The Centre Dozen

December 2010

PARTNERING FOR MARITIME INNOVATION

Experts Meet to Review Counter-Piracy and –Terrorism Technologies

For three days in November, 120 participants from North America, Europe, Asia, and Australia gathered to focus on the latest counter-piracy and -terrorism technologies and maritime surveillance. Hosted by NURC in Marina di Carrara, Italy, the 2nd International WaterSide Security Conference (WSS2010) featured new developments in:

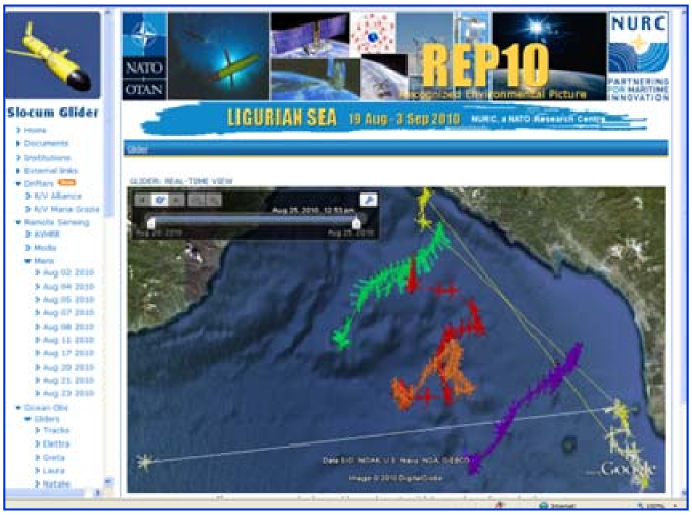
- Detection and tracking of small boats by radar and of underwater intruders by sonar
- Non-lethal response technologies to prove hostile intent and justify the use of force
- Integrated surveillance and response systems
- Unmanned vessels
- Using computer games for maritime security training

The conference opened with a keynote address by Commander S.G. Stein Olav Hagalid, Royal Norwegian Navy, and Branch Head of the NATO Shipping Centre (NSC) in Northwood, London. Commander Hagalid noted that at the time of the conference, 19 merchant vessels and about 430 crew members were being held captive in Somali waters. He emphasized the need for the merchant shipping industry to follow best management practices while looking to the research community for improved technologies in early detection and ship self-protection.

International collaboration was a recurring theme at the conference. Mr. George Loh, Assistant Director of Defence Research and Technology Office of Singapore, said, “Our little territory cannot work alone. We are here at the conference to partner with others in maritime security”. Singapore’s harbour and territorial waters accommodate 33% of the world’s maritime traffic, 50% of the world’s transported oil, and 150,000 vessels annually.

Dr. Ronald Kessel, Conference Chair and Project Manager for maritime Security at NURC, reinforced this message: “Technology developers from many different disciplines need to get together with each other and security providers, military and civilian, in order to counter maritime threats like piracy and terrorism in feasible and sustainable ways”. WSS2010 stimulated this interaction through presentations, interactive workshops and offline discussion. The next conference will be held in Singapore in 2010.

REP10: Helping NATO Operators Make Accurate, Quick Decisions



Navies rely on meteorological and atmospheric (METOC) data and forecasts to gain a better understanding of the environment in which they work. Typical observations and predictions include temperature, wave height, surface currents, and wind speed and direction. Highly trained operators analyze this data to make decisions during naval operations, but manually synthesizing this data and being able to assess its reliability can be challenging for even the most experienced operator. The Centre is developing tools that can help NATO navy operators make accurate decisions more quickly. These tools integrate sophisticated models with software to help operators make accurate, quick decisions. A recent experiment, called REP10 (REP stands for “recognized environmental picture”), focused on the decision support system software that the Centre has developed to help operators manage a fleet of small autonomous underwater vehicles (AUVs) known as gliders.

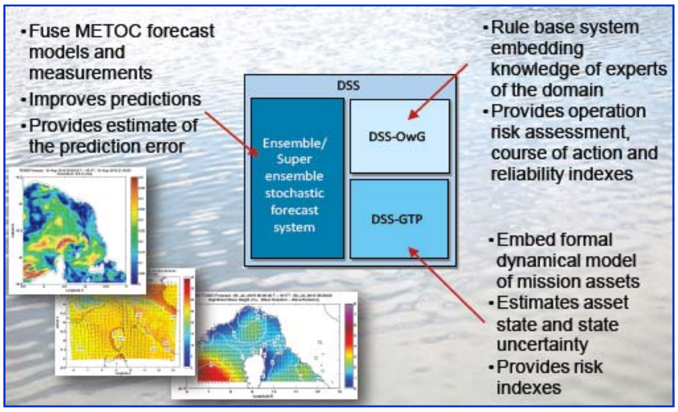
What is a decision support system?

A decision support system is software that provides recommendations to operators based on environmental inputs. It also provides some indication of the reliability of the recommendation. The Centre has been developing decision support systems since 2002 but is now extending that work into the area of AUVs. To date, the Centre has created two decision support systems for gliders: a decision support system for glider trajectory prediction (DSS-GTP) and one for supporting operations with gliders (DSS-OwG), for example glider deployment and recovery. These systems integrate models of glider

Continued on p. 2

REP10, continued

dynamics (DSS-GTP) and rules governing the operations of gliders (DSS-OwG) with powerful forecasting models developed at the Centre, known as "super-ensemble models". As the name suggests, the super-ensemble models are combinations of various models and research at the Centre and elsewhere indicates that the super-ensemble models can provide highly accurate weather and ocean forecasts.



Schematic of the Decision Support System being evaluated

Why a fleet of gliders?

AUVs are being used more frequently in naval operations to monitor areas of interest. Unmanned and stealthy, AUVs are a 21st century solution to anti-submarine warfare, mine countermeasures, environmental monitoring, and port and harbour protection. Gliders are a type of small AUV that offers longer endurance (up to 6 months), which is particularly valuable for long-term environmental monitoring.

Gliders have low energy demands because they are powered by buoyancy engines, which use changes in buoyancy to glide up and down the water column and shifts in mass to steer. Although larger AUVs can patrol an area by towing sophisticated sonar equipment, gliders can be gathering basic oceanographic data. This real-time oceanographic data can be combined with traditional METOC data into models of the marine environment, offering a high degree of accuracy.

Gauging the value

REP10's goal was to develop a methodology of testing the decision support system and whether it was improving the accuracy and speed of operator decision making. Although this is a narrow goal, the REP10 test was the first end-to-end test of an integrated decision support system used to manage a fleet of up to seven gliders. The goal of this experiment might sound simple, but the integrated components that were put into place to achieve this goal were complex and diverse and are the result of years of research and development:

- **Deployment of a fleet of up to seven gliders** thought to be the largest deployment of gliders in Europe
- **Development of a glider control centre** that visually presents METOC and glider data in real time or near real-time to operators who can use this interface to control the glider fleet
- **Data gathering from onboard the NRV *Alliance***, which was used to validate the models and glider data
- **Data gathering from two HF radar stations**, providing real-time surface currents
- **Implementation of two "super-ensemble" models,** which combine multiple models into a single model used to predict temperature and currents and their levels of uncertainty
- **Implementation of two decision support systems**, providing recommendations and a level of certainty to glider operators

During REP10, NURC had two operations experts from the Royal Netherlands Navy (a hydrographic operator and a METOC operator) provide feedback. The operators were given a questionnaire asking them to predict the positions of the gliders and assess the difficulty in deploying or recovering the gliders based on traditional METOC data. The operators were then given the decision support systems for trajectory (DSS-GTP) and operations (DSS-OwG) and were asked again to predict the trajectory and difficulty of deploying and recovering the gliders. The results from this pilot indicated that the methodology is valid. Based on the feedback, refinements will be made so that future tests accurately assess the value of the decision support systems that the Centre develops. The overarching goal is to offer NATO navy decision makers and operators the tools to help them make accurate, quick decisions during operations. Assessing the validity of these decision support tools is an important step to reaching this goal.

Seeking Sponsors for SAUC-E '11

In 2011, NURC will again host the Student Autonomous Underwater Challenge Europe (SAUC-E) competition. We are looking for companies or organizations to sponsor this important programme, which encourages young engineers to pursue careers in underwater technology. Last year's competition brought 9 teams to the Centre to test their AUVs in realistic missions.

In November, NURC was presented with the J. Guy Reynolds Memorial/MAST Award at the MAST (Maritime Systems and Technology) 2010 Conference and Exhibition in Rome for NURC's support of SAUC-E. 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".

http://www.sauc-europe.org

NURC Evaluates Hailing Devices

NURC recently conducted tests of and demonstrations with acoustic hailing devices. These devices are used to broadcast audible warnings and messages over long distances in maritime security scenarios, such as counter-piracy operations and military force protection in ports. As an example, hailing devices can be used to contact persons in a small boat to determine if their intent is hostile.

This is the third time that NURC has conducted tests of loud hailing devices for maritime security in the last two years, each time on different emerging products, in order to characterize them for use by military and civilian security providers in various maritime applications.

Three hailing devices being evaluated at the Centre.

During the recent test, NURC evaluated three products from Ultra Electronics' (USA) line of Hyperspike acoustic hailing devices. NURC reviewers made sound level measurements to characterize the beam strength and width as well as the message fidelity. Ultra Electronics personnel were available for an onsite demonstration for NURC staff, Italian Navy CSSN and COMFORGRAG, NATO military, Italian National Police, Italian Coast Guard, and commercial ship security personnel. The manufacturer demonstrated three models of Hyperspike acoustic devices: the self-contained portable HS-Micro, the long distance HS-16, and the HS-18 RAHD with remote pan-tilt control and a powerful search light.

According to the product's developer, Curt Graber, "The Hyperspike is a very powerful electrical device, broadcasting messages out to 3000 meter distance. We want our users to work in the easiest, most friendly way, so the devices can be connected to a normal mp3 player, such as an iPod, with a remote pan-tilt control option implemented using a familiar videogame joystick."

New Director Takes the Lead at NURC

Dr. Dirk Tielbuerger, Director of NURC

At the beginning of November, the directorship of NURC changed hands from Dr. François-Régis Martin-Lauzer, who has served as the Director from 2006, to the new Director, Dr. Dirk Tielbuerger.

Dr. Tielbuerger most recently served as the Deputy Director and Chief Scientific Officer of the Technical Centre for the Ships and Naval Weapons, Maritime Technology and Research, Eckernfoerde, Germany. Prior to that, he was the Acting Director at the Federal armed forces Institute on Underwater Acoustics and Geophysics in Kiel, Germany.

He previously held positions in Defence and Armament Policy with the German Ministry of Defence as well as the German Federal Office of Military Technology and Procurement in Koblenz. He was a visiting scientist at the Naval Research Laboratory in Washington D.C.

Dr. Tielbuerger holds a Ph.D. in Physics from the University of Heidelberg (1989).

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

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

GLINT10: AUVs Working Together to Track Submarines

This summer, 22 scientists and staff from the Centre were joined by scientists and engineers from MIT's Center for Ocean Engineering, the Naval Undersea Warfare Center, and Bluefin Robotics to test the latest advances in using autonomous underwater vehicles (AUVs) for antisubmarine warfare reconnaissance and surveillance. The GLINT10 experiment was conducted in the Tyrrhenian Sea north of Porto Santo Stefano. 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 sonar poses the greatest technical challenges. The tests 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 localizing, or finding, a target.

Engineers on board the Alliance prepare the OEX AUVs for deployment during GLINT10 exercises.

The scientists used three 21-inch AUVs running MOOS software, which controls the vehicles and allows them to operate autonomously. (See "MOOS: A Powerful Software Program for Robotics Systems" in the September issue of the Quarterly.) Autonomy is important because underwater communication is limited in the amount of data that can be transferred. AUVs must be able to react and adapt to data that they gather from the environment, transmitting only the highest level information among other AUVs and a central "topside" node where information about the environment is collected and shared.

The NRV Alliance served as the base from which the GLINT10 experiment was conducted, while the CRV Leonardo was used to deploy sonar targets. The AUVs used during the experiment included NURC's two Ocean Explorers (OEXs) and MIT's Bluefin21. The OEXs towed the three octave BENS arrays and acquisition systems for the processing of active sonar signals. One OEX also towed the mid-frequency TOSSA source for the transmission of acoustic messages. Both BENS and TOSSA were developed at the Centre. The MIT vehicle was a Bluefin21, which also towed a low-frequency array and acquisition system. All AUVs and the Alliance were fitted with Woods Hole Oceanographic Institute micro-modems for communications.

Two active sonar sources were used during the experiment: the DEMUS moored source and the Atlas MF source. These sources transmitted mid-frequency sonar waveforms that were detected and re-transmitted by an echo repeater deployed off the Leonardo. These signals were also measured by the towed arrays on the AUVs, along with reverberation, clutter, and noise from the underwater environment. Software developed for this project, known as an active sonar processing chain, was carried on each of the Centre's AUVs. The processing chain included beamforming to detect the direction of potential targets of interest, matched filtering to obtain gain against ambient noise and reverberation and detect time of flight, normalization and detection to pull targets of interest out of the beam-time series, and contact formation to feed potential targets to the Centre-developed tracking software, known as the Distributed Multi-Hypothesis Tracker (DMHT). The processing chain also provided target information for the OEXs.

During the GLINT10 experiment, the information used by the AUVs to form decisions was the output from the DMHT. Using MOOS software, several behaviours were developed to respond to that output. These included a collaborative behaviour to minimize the localization error and a behaviour to maximize the future signal-to-noise ratio of a target using a combination of approaching the target while simultaneously trying to keep it at broadside.

For the experiments involving collaborative behaviour, the Leonardo carried a transmitter that simulated the noise of a target of interest. One AUV, equipped with passive sonar processing, detected this target and subsequently activated the DEMUS source by way of an acoustic message. This allowed the second AUV to do active sonar processing. The second AUV's main behaviour was to maximize the future signal-to-noise ratio of the target's track.

The GLINT10 experiment was an important step toward demonstrating adaptive and collaborative use of AUVs for active sonar ASW. A follow-on experiment, GLINT11, is planned for next year where a heterogeneous network of off-board sensors will be used to detect, queue, and track a real target of interest.