

Continued Enhancement of Autonomous Marine Vehicle Testing in the South Florida Testing Facility Range 2001-2002

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LONG TERM GOAL

The general objective is to investigate basic and applied problems associated with the performance effectiveness of reconnaissance of littoral waters in support of mine warfare and oceanographic tasks.

OBJECTIVE

The future mine counter-measure scenarios will include autonomous underwater vehicle operations with integrated communication and navigation capabilities, built around a network of smart acoustic beacons, and RF buoys for real-time telemetry and control. The autonomous ocean sampling network scenarios will include rapid environmental assessment, ocean modeling and prediction, and tracking plumes and other physical and bio-chemical features and events. The main goal of this work is to develop advanced AUV operational capability in order to support military mine counter-measure and scientific ocean exploration tasks.

APPROACH

To achieve the above-mentioned objective, a set of tasks were adopted to maximize the utility of the Morpheus and Ocean Explorer AUVs developed at Florida Atlantic University. These tasks include expanding the baseline capability of the Morpheus and Ocean Explorer, and demonstrating their operational capabilities.

WORK COMPLETED

The work completed includes 1) characterization of the Morpheus and Ocean Explorer vehicles, 2) enhancement of their operational and development capabilities, and 3) at-sea missions performed since March 2002.

1. System Characterization

On Morpheus, we have determined in the lab a number of problems associated with the video capture software, GPS antenna, LonTalk network connection and its interface to the QNX operating system, and the acoustic modem electronics and connectors. On the Ocean Explorer B, we have determined, in

the lab, that the vehicle passed most of the mission check procedures, and all the LonTalk nodes appeared functional, except only that the fins were unable to maintain positions. All these problems have been dealt with and corrected.

2. Enhancing Operational and Development Capabilities

On the Morpheus, we have improved the systems reliability and flexibility by porting a number of important software programs from the OEX-C platform. We have worked on the side-scan sonar module, specifically its electronics and DSP software. At present, we are able to collect sonar images of fair quality. There needs to be further fine tuning in the DSP code in order to obtain results that are comparable to those on the OEX-B. We have also automated the side-scan usage by developing a look up table which selects the power level and chirp period of a sonar ping based on the operating condition in a given mission. On the mechanical side, we have designed a new control console which is oil filled, modified airflow system to improve the cooling performance of the battery module while charging, worked on the re-packaging of the Navigation module to add IMU/INS system. On the Electrical side, we are developing a WAAS capability (eliminate the DGPS antenna), and are characterizing the gas gauge performance and reliability. All these efforts constitute better reliability and capability on both systems.

In addition to the baseline modules that we have on Morpheus, we have also supported the development and testing of a flapping module designed and built by Nekton Inc. Specifically, we have provided a pressure tested module as the flapping payload, made available our spare fin, thruster and battery modules so that in-water testing could be performed without disrupting the routine work done on the Morpheus.

On the OEX-B, the operating system is VxWorks, and the CPU is based on Motorola 68060. These are very old technologies, which can be dated back to early 1990s. The maintenance becomes problematic due to high-cost associated with VxWorks license and discontinued support of hardware and electronics. Thus, we have upgraded the OEX operating system to QNX 4.25, which is the same as that on Morpheus so that all the vehicles can now share common software architecture and implementation. In addition, we have upgraded the Lon QNX gateway using a MIP 50 card, upgraded the LonTalk node software for self-installation, developed a LonMaker interface for the OEX, and finally added virtual RS232 communication via LonTalk network to Compass, CTD and DVL nodes (may also be added to the GPS in the near future). The final testing for the system upgrade is expected to be carried out in October of 2002.

3. At-sea Operations

We had a major personnel re-organization in our program last year. As a result, we have recruited a new team of AUV engineers, working on both the Morpheus and OEX-B since March of 2002. At the end of May, they were able to perform at-sea operations using Morpheus. The frequency of the sea-going missions has been approximately 1 per week. It should be noted that we have collected the first set of side-scan sonar data using Morpheus at sea. Our routine missions typically consist of video and side-scan survey off the coast of Ft. Lauderdale. Other vehicle data, such as CTD, DVL, TCM2, GPS, and Gyro, are also logged in every mission.

3.1 Biscayne National Park Survey

Besides the routine missions, we have also performed a coral reef survey at the Biscayne National Park during the first week of August of 2002. The main objective of the experiment was to characterize a specific marine habitat area using an airborne LIDAR, an underwater acoustic sonar, and an AUV. These missions were in collaboration with U.S. Geological Survey, NASA, Nova Southeastern University and RSMAS at University of Miami. With a proper permit provided by the National Park Service, we ran four missions in 2 days at both Anniversary Reef (2 meters) and Triumph Reef (50 meters). During these missions, we have collected close to 20Giga bytes of videos and 300Mega bytes of sidescan images.

3.2 Video Survey of the underside of a Boat

We have carried out a mission in which the video camera was mounted right side up. The objective of the mission was to characterize the feasibility of using the Morpheus to carry out surveillance tasks of monitoring the underside of a boat. This capability is in line with the current homeland security policy associated with potential terrorist acts. While we were able to collect video images during the mission, additional effort and funding will be needed to develop deployment logistics and tactics and to run the vehicle autonomously and safely in a cluttered environment, such as harbors.

3.3 Acoustic Communication with Mills Cross

It is planned that an acoustic communication demonstration will be performed towards November of 2002 when the Morpheus has the latest version of the acoustic modem software and electronics implemented, and the Mill Cross is ready for at-sea deployment.

RESULTS

Figure 1 shows the mission status of Morpheus during the Biscayne National Park survey. The vehicle performed an altitude following task with both the video and sidescan sonar. Figure 2 shows both a video image and a sidescan image collected in another Morpheus mission. The video image was a snapshot of a digitized video stream collected near the 2nd reef off Port Everglades using Morpheus when it performed an altitude following mission of 2 meters to the bottom. One can clearly see that the information regarding the vehicle state is displayed on the video image. The sidescan image clearly displays a number of previously deployed targets. We expect that once the DSP software has been corrected, the sonar image will be significantly improved. Figure 3 shows the video snapshot of the underside of the R/V Oceaneer taken in one of the Morpheus missions.

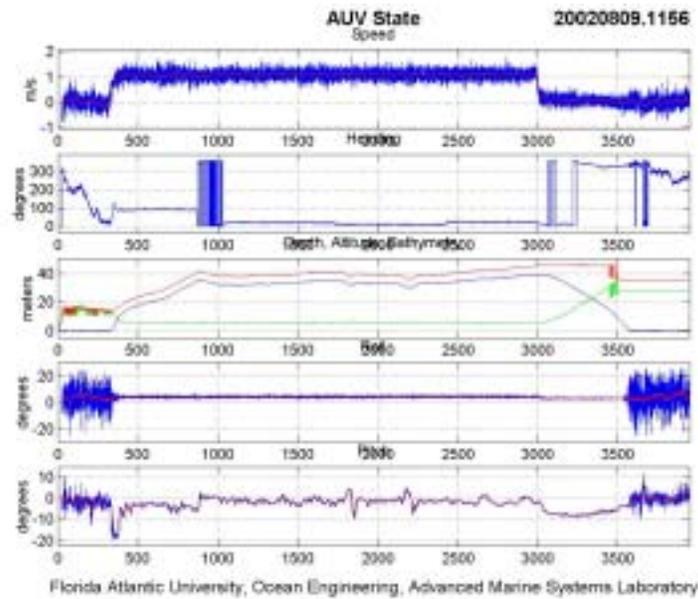


Figure 1. 30m contour, Plot 1 - AUV speed (blue – raw, red – running ave.) ; Plot 2 - heading; Plot 3 - depth (blue), altitude (green), and bathymetry (red); Plot 4 - vehicle roll (blue – raw, red – running ave.) ; and Plot 5 - vehicle pitch (blue – raw, red – running ave.) vs. time (seconds since start of mission)

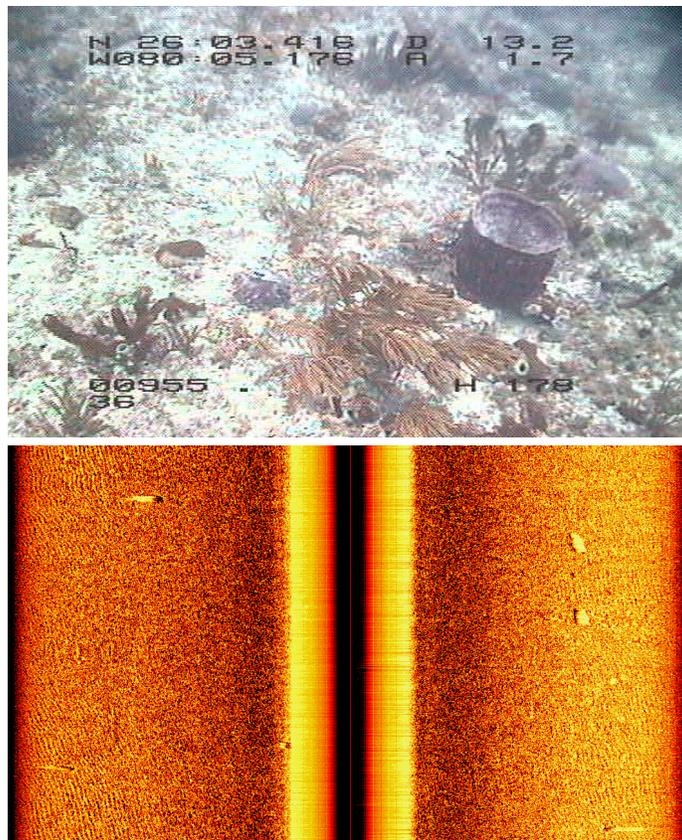


Figure 2: A video snapshot of the 2nd coral reef, and a side scan sonar image of previously deployed targets



Figure 3: A video snapshot of the underside of R/V Oceaneer

From the figure, the Morpheus was programmed to move along the center line of the boat from stern toward bow. Also, one can see the bubbles formed in the view, suggesting potential problems in reading highly detailed information off the boat.

IMPACT/APPLICATION

As a result of this project, the Morpheus and Ocean Explorer vehicles have greatly increased their oceanographic and military capabilities. These added values will prove invaluable in missions such as VSW MCM and newly established homeland security. In addition, the features of vehicle's re-configuration and modularity allow the U.S. military to continue to integrate and test state-of-the-art payloads/sensors as a system, rather than as a sub-system. We believe these features are the key in sustaining future naval capabilities with a long term vision on progressing the sensor and system technology.

TRANSITIONS

The Morpheus has been used in a collaborative exercise with NASA, U.S. Geological Survey, Nova Southeastern University on characterizing a coastal marine habitat.

RELATED PROJECTS

Navigation and Platform Development, ONR (end date: May 2003).

REFERENCES

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- [2] S.M. Smith, E. An, D. Kronen, K. Ganesan, J. Park, and S.E. Dunn, “The Development of Autonomous Underwater Vehicle Based Survey and Sampling Capabilities for Coastal Exploration.” IEEE Oceans 1996, Ft. Lauderdale Florida, Sept. 23 -26, 1996