NATO OTAN

The Centre Quarterly

NURC

PARTNERING FOR MARITIME INNOVATION

March 2011

Gliders Contribute Successfully to Proud Manta 11 Exercise

For the first time, NURC participated in full-scale anti-submarine warfare (ASW) exercise using gliders to gather *in situ*, three-dimensional environmental data to support operational planning for a major NATO exercise. Proud Manta 11 was held off the coast of Sicily from 14 January to 11 February and involved ships, aircraft, and submarines from 10 NATO nations. The overall objective of the exercise was to test and refine NATO's anti-submarine detection and tracking capabilities. Working in an area of 6,000 square kilometres, hunting submarines is a challenging task that is met with the use of active sonar, passive sonar, magnetic anomaly detection, and visual observation. Gliders offered a new element to these traditional ASW approaches.

A glider is a type of AUV that uses a buoyancy engine to control its pitch, allowing the vehicle to dive and surface, and it uses shifts in mass to change course. Unlike traditional AUVs that use propellers and have high energy requirements, gliders have low energy requirements, which allows them to stay at sea for months at a time.
Continued on p. 2

NURC staff recovering a Slocum glider, one of three that gathered continuous, real-time environmental data during Proud Manta 11.

NURC Partners with MIT to Improve Mine Countermeasures

As part of its mine countermeasure program, NURC is working with MIT and other partners to use autonomous underwater vehicles (AUVs) for mine countermeasures (MCM). Using autonomous vehicles keeps NATO personnel out of harm's way. Using multiple AUVs is a possible way to exploit novel sonar technologies and improve NATO's ability to find and dispose of mines.

The Shallow Water Autonomous Mine Sensing Initiative (SWAMSI) is a U.S. Office of Naval Research program aimed at leveraging MIT's GOATS concept. GOATS (Generic Ocean Array Technology Sonar) is an approach to MCM that uses a fleet of sonar-equipped autonomous vehicles in shallow water to map objects on the surface of the seafloor or buried under the seafloor. A technology known as multistatic sonar, using multiple sonar sources and receivers on separate platforms, is being investigated as a way to get more information about the seafloor and objects on or in it, as opposed to using traditional monostatic sonar with one transmitter and one receiver on a single platform. The potential improvements require sophisticated algorithms and software, which are being developed primarily by MIT and its collaborators for this program.

For SWAMSI, an experiment was carried out jointly by NURC and the MIT Laboratory for Autonomous Marine Sensing Systems (LAMSS). Conducted in La Spezia harbour, 10-21 January, the objectives of SWAMSI'11 included gathering large amounts of data to validate sonar models and demonstrating the ability of AUVs to work collaboratively and adapt autonomously to the environment.

In the GOATS concept, AUVs travel through shallow water in a coordinated configuration to map the sea floor (Figure 1). The
Continued on p. 2

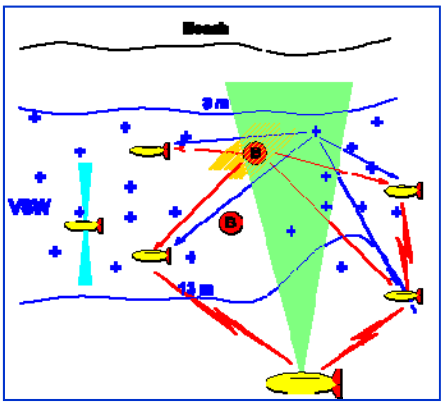

Figure 1. *SWAMSI is an approach to mine countermeasures that uses a fleet of AUVs and a low-frequency source to find man-made objects (the red Bs).*

Proud Manta 11, *continued*

For this exercise, two shallow-water gliders and one deep glider were operated continuously for 18 days, sending data every three hours through the Iridium satellite system to a command and control room at NURC. The three gliders provided a complete and real-time synthesis of environmental data to support improved operational planning and decision-making tools. According to Dr. Michel Rixen, NURC's Scientist in Charge for these exercises, "Glider data can be exploited continuously in ocean prediction systems and anti-submarine warfare tactical decision aids to support and optimize operational planning and asset management. For example, temperature salinity and optical data help us to understand environmental conditions that impact the operational effectiveness of submarines".

Proud Manta operations personnel were pleased with the additional capabilities that the gliders provided. According to one operations specialist, "Our interaction with the NURC glider team was very efficient and allowed us to fully automate the data assimilation process while keeping some oversight on platform guidance inputs. The data from the gliders was used in real-time and made a noticeable impact in improving the quality of the ensemble forecast in environmental variables important in operational planning, thus providing a good testing and validation data set".

SAUC-E'11

Student Underwater Vehicle Challenge—Europe

Find out how to sign up your team at **www.sauc-europe.org** and visit us on Facebook.

Perseus Project Gets Underway

The European Commission security research project known as PERSEUS held its kickoff meeting in the headquarters of the Guardia Civil in Madrid, Spain, 2-3 February. The project aims to improve EU maritime border security, particularly regarding information sharing and small boat detection and tracking. NURC is one partner among 29 making up the PERSEUS project team. The €27.8 million research project runs for 4 years and will include two major technology demonstrations, one in the western Mediterranean in 2013 and one in the eastern Mediterranean in 2014.

Mine Countermeasures , *continued*

objective is to detect and classify man-made objects, such as mines, using low-frequency sonar. Each AUV is controlled by robotics software that includes adaptive autonomous behaviours, such as circling a stationary target or keeping a moving target abreast. A communication network allows the AUVs to share the information that they gather.

For SWAMSI'11, two of MIT's AUVs and one of NURC's were used. The two MIT AUVs were used as receivers and the NURC AUV towed the TOSSA source and the SLITA thin array, both developed at the Centre. Two dockside vans provided a command and control centre. The software used on all vehicles was the MOOS-IvP software developed at MIT. (For more information on MOOS-IvP, see the September 2010 issue of the Centre Dozen.) A number of targets similar in size and shape to mines were placed in the test area.

SWAMSI'11 was a success in both its objectives: The AUVs gathered a large set of multistatic (and monostatic) data, and the AUVs ran a number of missions where they operated autonomously to find and identify targets and coordinated their efforts to avoid collisions. Figure 2 shows one multistatic mission where the NURC AUV towing the sonar source (red) is passing through the test area while the two AUVs from MIT (green and yellow) circle two targets of interest.

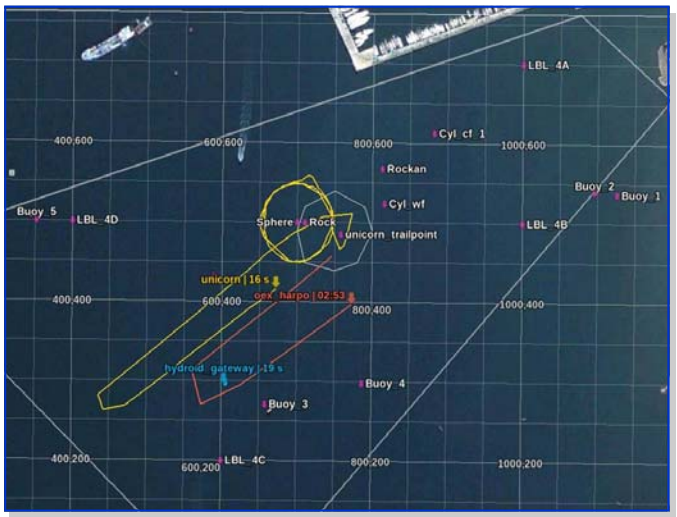

Figure 2. *Results from a mission where three AUVs worked together to find two targets and circle them.*

Researchers will be busy analyzing the large set of multistatic data for some time, but the immediate results from SWAMSI'11 demonstrated the value of using multiple AUVs in a cooperative fashion. The work being done by NURC and MIT is moving NATO closer to a reality where humans are removed from the dangerous work of finding, identifying, and disposing of mines – a job better left for AUVs.

Networking and Communication Team Makes Progress on Many Fronts

The Cooperative Anti-Submarine Warfare (CASW) project conducted a suite of experiments, collectively called ACommsNet10, in and around the Island of Pianosa in Italy's Tuscan Archipelago from 6 September to 1 October 2010. This sea trial was the first organized by the Acoustic Communication and Networking (ACommsNet) research team at NURC, and the objectives were to explore and validate a number of acoustic communication and networking capabilities that had been developed over the previous year as components of the ACommsNet roadmap, released in January 2010.

The specific goals of the ACommsNet10 trial were to test:

- Candidate Medium Access Control (MAC) protocols for underwater acoustic networking (in collaboration with University of Rome and University of Padua)
- A Delay/Disruption Tolerant Networking (DTN) software implementation at sea, enabling robust communication in the face of intermittent connectivity (in collaboration with University of Porto)
- A novel routing algorithm developed at NURC that could be used to support ad-hoc network creation and maintenance
- Modem-based navigation of an autonomous underwater vehicle (AUV), known as the eFolaga, to investigate the benefits of combined communication and navigation protocols (in collaboration with University of Porto and Graaltech)
- The reliability and statistical performance characteristics of four Evologics acoustic modems as a candidate Software Defined Acoustic Modem (SDAM) platform (in collaboration with Evologics)
- An idea, known as the UWAISTED scheme, to convert Automatic Identification System (AIS) signals from surface vessels to an underwater message that can be received and understood by submerged vessels, including autonomous vehicles, to avoid conflicts among assets on and below the surface (a process known as "deconfliction").

A broad suite of assets were deployed, using CRV *Leonardo* as the main platform with two Rigid Hull Inflatable Boats (RHIBs) providing day-to-day support. Below the surface, the Modem-On-A-Rope (MOAR), equipped with both Woods Hole Oceanographic Institute and Evologics acoustic modems, was laid out with the three nodes separated by approximately 1 km each. In addition, the team used six eFolaga hybrid AUV/gliders and three modem gateways (one mounted on a buoy and two used from RHIBs) as a simple and cost-effective way of adding mobile nodes to the communication network. Using this combination of assets, we were able to test the performance of protocols on networks with up to six modems at any one time, both stationary and moving.

The principal goal of the MAC tests was to measure link quality (in terms of percentage of packets correctly received) for various uplink/downlink communication patterns (over different periods of time) for different MAC protocols (CSMA, DACAP, T-LOHI), in single-hop and multi-hop configurations. These protocols have often been simulated, but some have never been tested on a live at-sea network, and certainly not with this many nodes.
Continued p. 4

Some of the many assets used for ACommsNet10 sea trials, loaded on the aft deck of the CRV Leonardo.

The NATO Undersea Research Centre

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

The Centre Quarterly is published four times a year in March, June, September, and December.

Networking and Communication, *continued*

The objective of the DTN experiments was to evaluate the suitability of a reference implementation to create networks composed of heterogeneous links (radio and acoustic) spanning both above- and under-water domains. An open-source software communication framework developed jointly by NURC and University of Porto, known as the Underwater Convergence Layer (UCL), made it possible to use acoustic modems from several vendors. The experiments were successful and the team identified changes needed to convert in-air radio wireless protocols to efficient underwater acoustic ones.

The routing test focused on providing a low-overhead protocol suitable for use in a complex environment with many assets without overly taxing the network. The initial implementation tested during ACommsNet10 is capable of handling the dynamic character of the medium, can link availability to moving nodes, tracks asymmetric links and uses that information to route messages. Preliminary results are encouraging and future trials are planned to further develop the protocol. Of particular interest is that links were often found to be asymmetric, a rare occurrence in terrestrial radio wireless communication and a factor that is usually ignored in protocol design.

An eFolaga can now be controlled by an intelligent payload, on which independent software is running.

With regard to progress in autonomous vehicle engineering, the functionality of the eFolaga hybrid AUV/glider was extended by adding a software module, hosted on a small form-factor Gumstix processor. Provided by the University of Rome, this software offers the capability to directly interpret commands from a generic payload module, posting commands to the vehicle and receiving feedback about the status of the vehicle.

Finally, during the UnderWater AIS TEst for Deconfliction (UWAISTED), an AIS receiver installed in the laboratory onshore was used to create a database of surface traffic, updated every 5 minutes. These database results were used to generate status reports that were broadcast underwater using the JANUS public messaging protocol. The 24 messages were transmitted (each 3 times) using the UAN PASU sonar source from a RHIB. The UAN vertical array (with seven hydrophones) was used to collect acoustic data for off-line decoding and the successful proof-of-concept of UWAISTED. The UWAISTED system is a candidate for experimentation in a future exercise, providing underwater assets an operational picture of surface vessel activity. This capability can help increase safety during submarine surfacing as well as during the operation of all types of underwater assets.

NURC Hosts Visitors from ONR, COMSUBSOUTH and U.S. Navy Sixth Fleet

On February 22, NURC hosted a visit by representatives from the Office of Naval Research (ONR), Commander Submarines Allied Naval Forces South (COMSUBSOUTH), and the U.S. Navy Sixth Fleet. NURC's Director, Dr. Dirk Tielbuerger, and other staff gave a tour of the Centre's facilities and of the NRV *Alliance*, the Centre's 93-meter research vessel. Led by Rear Admiral Nevin Carr of the U.S. Navy Sixth Fleet, the group included LT Michael Chestnut (ONR Flag Aide to the Chief of Naval Research), Dr. Ellen Livingston (ONR – Global, Associate Director), Mr. Chris Marcherfsky (ONR – Global, International Program Officer), CDR Mark Williams (ONR – Global, Regional Director), CAPT. Walter Luthiger (CoS COMSUBSOUTH), Dr. Peter Odgen (NAVEUR/NAVAF CAN Analyst), and Mr. Peter Bodycoat (NAVEUR/NAVAF-C6F ONR Science Advisor).

Visitors learn about the eFolaga hybrid AUV. Left to right: Dr. Joseph Arbour, Deputy Director NURC; Piero Guerrini, NURC; Rear Admiral Nevin Carr, Chief of Naval Research; Captain Walter Luthiger; Dr. Dirk Tielbuerger, Director NURC.