Centre: TRIBENS (left) and Slim BENS.

Underwater Communications:

On the face of it, it looks like a simple problem to solve. We are familiar with acoustics. Indeed, it is our primary means of communicating with one another in air. You talk, I listen, then I get to talk, and you listen. So what's the problem with extending this natural method of communication to the underwater environment? Well, plenty. Let's look at a few of the issues, starting with "language".

The Tower of Babel

Consider the simplest task: point-to-point communication underwater, where we have only two devices and one needs to transmit information to the other. Several reputable manufacturers of underwater acoustic modems can provide turn-key solutions to this challenge. But here's the problem: both ends of the communication link have to use modems from the same company, because each manufacturer uses a proprietary method to encode data onto an acoustic signal. This is partly because acoustic propagation underwater is so challenging, with long latencies, short channel coherences and significant channel spread in shallow water. A plethora of coding techniques have been used with each company optimising its design choices for the typical environment and application it is addressing for its customers. As a result, in the world of marine communication, we have a Tower of Babel, where none of the modems can "talk" or "listen" to modems from another manufacturer.

Yet a solution to the Tower of Babel is urgently needed. Maritime defence forces are moving from relatively few, expensive, manned platforms to distributed, autonomous sensing networks, networks that need to communicate, often underwater, to coordinate their activities. Interoperability is the key. Different organisations must cooperate when no single entity has the resources to conduct all the maritime surveillance and operations it requires, independently of its neighbours.

As a NATO research institute, NURC is acutely aware of this need and is addressing it with a proposed standard "language" called JANUS, a simple coding method that can easily be adopted by a wide range of existing manufacturers and which is already quite similar to one or two existing methods. Furthermore, it is applicable over a wide range of frequencies. JANUS provides a communication bridge between modem manufacturers. Even if it never becomes their first language, it will at least allow a conversation to be struck up. JANUS is already being adopted by several modem manufacturers, has been extensively tested in a wide range of environments and is now in process to become a NATO standard. JANUS is open-architecture software and freely distributed under the GPLv3 licence at www.januswiki.com, where the standard is being actively developed and refined by a user group.

The 2010 NURC network com tal hardware: Surface marke low-cost autonomous underv AUVs) (background left) and modem node tripods (backgr

The cocktail party

If we can succeed in promoting a common baseline core language, is it time to celebrate? That question brings us to the cocktail party, where we've progressed from point-to-point communications (where only two modems are active) to a collection of modems. In conversation, there is usually a common understanding that one does not begin to talk while others are already speaking. We wait our turn. This is a kind of Medium Access Control (MAC), apportioning the

The Tower of Babel & the Cocktail Party

right of access to the acoustic channel by allocating slices of time to each would-be speaker. But what if all our clocks run at slightly different rates (clock drift), or if the latency (time taken for an acoustic signal to travel from source to receiver) is large? Worse still, what if the number of nodes is sufficiently large that the communication capacity is simply insufficient if only one node is ever talking at once? Can we write rules that will allow nodes to communicate in a crowded environment, like a cocktail party?

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Working out how to schedule transmissions in a network turns out to be no simple task. The situation becomes even more complex when accessible nodes also need to be discovered and the connectivity may not be symmetric. That is, A may be able to hear and understand B, but B may be "blinded" by some local noise source that prevents it from hearing or being able to understand A. Many of the nodes might also be moving through the crowd, so we have also to deal with time-varying connectivity tables. If that's not already difficult enough, the message that A wishes to send might be intended for node P, far across the network, only reachable by a multi-hop passage. Just like choosing a language, there are many ways to choose how to discover neighbouring nodes, who gets to talk when (MAC), routing and multi-hop message delivery (network service). Unfortunately the protocols inherited from the cellular telephone and WiFi (802.11) radio frequency (RF) systems in air are unlikely to be suitable for underwater networks. The problem is in the different nature of the underwater acoustic communication channel. In air, the RF channel is relatively stable over long times compared to the length of a data signal packet and there is little latency in its delivery (the speed of light being a limitation, but a rather high one). Underwater, the speed of sound is comparatively very slow, the delays consequently long and the channel coherence time rather short, often shorter than the data packet length. Worse still, even the architectural model for designing protocols, the so-called OSI stack, appears increasingly unsuitable. NURC has responded to this impending crisis by proposing a simple replacement architecture that is backwards compatible with the traditional OSI stack, uses open-architecture, and is modular. It implements a publish-and-subscribe memory block that is accessible to all layers. Within the OSI layers, there is the flexibility to choose different protocols, based on a policy engine, leading to a Software-Defined Acoustic Modem (SDAM).

Quelling the cacophony

NURC is gathering key players in the underwater communications field to convene a workshop at which they will choose some canonical problems (consisting of environments plus applications) and channel models (consisting of propagation and noise models) that can be used as benchmarking examples for testing newly proposed protocols. NURC is also working towards building a semi-permanent modem farm at sea that can be accessed over the internet for live testing. With a little help from our friends, we hope to help quell the impending cacophony both of the Tower of Babel and the over-loud cocktail party where everyone can be heard but none understood.

[A longer version of this article, written by Dr. John L. Potter, appeared in "Defence Global", February 2011.]

Reaching Out to Advance

For 2010, NURC's Maritime Security Programme had two main thrusts: maritime situational awareness and port protection. Maritime situational awareness answers the question: is this ship behaving in a way that requires further investigation? Port protection answers the question: how do we ensure the safety of our ports, which are often located in densely populated areas, against potential intruders? Answering these questions will help solve emerging threats, including maritime interdiction and force protection in counter-terrorism, policing operations for counter-piracy, and merchant ship self-protection.

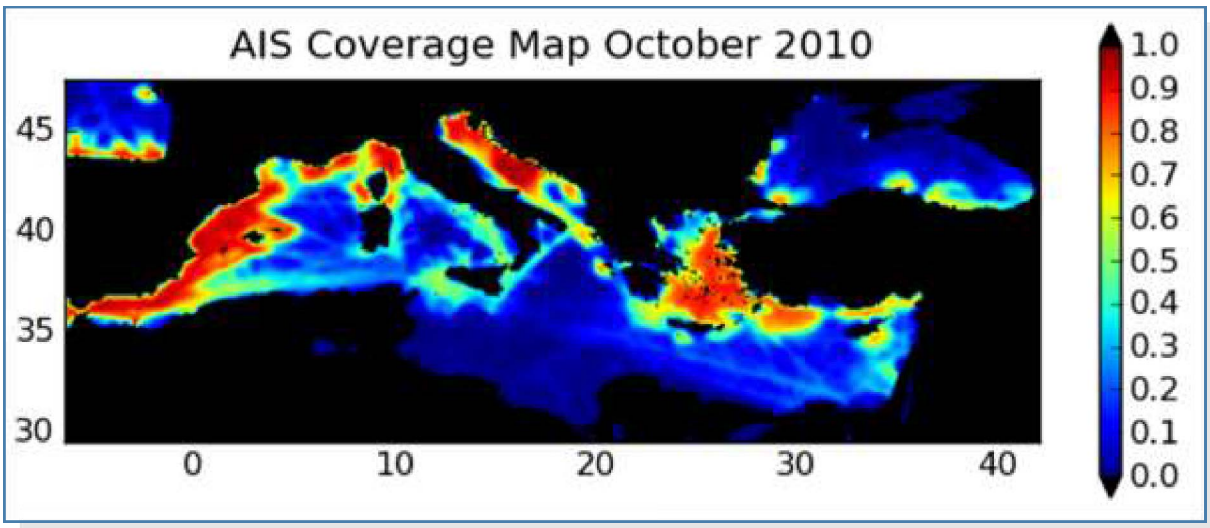
Maritime security offers many challenges for the scientists at NURC: how to merge large sets of data to develop an accurate real-time picture of the maritime environment; how to minimize false alarms for erratic or unusual shipping behaviour; how to disable an unauthorized and uncooperative small craft in a port-security zone; how to respond to unauthorized divers. NURC is working to develop capabilities for these and other challenges, but solving the technical challenges alone is not enough. The Centre is also working hard to bring stakeholders together in this relatively new field. The following are highlights of how the Centre has been promoting information exchange and collaboration, which will advance the state-of-the-art technologies and best practices in maritime security.

Operation Active Endeavour

Each month, NURC provides information services to Allied Maritime Command (MC) Naples in support of NATO's Operation Active Endeavour. The information shows areas of good and bad Automated Information System (AIS) coverage (see figure). Based on these maps, MC Naples can make decisions about the allocation of resources and can identify potential issues with AIS reporting.

Waterside Security Conference

NURC hosted the Second International Conference on Waterside Security (WSS2010), bringing together 125 military and civilian experts for three days last November to speak about the newest maritime security resources and technologies and how to move them into operations. WSS2010 was an excellent opportunity to stimulate collaboration between participants from a variety of disciplines and backgrounds who have a common interest in preventing terrorist attacks and criminal activity in world-wide ports, harbours, and coastal and inland waters.



NURC provides information services to MC Naples in support of Operation Active Endeavour. Shown above is an average AIS Monthly Coverage map highlighting areas of good and bad AIS coverage.

Maritime Security

Port security course

In conjunction with the WSS2010, NURC's short-course programme, called CORALL, offered a two-day session on "Port Security: Basics of Defence Against Underwater Intruders". This course introduced technologies for security against underwater intruders, including hands-on experience with commercially available equipment. Sixteen people attended the course. Portions of the course were featured later in a pilot course on maritime security held jointly by the Norwegian military (Bergen, Norway) and NATO's Allied Command Transformation (Norfolk, Virginia, USA).

Initiatives on non-lethal weapons

NURC participates in three NATO initiatives for advancing non-lethal weapons and capabilities. These initiatives keep NURC up-to-date on developments regarding legal issues and policy for non-lethal weapons and capabilities as well as on national programmes. NURC in turn reports on experimentation for developing non-lethal response technologies for maritime applications.

2010 TIDE Sprint

The Technology for Information, Decision and Execution Superiority (TIDE) concept is sponsored by NATO's Allied Command Transformation (ACT) to transform current forces and capabilities into forces capable of rapid reaction to any situation with the ability to achieve information, decision and execution superiority. During the 2010 fall bi-annual meeting, programmers from NURC, NATO C3 Agency (Belgium), and ACT integrated the NURC-developed Maritime Data Fuser (MDF) and BRITE, a maritime situational awareness prototype developed by ACT. (See "What is MDF?") This integration allows BRITE to use data fused tracks from MDF in its system via the Networked Interoperable Real-time Information Services (NIRIS), developed by NATO C3 Agency. This type of interagency collaboration is essential to solving real maritime situational analysis problems.

What is MDF?

The Maritime Data Fuser (MDF) is a program to take data from multiple sources and merge them into an accurate picture of the marine environment. Based on a similar program developed at NURC for antisubmarine warfare and mine countermeasures, MDF is used in maritime security to track vessels and identify abnormal behaviour. Data fusion relies on accessibility to multiple data sources. Currently, the sources for MDF are from coastal and navigational radar and the Automatic Identification System (AIS), a global system that tracks vessels with a gross tonnage of 300 or more tons. Ships of this size are required to transmit their unique ID. NURC is exploring the use of other data sources, such as spaced-based AIS, high-frequency radar, satellite-based SAR, and mobile sensors.

European Commission project

The SECTRONIC project seeks to improve civilian maritime security in ports, on ships, and on maritime energy platforms, through advanced information, sensor, and response technologies. Funded by the European Commission's Framework Programme 7 (FP7), SECTRONIC consists of a consortium of six research partners from industry, universities, and research centres plus five user partners from ports, shipping and energy platforms. NURC takes the lead on non-lethal response technologies and tactics.

Minimizing Risks

The year 2010 marked the beginning of a second decade of research on marine mammal risk mitigation at the Centre. The first decade of research resulted in the achievement of the programme's original goals, which included the development of:

- A habitat model for marine mammals in areas where NATO ships typically conduct active sonar tests
- Hardware and software tools to help detect marine mammals
- Policies, protocols, and guidelines for planning active sonar operations
- Public outreach and education programmes

The Centre will build on these successes, continuing to ensure that NATO and NATO nations have the information and tools needed to operate active sonar tests with minimal risk to marine mammals. As NATO's only maritime research facility, the Centre is in a pivotal position to provide scientific research, technological advances, and guidance on conducting sonar tests in the Mediterranean and North Atlantic in an environmentally responsible manner.

Gathering data beyond the Med

For the first time in the project's history, the NRV *Alliance* went outside the Mediterranean to carry out research on the presence of marine mammals in a region of the North Atlantic west of Portugal. This research trial, known as Sirena '10, was an opportunity to gather more data on the distribution of marine mammals in areas that NATO typically operates within and to gather more data to test and validate the habitat models the Centre has developed. It also provided the possibility to test new technology being developed to locate the marine mammals most at risk: the beaked whales.

Understanding beaked whales

Beaked whales are one of the least known groups of mammals, but recent field studies (conducted in conjunction with Woods Hole Oceanographic Institution and other partners) are piecing together the habitat for this species and their particular vulnerability to the effects of sonar. Beaked whales are known to be deep divers, with tagged whales diving as deep as 1900 metres, the deepest recorded dive of any air breathing animal. These deep dives require long periods of breath holding, which frequently exceed 60 minutes and can reach 85 minutes. Research at the Centre into the physiology of these dives indicates that a deep-diving Cuvier's beaked whale is in an anaerobic state for part of the dive, which puts their bodies under stress. A disruption, for example the type that can be caused by exposure to sonar, may increase the physiological stress and could harm the whales. This might explain why stranded Cuvier's beaked whales in areas of known active sonar operations have symptoms of decompression sickness.

Reducing risk to marine mammals

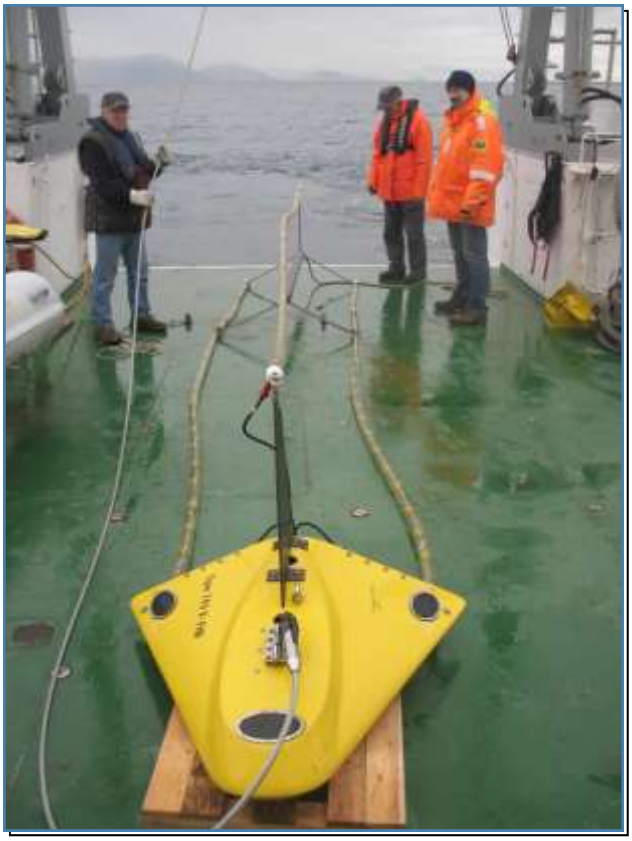
Understanding the vulnerability of whales to sonar is a first step. The next step is to minimize their exposure to sonar by ensuring there are no whales in

Beaked whales are elusive, deep-diving cetaceans and one of the least known groups of mammals.

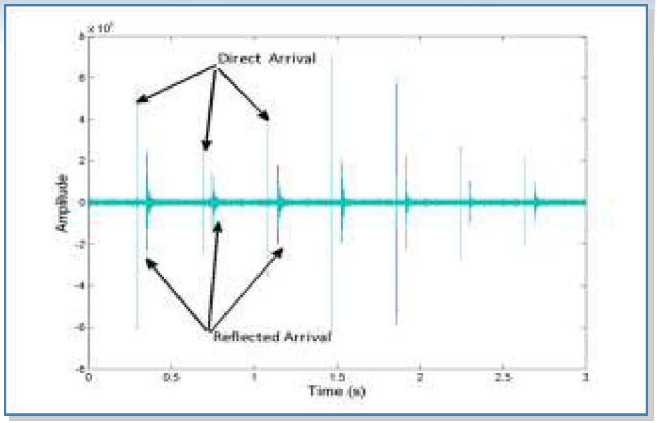
to Marine Mammals

the test area. The Centre is tackling this problem in two ways. First, we are developing planning software that can help determine the best times and locations for sonar tests to be conducted to avoid exposure to marine mammals. We are also developing sensors that can determine the presence of marine mammals in the sonar test area.

The Centre's Integrated Decision Aid is a software tool to help those who are planning sonar operations. The tool can assess the suitability of an area for sonar tests based on the substantial data that the programme has gathered on marine mammals in the Mediterranean and is starting to gather in areas of the North Atlantic. Historical whale sighting data is combined with various oceanographic predictors and bathymetric features to predict the likelihood that marine mammals will be in a specific area at a certain time of year.



The current version of CPAM consists of a V-fin body (yellow), which houses the electronics and maintains a depth of about 70 metres while the ship is underway, and a tetrahedral configuration of hydrophones on three arrays towed behind the V-fin.



Beaked whale clicks detected by CPAM, including the clicks that arrived directly from the deep-diving animal and the signal reflected off the surface.

The Centre is also refining the Compact Passive Acoustic Monitor (CPAM), three towed arrays that operate in unison to detect Cuvier's beaked whales by "listening" for their unique vocalizations. CPAM is interesting because of its configuration: an array of four hydrophones in a tetrahedral configuration. With this configuration, as well as depth and orientation sensors, CPAM cannot only detect the presence of Cuvier's beaked whales, but it can also localise the whales. Although CPAM is currently towed behind a ship, other configurations are possible, including a hand-deployed system, a bottom-mounted cabled system, or an autonomous buoy system, which is currently under development.

In time, moored systems will become the primary means of surveying an area for marine mammals. These systems will allow continuous data gathering, which will greatly improve our ability to predict the likelihood of whales in an area and therefore improve our ability to minimize risks to marine mammals.

Promoting Collaboration

The primary mission of the NATO Undersea Research Centre (NURC) is to develop products that anticipate the needs of NATO Navies. Historically, NURC has accomplished this through the development of purpose-built hardware and software. Although purpose-built systems can offer great technological advancements, they can be expensive, difficult to integrate into existing systems, and difficult to share among NATO nations. To make collaboration easier, to streamline costs and to allow for smoother integration into existing systems, scientists and developers at NURC have recently started using open-source software for several of the Centre's programmes.

The interoperability that the MOOS platform allows is of great advantage to NATO militaries trying to integrate and coordinate various hardware.

The MOOS-IvP platform is a suite of open-source programmes that lets teams of developers and scientists program robots, in this case autonomous vehicles. Started at MIT's Department of Ocean Engineering and since maintained by the Oxford Mobile Robotics Group, the Naval Undersea Warfare Center and MIT, MOOS stands for "Mission Oriented Operating Suite". MOOS was originally developed as software for autonomous underwater vehicles (AUVs), but it can be used in any environment where multiple applications and operating systems need to work together. The interoperability that this allows is of great advantage to NATO militaries trying to integrate and coordinate various hardware.

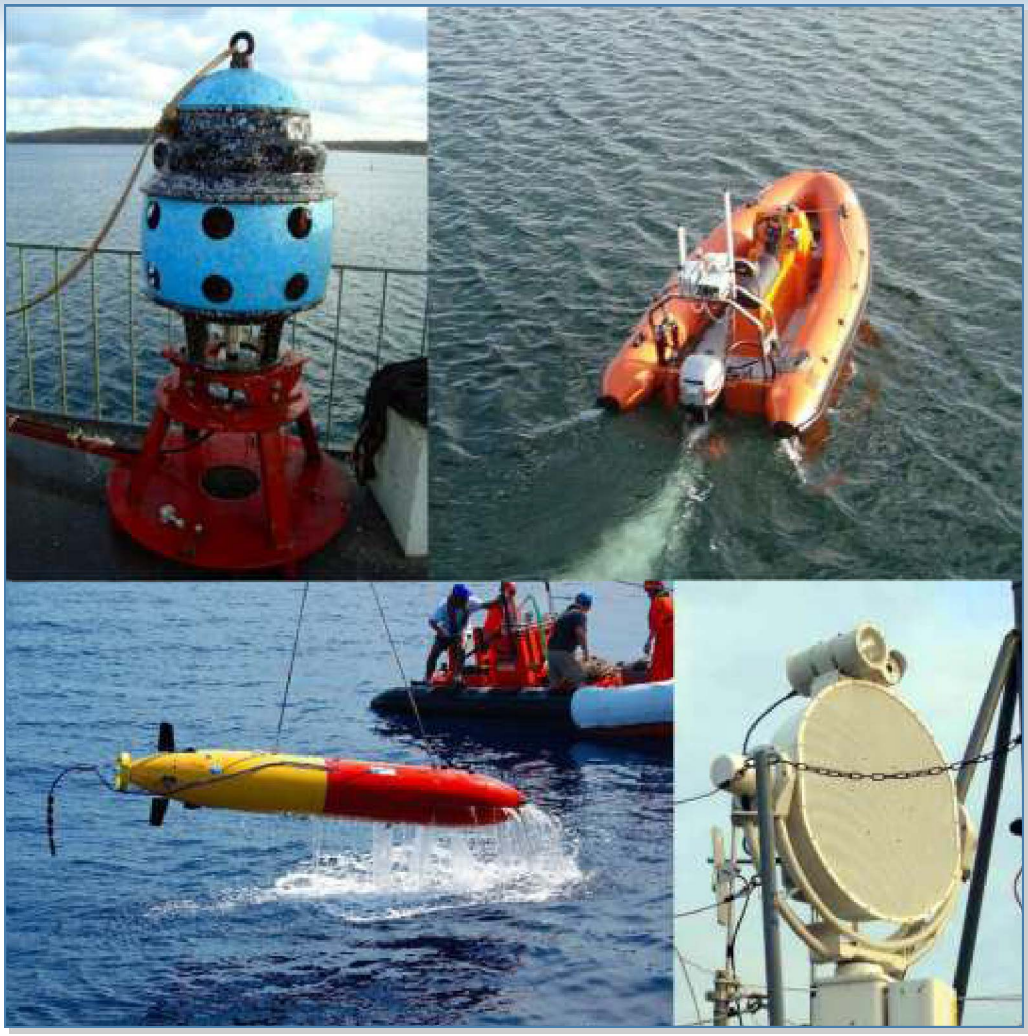
Simply described, developers use MOOS-IvP to program a set of behaviours that can be used to control autonomous underwater vehicles. Behaviours can be simple, such as maintain a course, or they can be highly complex, such as keep a certain distance and bearing away from a moving object. IvP stands for Interval Programming, a mathematical programming model for multi-objective optimisation. It determines the vehicle's next best action by combining all behaviours, and using the data the vehicle has acquired about the environment, it outputs the desired settings for speed, heading, and depth. MOOS-IvP is being used at the Centre in a number of different disciplines:

- For **port and harbour protection,** using AUVs, autonomous surface vehicles (ASVs), and a variety of sensors and warning devices to identify and deter small boats and swimmers from entering a restricted area.
- For **mine countermeasures**, using AUVs and ASVs to find, classify, and dispose of mines.
- For **antisubmarine warfare**, using AUVs to gather underwater data and behave in ways that are specific to the current environment and more importantly the anticipated environment.

A specific example of how MOOS-IvP can be used for antisubmarine warfare was shown last summer during the GLINT10 experiment. The goal of the 20-day experiment was to test a small fleet of AUVs for their ability to operate autonomously and cooperatively in shallow waters near shore where using

MOOS on board: Decal on NURC's OEX AUV.

through Open-Source Software



MOOS software runs on a variety of hardware platforms at NURC, including (from top-left counterclockwise): a fixed sonar diver-detection system, the Mandarina ASV, a long-range acoustic device, and the Ocean Explorer AUV.

sonar poses the greatest technical challenges. The tests, which included three 21-inch AUVs running MOOS software, showed that AUVs can be programmed with behaviours that allow them to track a target autonomously and that AUVs can work together to minimize the errors associated with finding a target. More complex behaviours will be tested as part of GLINT11.

Scientists and developers at NURC like using MOOS-IvP because it offers a modular approach to complex projects and it allows multiple people to work simultaneously yet independently. Because the Centre works with so many organizations, software such as MOOS-IvP that facilitates collaboration is extremely valuable. They also like it because programming is done in C++ on small computers and MOOS has a relatively quick learning curve. This latter feature is particularly important at NURC because rapid prototyping is common and because of the rotational nature of staffing, scientists need to ramp up quickly and integrate their work into existing projects.

The NATO military is a collaborative and rapidly changing institution. It is also an institution where legacy systems and new systems must be integrated. Using open-source software, such as MOOS-IvP, is a cost-effective means for rapid, collaborative development that allows for interoperability of existing and new systems.

[A version of this article was originally published in the *ACT Transformer*, Winter 2011 issue.]

Fostering the Next Generation

Bring together nine teams of university students and their one-of-a-kind autonomous underwater vehicles (AUVs) and then mix that with a competitive challenge. Add in a heat wave and you have the 2010 Student Autonomous Underwater Vehicle Challenge—Europe (SAUC-E). Sponsored by the Centre and held at our facilities and harbour in La Spezia, Italy, the event was an opportunity for scientific and engineering students to gain real-world experience and interact with and share ideas with other university students and professionals in the field.

During the last week of June, eighty five students worked all day and sometimes into the night to prepare for the final competition on 4 July. The competition included an AUV mission consisting of a series of tasks defined by the event organisers. These tasks, which included passing through an underwater gate and performing a "pipeline" inspection, had to be completed autonomously by the vehicles in the realistic conditions posed by the Centre's boat harbour. Teams were also required to submit a technical paper describing the vehicles design and approach to the mission and to give a presentation. The teams were judged on technical merit, successful completion of mission tasks, quality of the technical paper, safety of the design, craftsmanship and innovation. Teams could include university instructors or industry professionals, but students were required to make up 75 percent of the team.

University of Cambridge team getting ready to deploy their AUV.

2010 Teams

- 1st place: University of Girona (Spain)
- 2nd place: Heriot-Watt University (UK)
- 3rd place: ENSIETA (France)
- University of Lübeck (Germany)
- University of Bremen (DFKI RIC Bremen, Germany)
- University of Cambridge (U.K.)
- University of Southampton (U.K.)
- University of West England (U.K.)
- ESIEA (France)

2010 Sponsors

- Office of Naval Research Global (USA)
- THALES (UK)
- ACSA Underwater GPS (France)
- CSSN (Italian Navy)
- Defence Science and Technology Laboratory (UK)
- ECA (France)
- Subsea Asset Location Technologies Ltd. (UK)
- NURC

# of Scientists and Engineers

SAUC-E is an annual event to encourage young scientists and engineers to pursue careers in underwater technology and to expose them to organizations involved in this area of research and development. SAUC-E is also a recruitment opportunity for sponsoring companies and agencies, which get to see young talent in action. An annual event since 2006, SAUC-E was hosted by the Centre in 2010 for the first time. The Centre will host the event again in 2011 and 2012, which will provide continuity and allow organizers to make improvements each year.

University of Lübeck team making final adjustments.

Despite the searing heat at the event and various technical and logistical challenges that students faced, the level of energy and enthusiasm that these future engineers displayed was inspiring. One participant said that his experience in SAUC-E'10 confirmed his decision to continue studies in this field, believing that underwater robotics has a bright future with many innovations to come. Others noted that they learned a lot from the event, not only the technical aspects of getting an AUV to complete autonomous missions, but also about the importance of team work, how to work efficiently under the pressure of time constraints, and how to solve problems with limited resources. The students also benefited from and enjoyed the interactions with other team members, judges, scientists, and engineers.

Eventually students had to test their inventions in the realistic conditions of NURC's harbour.

As a world leading institution in maritime research and development, NURC believes that SAUC-E will pave the way for the next generation of scientist and engineers to make advancements in AUVs, which are being studied in all disciplines at the Centre (see "A New NATO Fleet", p. 6).

NURC Receives Outreach Award

To acknowledge NURC's hosting and sponsorship of the SAUC-E competition in 2010 and for the next two years, the Centre was presented with the J. Guy Reynolds Memorial/MAST Award at the MAST (Maritime Systems and Technology) 2010 Conference and Exhibition in Rome, December 2010. The award is part of the MAST educational outreach initiative, "to provide an educational opportunity, allowing younger scientists and engineers to learn and work with the most senior leaders in the community".

2010 Publications

NURC Reports

Bryan, K., Ranelli, P., Lewis, C., Coraluppi, S., Carthel, C., Baldacci, A., Neumeyer, J.
MSA experimentation 2009: Final analysis report. NURC-FR-2010-010. NATO Unclassified.

Baldacci, A., Cappelletti, M., Coraluppi, S., Carthel, C., Bryan, K., Arcieri, G., Ranelli, P.
Anomaly detection during the MS09 experiment. NURC-FR-2010-001. NATO Unclassified.

Carthel, C., Coraluppi, S., Bryan, K., Arcieri, G. Real-time wide-area tracking with intermittent multi-sensor data. NURC-FR-2010-003. NATO Unclassified.

Chiggiato, J. Implementation of the two-way coupled ocean-atmosphere COAWST model in the Marmara Sea. NURC-FR-2010-014. NATO Unclassified.

Chiggiato. J. Numerical modelling of wave-current interactions in the Sea of Marmara. NURC-FR-2010-015. NATO Unclassified.

Coraluppi, S., Carthel, C. Exploratory research final report: advanced data fusion. NURC-FR-2010-011. NATO Unclassified.

Grasso, R., Cecchi, D., Trees, C., Rixen, M., Alvarez, A., Strode, C. Model based decision support for glider operations. NURC-FR-2010-005. NATO Unclassified.

Guerriero, M., Coraluppi, S., Carthel, C. Analysis of AIS intermitency and vessel characterization using a hidden Markov model. NURC-FR-2010-002. NATO Unclassified.

Horstmann, J., Falchetti, S. Synthetic aperture radar wind field retrieval. NURC-FR-2010-009. NATO Unclassified.

Mourre, B., Lenartz, F., Rixen, M. A pilot 3D super-ensemble algorithm: evaluation using LSCV08 data. NURC-FR-2010-008. NATO Unclassified.

Trees, C., Pennucci, G. Atmospheric corrections algorithms for high resolution remote sensing (SPOW 2009 document). NURC-FR-2010-007. NATO Unclassified.

Hamilton, M. The OEX SLITA signal processing chain: current progress and issues. NURC-FR-2010-004. NATO Unclassified.

Kessel, R. Countermeasure effectiveness: how much protection is enough? NURC-FR-2010-016. NATO Unclassified.

Kessel, R. Non-lethal response technologies for port protection: 2009 survey report and options. NURC-FR-2010-006. NATO Unclassified.

Strode, C. Transitioning the Multistatic Tactical Planning Aid (MSTPA) towards decision support. NURC-FR-2010-013. NATO Unclassified.

Kessel, R., Pastore, T. Rapid contact designation and warning for port protection: EPOW 2009 quick-look report. NURC-MR-2010-001. NATO Unclassified.

2010 Publications, continued

NURC Conference Proceedings

Ranelli, P., Bryan, K. Maritime Surveillance 2009 (MS09) Experiment Post-Analysis Workshop NURC-CP-2010-001. NATO Unclassified.

Journal Articles (published)

Alvarez, A. Redesigning the Slocum glider for torpedo tube launching. *IEEE Journal of Oceanic Engineering, 2010,* vol. 35 (4) pp 984-991.

Djapic, V. and Nad, D., Collaborative autonomous vehicle use in mine countermeasures. *Sea Technology,* 2010, Vol. 51 (11), pp. 19-23.

Doisy, Y., Deruaz, L., Been, R. Interference suppression of subarray adaptive beamforming in presence of sensor dispersions. *IEEE Transactions on Signal Processing, 2010,* Vol. 58 (8), pp. 4195-4212.

Dosso, S.E., Wilmut, M.J., Nielsen, P.L. Bayesian source tracking via focalization and marginalization in an uncertain Mediterranean Sea environment. *Journal of the Acoustical Society of America,* 2010, Vol. 128 (1), pp. 66-74.

Ehlers, F., Daun, M. Tracking algorithms for multistatic sonar systems *Eurasip Journal on Advances in Signal Processing,* 2010, art. no. 461538.

Fornshell, J.A., Tesei, A., Fox, P.D. Acoustic signatures of three marine arthropods, squilla mantis (linnaeus, 1758), homarus americanus (h. milne edwards, 1837), and nephrops norvegicus (linnaeus, 1758) (arthropoda, malacostraca). *Marine Technology Society Journal,* 2010, Vol. 44 (5), pp. 67-80.

Grasso, R., Coccoccioni, N., Rixen, M., Trees, C.C., Baldacci, A. A generic decision support architecture for maritime operations. *International Journal of Intelligent Defence Support Systems*, 2010, Vol. 3, pp.281-304.

Hamilton, M.J., Kemna, S., Hughes, D. Antisubmarine warfare applications for autonomous underwater vehicles: The GLINT09 sea trial results. *Journal of Field Robotics*, 2010, Vol. 27 (6), pp. 876-889.

Lenartz, F., Beckers, J.-M., Chiggiato, J., Mourre, B., Troupin, C., Vandenbulcke, L., Rixen, M. Super-ensemble techniques applied to wave forecast: Performance and limitations. *Ocean Science*, Vol. 6 (2), pp. 595-604.

Lenartz, F., Mourre, B., Barth, A., Beckers, J.-M., Vandenbulcke, L., Rixen, M. Enhanced ocean temperature forecast skills through 3-D super-ensemble multi-model fusion *Geophysical Research Letters,* 2010, Vol. 37 (19), art. no. L19606.

Lenartz, F., Beckers, J.-M., Chiggiato, J., Troupin, C., Vandenbulcke, L., Rixen, M. Super-ensemble techniques applied to wave forecast: Performance and limitations *Ocean Science Discussions,* Vol. 7 (2), pp. 709-737.

Magaldi, M.G., Özgökmen, T.M., Griffa, A., Rixen, M. On the response of a turbulent coastal buoyant current to wind events: The case of the Western Adriatic Current. *Ocean Dynamics,* 2010, Vol. 60 (1), pp. 93-122.

Pastore, T.J., Djapic, V. Improving autonomy and control of autonomous surface vehicles in port protection and mine countermeasure scenarios. *Journal of Field Robotics,* 2010, 27 (6), pp. 903-914.

2010 Publications, continued

Journal Articles (published), continued

Ehlers, F., Fox, W.F.J., Maiwald, D., Ulmke, M., Wood, G. Advances in signal processing for maritime applications. *Eurasip Journal on Advances in Signal Processing* 2010, art. no. 512767.

Grasso. R., Cococcioni, M., Rixen, M., Baldacci, A. A decision support architecture for maritime operations exploiting multiple METOC centres and uncertainty. *International Journal of Strategic Decision Science*, 2011, Vol. 2 (1), pp. 1-27.

Groen, J., Coiras, E., Williams, D.P. Effective false alarm rejection for sea mine classification. *Sea Technology*, March 2011.

Hamilton, M.J., Kemna, S., Hughes, D. Anti-submarine warfare applications for AUVs: the GLINT09 sea trial results. *Journal of Field Robotics Special Issue* (Maritime USVs and AUVs), 2010, Vol. 27, pp. 890-902.

Harrison, C.H. The relation between the waveguide invariant, multipath impulse response and ray cycles. *Journal of the Acoustical Society of America*, 2011, Vol. 129, pp. 2863-2877.

Sabra, K.G., Conti, S., Roux, P., Akal, T., Kuperman, W.A., Stevenson, J.M., Tesei, A., Guerrini, P., *Journal of the Acoustical Society of America,* Vol. 127 (6), pp. 3430-3439.

Siderius, M., Song, H., Gerstoft, P., Hodgkiss, W.S., Hursky, P., Harrison, C. Adaptive passive fathometer processing. *Journal of the Acoustical Society of America,* Vol. 127 (4), pp. 2193-2200.

Signell, R.P., Chiggiato, J., Horstmann, J., Doyle, J.D., Pullen, J., Askari, F. High-resolution mapping of Bora winds in the northern Adriatic Sea using synthetic aperture radar. *Journal of Geophysical Research C: Oceans,* 2010, Vol. 115 (4), art. no. C04020.

Trees, C., Sanjuan Calzado, V., Besiktepe, S. Improving optics-physics-biology coupling in ocean ecosystem models. *Eos,* 2010, Vol. 91 (16), p. 144.

Williams, D. Label-alteration to improve underwater mine classification. *IEEE Geoscience and Remote Sensing Letters*, 2011, Vol. 8 (3), pp. 488-492.

Journal articles submitted or accepted for publication

Anderson, S., Sabra, K., Zakharia, M., Sessarego, J.P. Time-frequency analysis of bistatic acoustic scattering from a spherical elastic shell. *Journal of the Acoustical Society of America*, submitted for publication.

Bouchage, G., Zakharia, M. The effect of sea surface roughness on inversion procedures. *Acta Acustica* united with *Acustica*, submitted for publication.

Coiras, E., Lo-Iacono, C., Gracia, E., Danobeitia, J.HJ., Sanz, J.L. Automatic segmentation of multi-beam data for predictive mapping of benthic habitats. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, accepted for publication.

2010 Sea Trials and Engineering Tests

Automatic Sea Vision Demonstration	28 - 29 January	NURC waterside, La Spezia
MUSCLE engineering trial	18 - 24 January	La Spezia coastal waters
SECTRONIC Build 2	18 January - 5 February	NURC waterside, La Spezia
TOSSA & CPAM systems engineering test	15 - 19 February	West of Palmaria Island, La Spezia
MUSCLE engineering trial	22 - 25 March	La Spezia coastal waters
Scanfish and Slocum undersea gliders	15 - 19 March	West of Palmaria Island, La Spezia
MUSCLE engineering trial	19 - 22 April	La Spezia coastal waters
CASW'10 engineering trial	6 - 15 April	West of La Spezia
SIRENA'10	30 April - 14 June	Atlantic Ocean, SW of Portugal
Radar Based Surface Current and Wave	1 May - 30 September	Ligurian Sea
ITN MUSCLE AUV training	4 - 7 May	La Spezia coastal waters
AMiCa'10 (Autonomous Mine Clearance)	14 May - 10 June	Bay of La Spezia
NURC's glider fleet engineering test	16 June - 16 July	Ligurian Sea
ARGOMARINE AUV tests	11 - 14 July	Marciana Marina (Elba)
GLINT'10	28 July - 16 August	South of Elba
REP'10 (Recognized Environmental Pic-	30 August - 3 September	Ligurian Sea and Gulf of Lyons
ANT2010 special engineering trial	23 - 29 September	Murter, Croatia
AUTOLARS engineering test	14 - 15 October	Gulf of La Spezia
MUSCLE engineering trial	4 - 8 October	La Spezia coastal waters
ANT'10 (Autonomous Neutralisation Trial)	3 - 30 November	Elba in the Tuscan archipelago
NURC's glider fleet engineering test	10 - 22 November	Ligurian Sea
CLEANSEA engineering trial	2 - 10 December	La Spezia coastal waters
HYPEREX: technology validation	7 December	NURC, La Spezia
XPS REC engineering trial	2 - 3 December	La Spezia coastal waters

Summary of Articles in Italian

Costruire un significativo programma di ricerca

Il Centro supporta l'attuale trasformazione militare interna alla NATO, sviluppando il proprio lavoro in quattro settori (contromisure mine, guerra sottomarina, sicurezza marittima, conoscenza ambientale ed efficacia operativa) che caratterizzano tutte le ricerche condotte al suo interno. L'opera del NURC è poi rafforzata da altrettante competenze chiave, di ambito interdisciplinare, come la conoscenza dei processi oceanici, lo sviluppo tecnologico, la sperimentazione in mare e le attività di rete e collaborazione.

Leggere l'oceano attraverso radar marini

I radar marini sono diffusi e usati principalmente per finalità di controllo del traffico navale e di sicurezza della navigazione. Fanno parte dell'equipaggiamento di quasi tutte le piattaforme offshore che sulla maggior parte delle navi. Grazie all'aggiunta di componenti hardware prefabbricate e software sviluppati dal NURC, il radar può essere anche utilizzato come sensore per monitorare venti, onde, correnti marine nonché altre caratteristiche della superficie oceanica che risultino utili per le operazioni commerciali e militari in mare aperto o nei porti.

Una nuova flotta NATO: una soluzione migliore per la sorveglianza e la ricerca

Nel rispetto degli approcci tradizionali nella ricognizione navale e nella ricerca oceanografica, le Marine Militari dei Paesi NATO stanno cercando modalità più vantaggiose e continuative per il monitoraggio sui mari. La soluzione potrebbe essere costituita da una nuova flotta NATO di veicoli autonomi sottomarini e di superficie, la cui efficacia è già dimostrata già impiegati dal NURC in svariati settori, come la sorveglianza sottomarina, le contromisure mine, la protezione dei porti, la conoscenza ambientale e le operazioni offshore. La nuova flotta di veicoli autonomi che si sta andando così a configurare può offrire alla NATO un numero considerevole di vantaggi in più rispetto alle tecniche tradizionali di ricerca e vigilanza: tali mezzi sono, infatti, relativamente economici, piccoli, discreti, in grado di lavorare anche in bassi fondali, senza esporre il personale che li gestisce a possibili pericoli.

Comunicazioni sottomarine: la Torre di Babele e il Cocktail Party

Sono numerose attualmente le sfide nelle comunicazioni sottomarine. In tali contesti, il suono si trasmette infatti piuttosto lentamente, il ché può talvolta portare a messaggi troncati e tempi lunghi di recapito. Inoltre, poiché la maggioranza dei produttori di modem usa sistemi riservati per codificare i dati in segnali acustici, modem diversi non possono comunicare tra loro, rendendo difficile per le Marine Militari dei Paesi NATO un coordinamento degli sforzi in programmi che richiedono interoperabilità, come ad esempio quelli inerenti le reti sottomarine di sensori. A tal proposito, il NURC sta lavorando a un linguaggio standard chiamato JANUS, basato su un semplice metodo di codificazione che potrebbe essere facilmente adottato da un ampio numero degli attuali produttori di modem. JANUS è un software open-source liberamente distribuito sul sito www.januswiki.com, il cui standard viene continuamente sviluppato e raffinato da una community di specialisti. Il NURC sta anche predisponendo uno standard idoneo a definire una migliore governance delle comunicazioni in presenza di una molteplicità di modem, e sta predisponendo un modello di architettura semplice per facilitare la comunicazione nei sistemi complessi.

Verso una più avanzata sicurezza marittima

Nel 2010 il Programma di Sicurezza Marittima del NURC si è concentrato su due obiettivi principali:

- la conoscenza della situazione operativa in mare che può essere riassunta nella domanda: questa nave si sta comportando in maniera tale da richiedere indagini ulteriori?
- la protezione dei porti, che ci porta a chiederci: come possiamo assicurare la sicurezza dei nostri

Summary of Articles in Italian, cont.

porti, spesso localizzati in aree densamente popolate, contro il rischio di potenziali intrusioni?

Il NURC sta provando a rispondere a tali quesiti lavorando sulle minacce emergenti, con sistemi di interdizione marittima e di protezione anti-terrorismo, strategie di contrasto alla pirateria e meccanismi di autoprotezione per navi mercantili adibite a finalità commerciali.

Minimizzare i rischi per i mammiferi marini

Il 2010 ha segnato per il NURC l'inizio della seconda decade di ricerca sulla mitigazione dei rischi riguardanti i mammiferi marini, anche in ragione degli obiettivi raggiunti nel periodo precedente, dedicato allo sviluppo di:

- un modello di habitat per i mammiferi marini nelle aree dove le navi NATO conducono abitualmente test con sonar attivo;
- strumenti hardware e software di supporto nell'individuazione dei mammiferi marini;
- politiche, protocolli, linee guida per la pianificazione di operazioni con il sonar attivo;
- sensibilizzazione pubblica e programmi educativi.

A partire da tale esperienza il Centro continuerà ad assicurare nel tempo all'Alleanza Atlantica e ai Paesi aderenti, gli strumenti e le informazioni necessarie per poter utilizzare il sonar attivo con rischi minimi per i mammiferi marini. Il contributo del NURC è di fondamentale importanza per la ricerca scientifica, l'avanzamento tecnologico, la conduzione di test sonar nel Mediterraneo e nel Nord Atlantico, nel pieno rispetto dell'ambiente.

Promuovere la collaborazione attraverso software open-source

La missione primaria del NURC è quella di sviluppare prodotti in grado di anticipare le necessità delle Marine Militari dei Paesi NATO. Storicamente, il NURC ha perseguito questo obiettivo attraverso lo sviluppo di hardware e software concepiti ad hoc. Nonostante questo tipo di prodotti possano offrire importanti spunti di avanzamento tecnologico, sembrano essere costosi, difficili da integrare in sistemi esistenti e ardui da condividere anche tra nazioni NATO. Per rendere più semplice la collaborazione, razionalizzare i costi, permettere una più naturale integrazione con i sistemi esistenti, scienziati e sviluppatori del NURC hanno cominciato recentemente a usare software open-source in diversi programmi. Per esempio la piattaforma MOOS-IvP è una suite di programmi open-source che permettono a squadre di esperti programmatori di concepire robot, in questo caso veicoli autonomi di superficie e sottomarini. MOOS-IvP è in uso al Centro in diversi progetti inerenti alla protezione dei porti, alle contromisure mine e alla sorveglianza sottomarina.

Nutrire la prossima generazione di scienziati e ingegneri

Il Student Autonomous Underwater Vehicle Challenge – Europe (SAUC-E) è una competizione internazionale che cerca di incoraggiare giovani scienziati e ingegneri ad intraprendere carriere nel settore della tecnologia sottomarina, facendoli incontrare con gli attori coinvolti in quest'area di ricerca e sviluppo. La gara solitamente include una missione da compiersi con un AUV, articolata in una serie di prove studiate dagli organizzatori. Questi test, quali per esempio il superamento di una barriera sottomarina o il controllo di una conduttura, vengono portati a termine in un contesto realistico appositamente ricreato.
Evento ormai annuale dal 2006, il SAUC-E è stato ospitato per la prima volta dal NURC nelle acque antistanti il Centro nel 2010 e lo sarà ancora nel 2011 e nel 2012. Per lo sforzo di divulgazione di cui è portatrice, l'iniziativa è stata premiata a Roma con il J. Guy Reynolds Memorial/MAST Award durante l'edizione 2010 della Maritime Systems and Technology Conference. L'inizio del SAUC-E '11 è previsto per il 4 luglio. Per maggiori informazioni consultare il sito www.sauc-europe.org.

Summary of Articles in French

Construire un Programme de Recherche Pertinent

Le Centre supporte l'actuelle transformation militaire au sein de l'OTAN, en développant son activité de recherche autour de quatre domaines d'application et autant de compétences clés. Les premiers sont la guerre des mines, la lutte sous la mer, la connaissance de l'environnement et l'efficacité opérationnelle et la sécurité maritime. Les compétences clés de nature interdisciplinaires servent de base aux travaux entrepris au NURC connaissance des processus océaniques, développement technologique, essais en mer et activités de réseau et collaboration.

Lire l'Océan à Travers les Radars Marins

Les radars marins, largement répandus, sont principalement employés pour le contrôle du trafic maritime et de la sûreté de la navigation. Ils sont installés sur presque toutes les plates-formes offshore et sur la plupart des navires. En ajoutant des composants matériels disponibles sur étagères et un logiciel développé au NURC, le radar peut être aussi utilisé comme capteur pour surveiller vents, vagues et courants marins ainsi que d'autres caractéristiques de la surface océanique d'une grande utilité pour des exploitations commerciales et militaires en haute mer ou dans les ports.

Une Nouvelle Flotte OTAN : une Meilleure Solution pour la Surveillance et la Recherche

Avec le plus grand respect pour les méthodes traditionnelles de reconnaissance navale et de recherche océanographiques, les Marines de l'OTAN recherchent des méthodes moins couteuses et plus permanentes pour la surveillance des océans. La solution pourrait être une nouvelle flotte OTAN de véhicules autonomes sous-marins et de surface. Au NURC, les véhicules autonomes sont déjà utilisés dans tous les secteurs d'application cités.

Cette nouvelle flotte de véhicules autonomes offre à l'OTAN de nombreux avantages par rapport aux techniques traditionnelles de recherche et surveillance : de tels moyens sont, en effet, relativement peu coûteux, petits, discrets ; ils peuvent être utilisés en petits fonds et permettent de tenir le personnel à l'écart des risques.

Communications sous-marines : la Tour de Babel et le Cocktail Party

Les défis dans le domaine des communications sous-marines sont actuellement nombreux. En ces contextes, le son se transmet en effet plutôt lentement, en causant le retranchement des messages envoyés et temps longs pour leur remise.

La majorité des producteurs des modems sous-marins emploie des systèmes propriétaires pour coder les données en signaux acoustiques, ce qui signifie que des modems différents ne peuvent communiquer entre eux. Ceci complique la tache de coordination des marines de l'OTAN au sein de programmes nécessitant une interopérabilité, comme, les réseaux sous-marins de capteurs.

Le NURC propose un langage standard appelé JANUS, méthode de codage simple pouvant être utilisée par un grand nombre de constructeurs de modems.

JANUS est un logiciel à architecture ouverte et distribution libre (www.januswiki.com), où le standard est sans cesse amélioré par le club des utilisateurs. Le NURC travaille aussi sur un standard de contrôle des communications dans le cas de multiples modems. Il propose un modèle d'architecture optimisée permettant de simplifier la communication dans des systèmes complexes.

Vers une Sécurité Maritime plus Avancée

En 2010 le programme de la sécurité maritime du NURC s'est focalisé sur deux objectifs principaux :

- l'alerte maritime anticipée ; ce navire possède-t-il un comportement suspect nécessitant un examen plus approfondi?
- et la protection portuaire ; comment assurer la sécurité des ports, localisés dans aires fortement peuplées, contre le risque de potentielles intrusions?

Summary of Articles in French, cont.

Le NURC répond à ces questions pour aider à se prémunir de menaces émergentes : interdiction maritime, protection des forces contre les terroristes, opérations anti-piraterie et autodéfense des navires marchand.

Minimiser les Risques pour les Mammifères Marins

L'année 2010 a marqué, au Centre, le début d'une seconde décade de recherche sur la mitigation des risques concernant les mammifères marins.

La première décade a conduit à l'aboutissement des objectifs originaux du programme qui ont couvert le développement de :

- un modèle d'habitat pour les mammifères marins dans les zones courantes d'opération des navires OTAN avec un sonar actif,
- instruments et outils logiciel pour la détection de mammifères marins,
- politiques, protocoles, directives pour la planification d'opérations avec sonar actif,
- sensibilisation publique et programmes éducatifs.

Le Centre s'appuie sur ces succès pour continuer à assurer aux nations de l'OTAN les outils et informations nécessaires à l'utilisation des sonars actifs avec un risque minimal pour les mammifères marins.

Le Centre est le pivot permettant de fournir de la recherche scientifique, des avancées technologiques et des conseils pour effectuer des essais sonars respectueux de l'environnement dans la Méditerranée et le Nord Atlantique.

Encourager la Collaboration à Travers des Logiciels Open-Source

La mission première du NURC est de développer des produits anticipant les besoins de Marins de l'OTAN.

Historiquement, le NURC y est parvenu en développant des instruments et des logiciels spécifiques. Même si ces produits peuvent conduire à d'importantes avancées technologiques, ils peuvent être coûteux, difficiles à intégrer dans les systèmes existants et ardus à partager entre les nations de l'OTAN.

Afin de faciliter la coopération, de rationaliser les coûts et de faciliter l'intégration dans des systèmes existants, les chercheurs et développeurs du NURC ont récemment commencé à utiliser des logiciels open-source dans de nombreux programmes du centre.

A titre d'exemple, la plate-forme MOOS-IvP est une suite de programmes open-source qui permettent aux équipes de chercheurs et programmeurs de programmer des robots, dans ce cas, des véhicules autonomes de surface et sous-marins. MOOS-IvP est employée au Centre dans plusieurs projets concernant la protection des ports, la lutte contre les mines et la surveillance sous-marine.

Encourager la Prochaine Génération de Chercheurs et Ingénieurs

Le « Student Autonomous Underwater Vehicle Challenge – Europe » (SAUC-E) est une compétition annuelle visant à encourager des jeunes étudiants à embrasser une carrière dans les technologies sous-marines et de les mettre en contact avec les organismes du domaine.

La compétition inclut une mission d'AUV qui doit être accomplie de façon autonome dans des conditions réalises. Elle consiste en une série de taches prédéfinies comme le passage d'une porte ou l'inspection d'un pipeline.

Initié en 2006, SAUCE-E a été accueilli par le Centre dans son port en 2010 et le sera encore en 2011 et 2012.

Pour cet effort de sensibilisation, le Centre a reçu le prix J. Guy Reynolds Memorial/MAST Award pendant l'édition 2010 de la conférence Maritime Systems and Technology. SAUC-E 2011 débute le 4 juillet (www.sauc-europe.org).

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