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NURC
PARTNERING FOR MARITIME INNOVATION

June 2010

Engineering trial reduces risks of upcoming sea trials

Engineering trials are part of the normal activities of the Centre, especially when there is a need to test, evaluate or calibrate new or recently modified equipment. This is particularly important when major sea trials are planned, in order to reduce the risks of critical equipment not functioning as expected while at sea. The Co-operative ASW Engineering Trial (CASW10 ET) was held in the Ligurian Sea from 6-15 April for just this purpose.

The primary goal of the trial was to investigate and demonstrate the use of the Centre's second Ocean Explorer Autonomous Underwater Vehicle (OEX AUV) that has been developed at the Centre, and to show how it can be used co-operatively with the existing OEX that has been such a successful and reliable part of the Centre's collaborative ASW programme. Both AUVs can pull the Centre's towed arrays; both contain acquisition systems and can carry out onboard signal and data processing, including tracking. Furthermore, both can be configured to work with the Centre's Towed Acoustic Sound Source (TOSSA). The second AUV—called Harpo—has been designed based on lessons learned from the development of the former—called Groucho. This has allowed the AUV to be designed, engineered and to be ready for at-sea tests, gathering useful data, in less than a year.

Above: Harpo and Groucho on the deck of the NRV Alliance. CASW10 ET was the first opportunity to deploy the two vehicles together.

As part of the same programme of work NURC's Engineering Department has developed two new towed arrays which were to be tested during the CASW10 ET. One array has been constructed with small triplets of hydrophones to allow the array to break the left-right ambiguity problem which is inherent in most standard linear arrays. This technology is becoming standard for frigate based systems. Here, as part of the AUV system development, it will allow NURC researchers to assess the performance improvement and help assess future array development. Several datasets were collected on this array

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University of Girona takes 1st prize at SAUC-E '10

The University of Girona team putting its AUV "Sparus" into the water during the final run

The University of Girona, Spain, triumphed over 8 other teams to win the SAUC-E '10, the 5th Student Autonomous Underwater Challenge Europe. The team's AUV "Sparus" successfully completed a number of mission tasks, established by the event organisers including passing through an underwater gate and performing a "pipeline" inspection, all of which must be performed autonomously by the vehicle. The 2nd prize went to Heriot-Watt University from the UK with its AUV "Nessie V", while ENSIETA from France took home the 3rd prize. The other participating teams were from the 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.) and ESIEA (France).

Prior to the final in-water run, each of the 9 teams had to make oral presentations and write a technical paper describing the vehicle's design and their approach to the mission. The teams were judged on technical merit, mission tasks completed, journal paper, safety of the design, craftsmanship and innovation. SAUC-E '10 was sponsored by the 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) and NURC, the NATO Research Centre who hosted the event.

The University of Southampton team calibrating its AUV in a test tank for before putting it into the harbour

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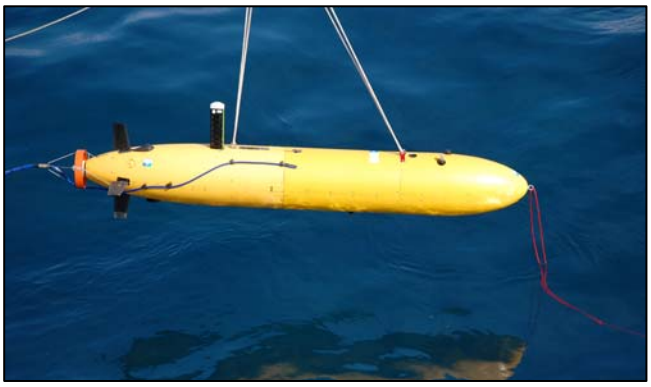
Engineering trial

for post-trial analysis. The other array is a 'thin-line' array which has been developed to reduce the drag of the array to the vehicle and is expected to play an important role for long term AUV missions and glider operations. This array was not tested due to time constraints.

The approach to the Engineering Test was incremental, building up to the last day when both AUVs were in the water. Both AUVs were acquiring data from their towed arrays. One was towing the standard linear array, the other the new triplet array as described above. The opportunity was taken to gather data that would be of scientific use and interest. To that end, during the experiment, the Centre's research ship NRV ALLIANCE acted as an active source transmitting energy around 3kHz and NURC's coastal research vessel LEONARDO, with an Echo Repeater (ER) deployed, acted as a false target. The experimental ranges were relatively short, but it is expected that the dataset will allow researchers the first opportunity to assess the possibility of fusing information across the two AUVs. This data in itself will provide valuable insight in planning for the GLINT 10 trial to be held later in the year.



The new OEX AUV 'Harpo' being lowered from the NRV Alliance for its first at-sea test. The AUV worked perfectly and is expected to work in tandem with the existing AUV: 'Groucho'.

One scientific point of interest of the CASW10 ET was to test some of the latest developments in the Centre's underwater communication effort. There is a move towards a software-defined underwater modem capability so as to make use of the already available acoustic systems onboard to exchange data. This concept was tested by integrating JANUS onboard an OEX AUV. JANUS is a physical layer protocol proposed by NURC, intended to be used for beacon message exchanges. It is currently advancing in the STANAG process to become a standard within NATO nations. Until now the testing with JANUS had been done with pre-encoded, pre-recorded messages. Those tests were conducted to assess performance under varying conditions, essential to properly document the STANAG process. The goal set for the CASW10 ET on the communication front was, for the first time, to integrate and use JANUS in an AUV, decoding incoming messages, generating new communication packets and transmitting them. During the trial, a complete reactive reception and transmission loop was demonstrated between two nodes, one from the NRV ALLIANCE and the other from the OEX AUV. Subsequent work will focus on a scientific assessment of overall performance. The successful demonstration of this concept is an important step towards the eventual goal of configurable, software-defined modems within the CASW project.

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SAUC-E '10

The first SAUC-E started in 2006 to encourage young engineers and scientists to think about underwater technology and its future possibilities, as well as to foster ties between students and the organizations involved in underwater robotic technologies. "The Centre is pleased to organise this year's SAUC-E, and will be hosting the event in 2011 and 2012 as well," said the Director of NURC, Dr. Martin-Lauzer. "We want to be involved in providing students with the opportunity to experience first-hand the challenges of underwater technologies, and to nurture interest in this area of research."

Participating teams arrived on 28 June to put their vehicles into the water during practice runs. For many of the teams, this is the first time their vehicle was tested in a real harbour environment, with dynamic conditions such as changing wave action and salinity levels. The students worked from morning until late in the evening to resolve technical problems and to adjust mission plans and algorithms. After 4 days of practice, all 9 teams qualified for the final runs on 4 July 2010.

Despite the hot weather and various technical/logistical challenges encountered during the week, the level of energy and enthusiasm 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, and that underwater robotics has a bright future and there are still 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 due to time constraints, solve problems with limited resources, and from interaction with other teams, judges and scientists and engineers. These comments reflect the objectives of the SAUC-E, re-iterated by the NURC Director during the awards ceremony: these participants will someday replace the scientists and engineers at the Centre, in the research labs of their own countries and in industry.

Register Now for these NURC affiliated events

(see websites listed below for details)

WSS2010: The 2nd International Conference on Waterside Security
3-5 November 2010, Marina di Cararra, Italy
http://www.wss2010.org

CORALL: short courses on
- Marine Vehicle Autonomy (Sep 2010)
- Port Security (Nov 2010)
- Environmental monitoring (in Italian, Nov 2010)

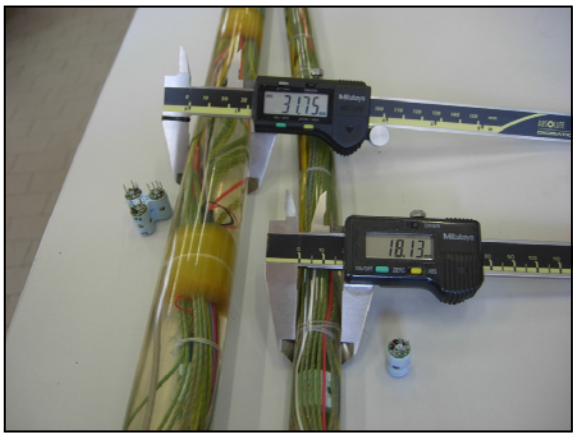
http://www.nurc.nato.int/corall/

MREA 10: Maritime Rapid Environmental Assessment Conference
18-22 October 2010, Lerici, Italy
http://geos2.nurc.nato.int/mrea10conf/

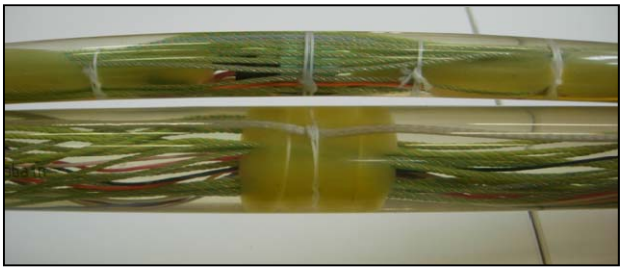
Thin towed array: recent developments

In August 2007, NURC started to design and build a new thin high-frequency (up to 20 kHz) nested towed array (31 mm diameter) and to integrate its electronics and recording device within its OEX AUV. Since then, this array has been extensively used in the cooperative anti-submarine warfare (CASW) trials in 2008 and 2009. At the end of 2009, as part of the CASW programme, the Centre decided to investigate the development of two new towed arrays.

A new array that was built, the TRIBENS, was partially populated with small triplets of hydrophones to allow the array to break the left-right ambiguity problem which is inherent in most standard linear arrays. The array is a 31mm diameter three octaves array populated as well with non acoustic sensors to determine, while at sea, the exact position of the triplets which is critical for data processing. Array data was collected at sea during the CASW engineering trial in April while the array was towed behind the NURC OEX explorer. Preliminary analysis confirmed that the data collected was of very good quality.



Above: Comparison of the diameter size of the TRIBENS and the slim BENS array. Below: close up of both arrays



The second array built is a thinner array with a diameter 18mm which was developed to reduce the drag of the array by an AUV and is therefore capable of being towed by small sized AUVs and gliders currently in the market. In addition to the reduction of array diameter to reduce drag, the slim BENS array was specifically designed to reduce the overall power consumption which is critical for its integration with small vehicles that have low energy availability. Array power consumption has been reduced to 0.7W, compared to the more traditional NURC array which consumes 9.5W. The array has an external diameter of 18mm, a total hosed length of 25.7m and is composed of 46 channels. The array has 3 sets of Non Acoustic Data, (NAD), multiplexed onto a single serial LVDS Data Stream and The array is compatible with the existing OEX /BENS towing and acquisition system. The slim BENS array has been fully built and will be tested at sea in this summer.

CRV LEONARDO reflagged

On 13 May 2010, the NURC Coastal Research Vessel LEONARDO was reflagged from its public status to that of an Italian Navy vessel. VADM Binelli Mantelli, CINCFLEET of the Italian Navy presided over the Reflagging Ceremony at the Centro di Supporto e Sperimentazione Navale (CSSN) Compound adjacent to NURC main building. The vessel, although owned by NATO and whose operations are managed by the NURC, is introduced into the Italian Navy fleet to be manned by Italian Navy crews. This plan, courtesy of the Italian Navy, decreases the cost of operating the vessel for research and increases her availability at sea.

Launched in 2002, CRV LEONARDO is a valuable asset in the NURC programme of work, contributing significantly to the scientific successes of the Centre. The vessel provides excellent access to sea for small research experiments, engineering trials and military experimentation, with an increasing role in AUV and port protection work. It is the smallest research vessel in the world that is fitted with dynamic positioning and substantial deck handling equipment.

NURC Director, Dr François-Régis Martin-Lauzer, together with members of the NURC Management team participated in the re-flagging ceremony. The director expressed his appreciation to the previous CRV LEONARDO Captain Andrea Iacono and his crew, noting that their operational, logistic and technical support had made possible the research activities on the CRV LEONARDO. Thanks also went to Mr. Ian Sage, head of NURC's Ship Management Office, for the well prepared and smooth transition of the CRV LEONARDO to the Italian Navy, and to the Italian Navy for its support of NURC activities. The Director concluded with a welcome to Italian Navy Tenente di Vascello Arico' and his crew who will take over the operations of the vessel.

VADM Binelli also expressed a warm thank you to the NURC crew for serving the vessel so well. He added that the Italian Navy is proud to count a research vessel like CRV LEONARDO amongst the Italian Naval Fleet and that it is an honour to serve NATO and its member countries. The Admiral ended his speech with a popular Italian Navy phrase: "Mari calmi e venti favorevoli" (Calm seas and fair winds).

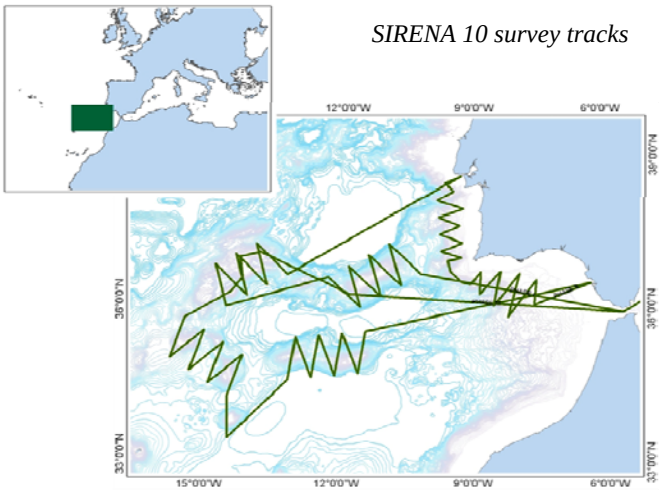
CRV LEONARDO remains an asset owned by the NATO Nations while managed by the Italian Navy. This benefits both the NURC and the Italian Navy as the Centre can count on more usage of the vessel due to continuous staffing by the Italian Navy who in turn will be able to use the spare capacity to support their military scientific activities. The vessel will remain in the NURC compound to allow scientists and technicians easy access for at-sea activities.

SIRENA 10 fielded updated technologies, collected new data

The NURC Marine Mammal Risk Mitigation (MMRM) project conducted the SIRENA 10 sea trial from 30 April to 14 June 2010 in the Atlantic Ocean, southwest of Portugal, aboard the *NRV Alliance*. The objectives of the cruise were to:

- Perform a visual and acoustic survey for marine mammals in an area associated with potential risks of tactical active sonar use.
- Deploy and compare passive acoustic monitoring technologies, including towed arrays and fixed buoys.
- Develop a habitat model of beaked whales and local distribution models of multiple marine mammal species by determining the presence and absence of these animals using visual and passive acoustic methods.
- Investigate the relationship between the physical, chemical, and biological environment and marine mammal distribution.

The sea trial involved the cooperation of 42 scientists and engineers, representing 17 organizations from seven countries. Five passive acoustic systems, three detection and classification algorithms, one identification and data collection system, and one visual data collection system were tested. The sea trial was separated into three phases based on geographical areas. In each phase, a line transect survey was performed using acoustic and visual methods to determine the presence and absence of marine mammals.



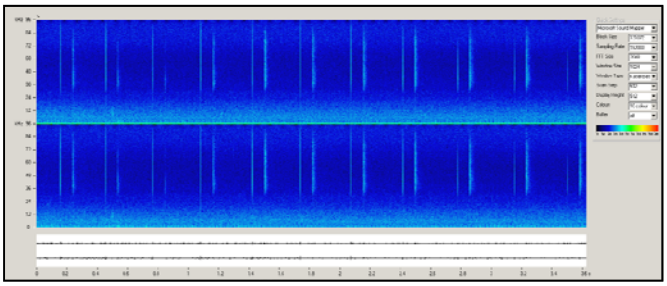
SIRENA 10 survey tracks

The towed passive acoustic technologies evaluated were the Towed Tetrahedral Passive Acoustic Monitor (T^2PAM) and the ALBORAN array. T^2PAM (right photo) is composed of three 5m long oil filled hoses which are attached behind a v-fin body and then towed at a depth of 85 - 100m when towed at speeds between 4 - 4.5kts. The three hoses contain four hydrophones (one hydrophone in each of two hoses and two hydrophones in the third hose) in a tetrahedral arrangement with a 1m spacing, thereby allowing the unambiguous determination of azimuth and elevation of an incoming marine mammal signal. The ALBORAN array is a 15m oil filled hose containing two wideband hydrophones positioned 8m apart. At vessel speeds of 4 kts, the array was positioned at approximately 18m depth. Preliminary data from the ALBORAN array show that in over 300 hours of recording, 210 hours had biological detections. In addition to the towed systems, sonobuoys and six moored buoys were deployed to gather passive acoustic data of marine mammals.

The visual survey was performed by two visual teams, each composed of four persons, who used a combination of big-eyes, regular binoculars, and naked-eye to conduct observations. The survey was conducted in two modes: On-effort and Off-effort. On-effort is defined as observations made from the flying bridge when Beaufort wind force scale was mostly less than or equal to 4. Off-effort observations were made from the flying bridge or bridge in Beaufort scale greater than 4 and also included opportunistic sightings made by other personnel on the ship.

Oceanographic data was collected in situ at selected oceanographic stations, in situ while on transit, and via remote sensing methods concurrent to the surveys. Fifty-three oceanographic stations were performed to collect salinity, temperature, oxygen, and optical parameter data; similar data were also collected from a towed system while the vessel conducted the line transect survey. In addition, sea surface temperature and chlorophyll_a imagery from satellites was downloaded daily.

The acoustic, visual, and oceanographic data collected during this trial will be analyzed and integrated into habitat, distribution, and presence/absence models of marine mammals that are being developed at the Centre. This sea trial supported the overall objectives of the MMRM project which are to develop technologies to enable use of high intensity sound sources while mitigating risk of injury to marine mammals and to develop MMRM guidelines and protocols. The success of this sea trial was largely dependent on the cooperation of and collaboration with international partners from France, Germany, Italy, Portugal, Spain, and the United States.



Probable beaked whale clicks detected below the T^2PAM

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