MINEWARNEWS

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LCS Mission Package Rollout

AOFNC breaks new ground for marine robotics

By Ashley Lovejoy

Nearly three years into Office of Naval Research's (ONR) visionary program to develop Enabling Capabilities (ECs) that will close war fighting gaps, the mine countermeasures system Autonomous Operations Future Naval Capability (AOFNC) is making strides in marine robotics with its synthetic aperture sonar (SAS) imaging and automatic target recognition (ATR).

AOFNC, a system of multiple vehicles, has the automated processing capability to detect and classify proud targets and report its findings to a network that terminates miles from the search area.

AOFNC consists of one search-classify-map (SCM) unmanned vehicle, two unmanned mobile navigation aid vehicles, one communications buoy that converts acoustic communications messages to radio frequency messages, a Very High Frequency to High Frequency (VHF-HF) converter and a manned command and control station on shore. Each component of the system was developed separately. Bluefin Robotics built the SCM unmanned vehicle and Massachusetts Institute of Technology developed two kayaks that provided a moving long baseline (MLBL) navigation subsystem to the network. Pennsylvania State University's Applied Research Laboratory produced the payload hardware which included the

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synthetic aperture sonar, the data acquisition processor, the sonar power supplies and the real-time processor stacks for sonar and automatic target recognition. Naval Surface Warfare Center Panama City (NSWC PC) developed the real-time processes for sonar data imaging, motion compensation for the aperture synthesis and integration of several target recognition algorithms into a program that took advantage of algorithmic diversity to optimize automatic target recognition (ATR).

"AOFNC is a team of vehicles that communicate, cooperate and search an area for mine-like targets," NSWC PC engineer Anthony Matthews said.

Initial demonstration 2006

After three years of development, the multiple institutions came together for their first joint demonstration in December 2006. Targets were placed on the bottom of the Gulf of Mexico, about 60 feet down in two rows of four. The acoustic communications (ACOMM) buoy was anchored about 300 meters south of the target field. Most of the network runs were made on an East-West axis. The SCM vehicle led the network, adjusting course according to the information passed from the MLBL kayaks over the ACOMM link between kayaks and SCM.

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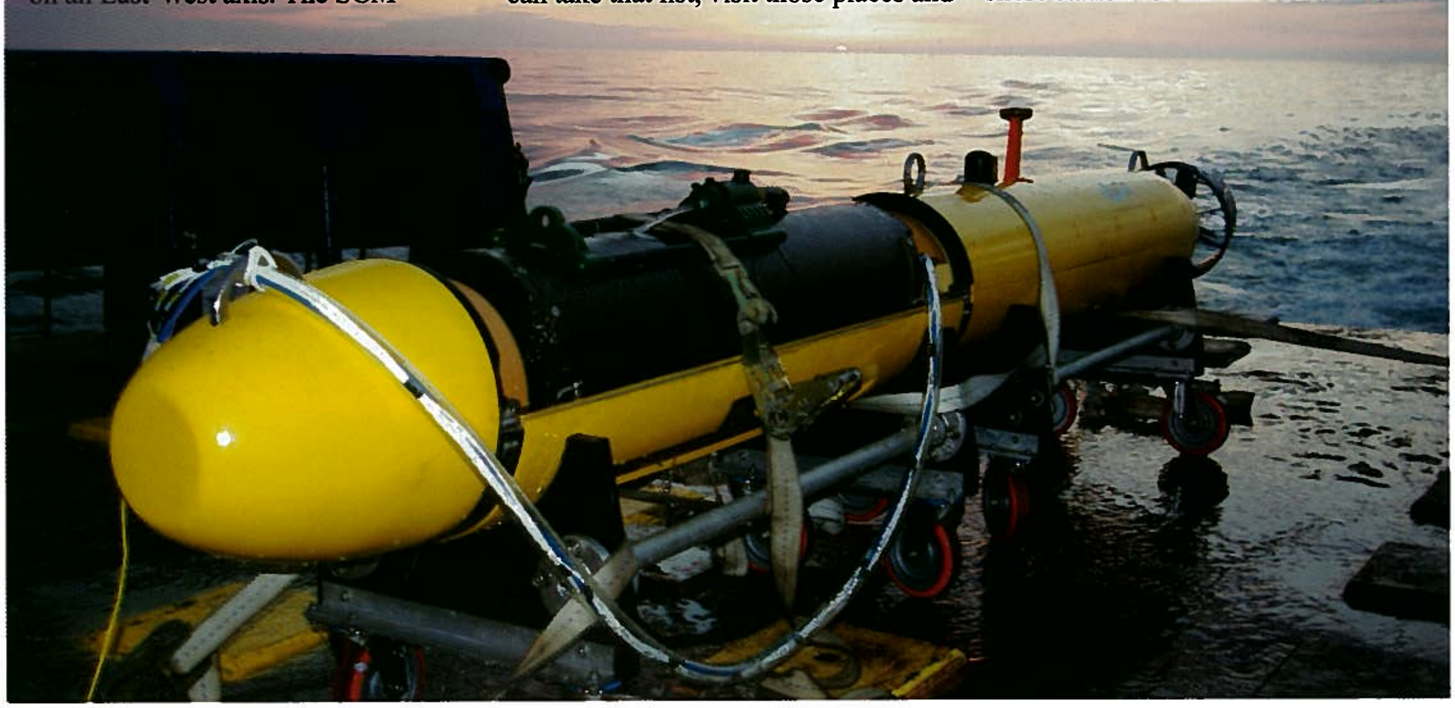
The kayaks were equipped with global positioning system (GPS) receivers. They transmitted their positions periodically to the SCM which, in turn, used these coordinates to determine its own position.

The AOFNC mission of search, classify and map precedes the reacquire, identify and neutralize mission, Matthews said. This system provides a list of contacts that are classifications, image snippets and locations in space. It provides a confidence level of those classifications. Then the RIN phase can take that list, visit those places and raise classification to the more refined level of identification. Matthews said the object is to keep all these vehicles at depth and on mission, avoiding wasteful excursions to the surface for navigation information.

Real time processor stacks, consisting of eight single board computers, ran the NSWC PC programs for motion compensation, aperture synthesis and automatic target recognition (ATR). The ATR evaluated any target that exceeded a detection threshold, assigned a confidence level and calculated a target position. These data were compiled into a contact report that was sent out over the ACOMMS link to the buoy with an image snippet.

These small images were excerpted from the full resolution imagery at the ATR detection locations. The images were then reduced in resolution to accommodate the communications link restrictions. These lower resolution sub images are often referred to as snippets. The buoy forwarded the report over a VHF link to the support ship. This link was mated to the HF radio link that carried the contact reports and snippets to the shore station for human consideration.



All photos by Alexander Bahr
Full page: A kayak provides a moving long baseline (MLBL) navigation subsystem for the AOFNC network. Left page: Bluefin's unmanned vehicle rests in its carrier. Left: An unmanned vehicle is prepared for launch during a demonstration in December 2006. Below: A ship and chase boat follow another boat hauling kayaks to a testing site in the Gulf of Mexico.

ONR gave the demonstration successful marks. Matthews said the test marked a first in the development of marine robotics. It introduced motion compensated synthetic aperture sonar (SAS) imaging to automatic target recognition (ATR) in a real-time operating environment within an autonomous distributed network. A demonstration with these capabilities had not been attempted before. "The success of this attempt represents a watershed event in the history of these technologies in general and marine robotic examination of the sea floor in particular," Matthews said.

AUV Fest 2007

The December 2006 experiment was rerun with modest changes at the June 2007 Autonomous Underwater Vehicle Fest held in Panama City, Fla. These changes included moving the MLBL (navigation aid) functions from MIT's kayaks to Bluefin's UUVs and moving the acoustic communications relay (communications aid) function from the buoy to an MIT kayak. Following the festival, the components of AOFNC were returned to their various owners.

Next up for the system, Matthews said AOFNC is making application for funding so that AOFNC can be integrated into the Undersea Cooperative Cuing and Intervention (UC2I) system starting in October. UC2I will focus on the development of the system's autonomy.