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NAVAL POSTGRADUATE SCHOOL

Monterey, California

SHALLOW WATER HYDROTHERMAL VENT SURVEY IN AZORES WITH COOPERATING ASV AND AUV

by

A. J. Healey, A. M. Pascoal, R. Santos

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PROJECT REPORT

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NAVAL POSTGRADUATE SCHOOL

Monterey, California 93943-5000

RADM Ellison	R. Elster
Superintendent	Provost

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This report was prepared by:

Anthony J. Healey

Reviewed by:	Released by:
Terry R. Mac Nelley	D. W. Netzer
Department of Mechanical Engineering	Associate Provost and Dean of Research

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Anthony J. Healey, A. M. Pascoal, R. Santos, et. al.

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Naval Postgraduate School

Monterey, CA 93943-5000

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I. SHALLOW WATER HYDROTHERMAL VENT SURVEY IN AZORES WITH COOPERATING ASV AND AUV

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ISR/IST

A. Pascoal

C. Silvestre

P. Oliveira

L. Sebastiao

M. Rufino

J. Alves

Ricardo Serrão Santos, Director

University of the Azores

Department of Oceanography and Fisheries(DOP)

PT- 9901-862 Horta (Azores)

Portugal

Phone: +351.292292944/292292945/ 292292988/ 292293460

FAX: +351.292292659

e-mail: ricardo@horta.uac.pt

www.horta.uac.pt

www.imar.pt

www.pg.raa.pt/oceanos (Forum Oceanos)

IMAR/DOP/UAzores

R. Santos

F. Cardigos

Author: _____

Anthony J. Healey

ABSTRACT

Objectives

- Demonstrate two vehicle communication
- Obtain Video confirmation of Shallow Water Hydro-Thermal Vent Activity using Video with location obtained from an independent source

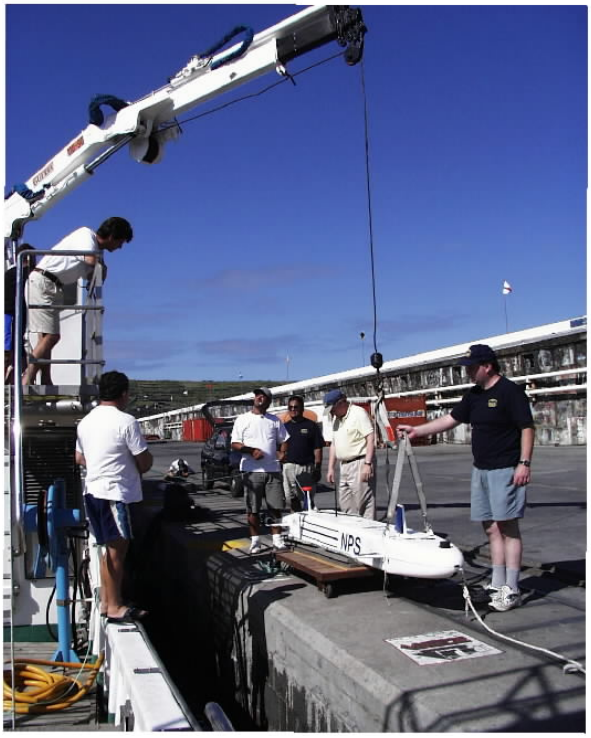
Major Results

- Navigational Accuracy Mostly Errors < 4m Obtained With GPS Popup
- Video Acquisition Obtained Of Vent Area Given Position from Independent Source. Vent bubbles found
- Acoustic Communications Between Delfim And Aries With FAU Modem:
- All commands received were acted upon with no repeats. Commands sent from Delfim to Aries. Ranges up to 700m with 2 vehicles underway.

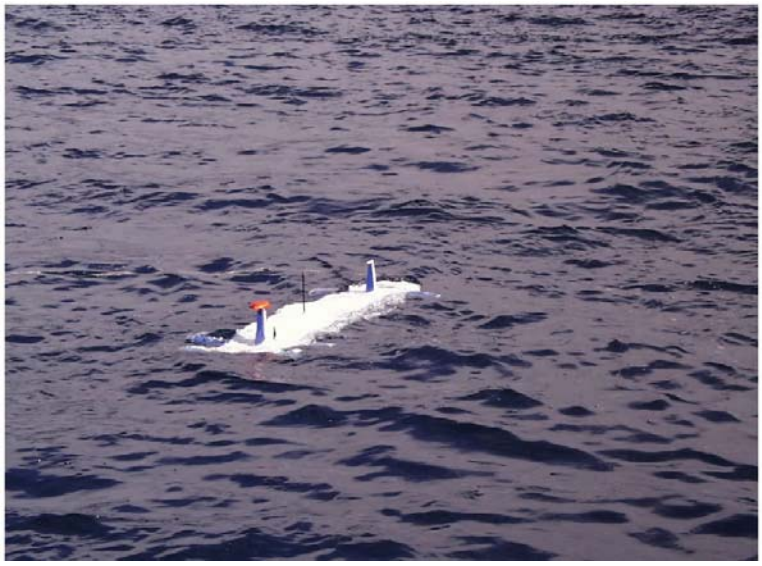
Picture Gallery

Map of The Island of Faial, Azores - Operational Area North East ofHorta

ARIES being Loaded onto the Research Vessel Arguipeligo - August 9, 2001

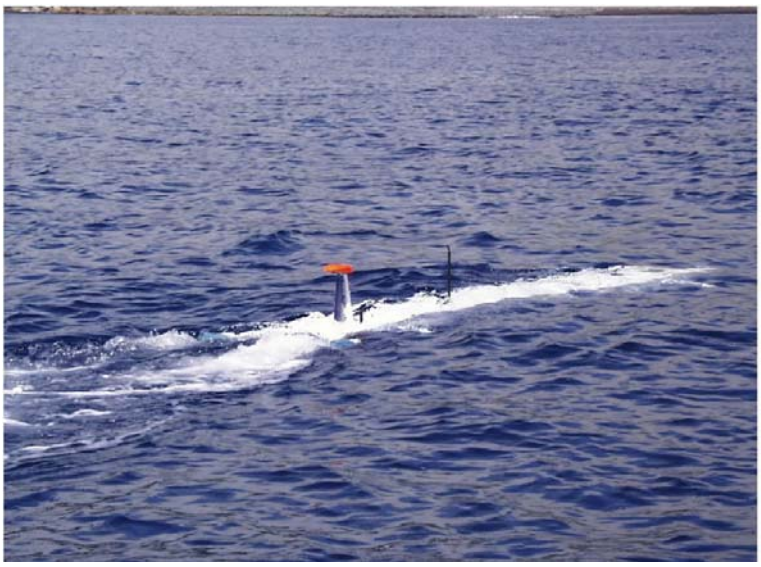


Aries loading onto Arguipeligo, August 9, 2001



Aries in water - Mission tests August 10, 2001

Aries at the start position (GPS0) for most of the Missions August 10, 2001



Aries underway during GPS popup on Mission - August 10, 2001

Aries and Arguipeligo - At 1 meter depth on Mission August 12, 2001

Aries Being Recovered on Mission August 12 2001 - PICO in Background

Aries and Delfim in Acoustic Communication with each Other. Delfim sends ABORT and Change Depth Commands to Aries

Aries and Delfim - Aries Mission Aborted

Aries Follows Delfim

Research Vessel Arguipeligo - Near Vent Area

Aguas Vivas Diving Support Vessel

The Church at Prias do Almouagle

In The Laboratory At University of The Azores

Results With Acoustic Communications

Installation of FAU Modem

Installation of the FAU Modem was conducted in June 2001 at NPS. Both the modem hardware was installed into ARIES, and the software required to have acoustic messages read into the ARIES Execution level code was developed.

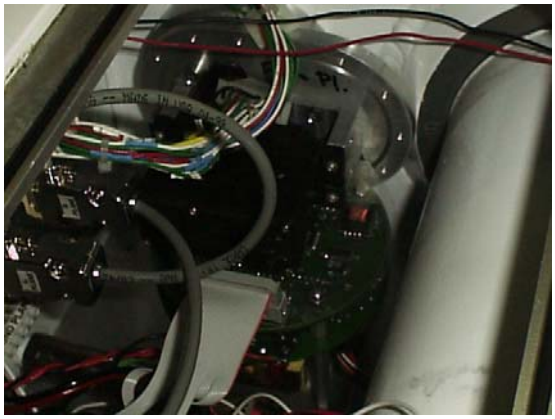


Figure 1 Transducer Head on ARIES ***Figure 2 Electronic Modules Inside ARIES***

Software integration into ARIES

(Figure 3 and 4)ave

Hardware installation on Delfim

On DELFIM, the transducer head was mounted on the center pod, while the electronics can was carried at the center mast. The signals were transmitted from the control computer to the modem can using a serial connection and a radio transmission using a freewave radio system with a small blade antenna attached to the propulsion stands.

Figure 5 Blade Antenna on Delfim ***Figure 6 Modem Can on Delfim***

Figure 7 Transducer Head on Delfim

Figure 8 ARIES and Delfim in Acoustic Communication

All Commands Sent To ARIES From Delfim Were Received And Acted On Without Need For Repeats over ranges to 700m. with vehicles underway.

Results

Activities conducted by day are listed in the table below

Date	Activitiy
Monday, August 6	Unpack ARIES
Tuesday August 7	Partial Re-Assembly of ARIES
Wednesday August 8	System Connections and Testing
Thursday August 9	Acoustic Modem Software Integration and Testing
Friday August 10	Deployment of ARIES to ARGUIPELIGO Modem test and evaluation in Harbor Balast tests in Harbor. Transit to Site, Mission 0
Saturday August 11	Transit to Site Navigation Tests of ARIES at Site, Development of New Deviation Table; Mission 1, 2, 3 - Navigation
Sunday August 12	Missions 4,5,6. Missions 7,8,9

Monday August 13	Off load ARIES
Tuesday August 14	Pack up ARIES for Transportation
Wednesday August 15	Pack up ARIES for Transportation

Navigation Files and Tracks

Files obtained for Navigational Accuracy Studies are given in the table below.

Data File	Comments
Mission 0; d081001_01.d	In Harbor Comms Tests
Mission 1; d081101_01.d	Navigation test
Mission 2; d081101_02.d	Navigation test
Mission3; d081101_03.d	Navigation test
Mission 4; d081201_01.d	Video Acquisition tests
Mission 5; d081201_02.d	Video Acquisition Tests
Mission 6; d081201_03.d	Video Acquisition Tests
Mission 7; d081201_04.d	Acoustic Comms Tests
Mission 8; d081201_05.d	Acoustic Comms Tests
Mission 9; d081201_06.d	Acoustic Comms Tests

Track Design

A box search pattern was used to circle the vehicle about the target point(GPS0). This is shown in red in Figure xx

Navigation Accuracy Compared to GPS

At each pop up, There is a difference between the Navigation Filter Estimate of position and the first GPS reading. These are given in the table below.

Number of GPS pop up	Error between First GPS Reading and Filter Estimate

Model Prediction vs Actual Track

GPS 0

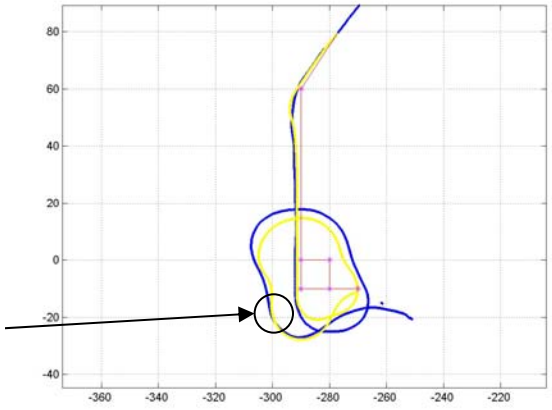


Figure 9 Path Plot for Video Acquisition Using Box Search Pattern

East(meters) vs. North(meters) from GPS Origin.

Yellow -Predicted; Blue-Data; Magenta-Design Box Pattern

Figure 9 shows the comparisons between the actual data for position as recorded in the vehicle navigation filter together with the model predicted position using a start point somewhat near to the search circle. What is shown illustrates that errors withing 3 meters or so are established between position of the vehicle and the design track . These are due to the fact that the tight circling designed into the box search pattern put the vehicle into a dynamic mode.

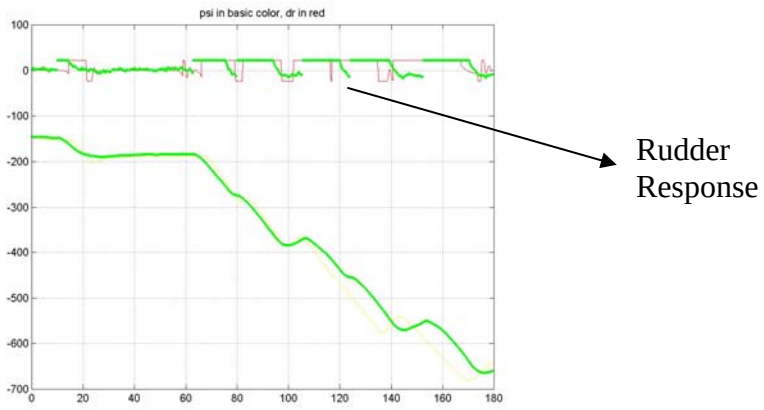


Figure 10 Heading in Green Predicted Heading Yellow; Red is the Predicted Rudder Response

Figure 10 shows the comparison of the predictive model and actual data for heading and rudder control activity, while Figure zz shows control parameters related to the cross track error versus time.

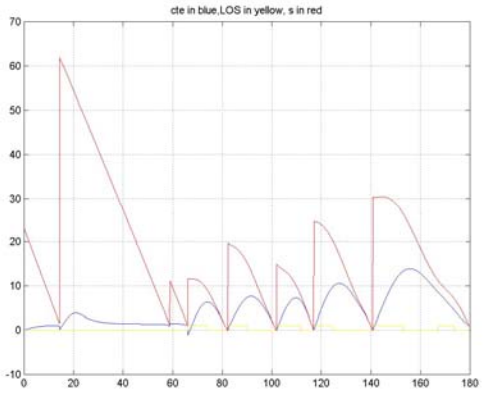


Figure 11 shows control parameters related to the cross track error (meters) versus time (Seconds).

Video Capture of Bottom and Vent Activity

Analysis of several video streams captured to the onboard DV recorder shows that the bottom was very rocky. Clear indications of rock formations were seen. During the second pass in the viscinity of the specified location, vent bubbles were observed. The digital movies obtained are recorded on file and on a CD if needed. A small snippet video was extracted under the fiile name BUBBLE2.AVI. Still pictures of selected scenes are provided in the four *.jpg files shown in Figure 12

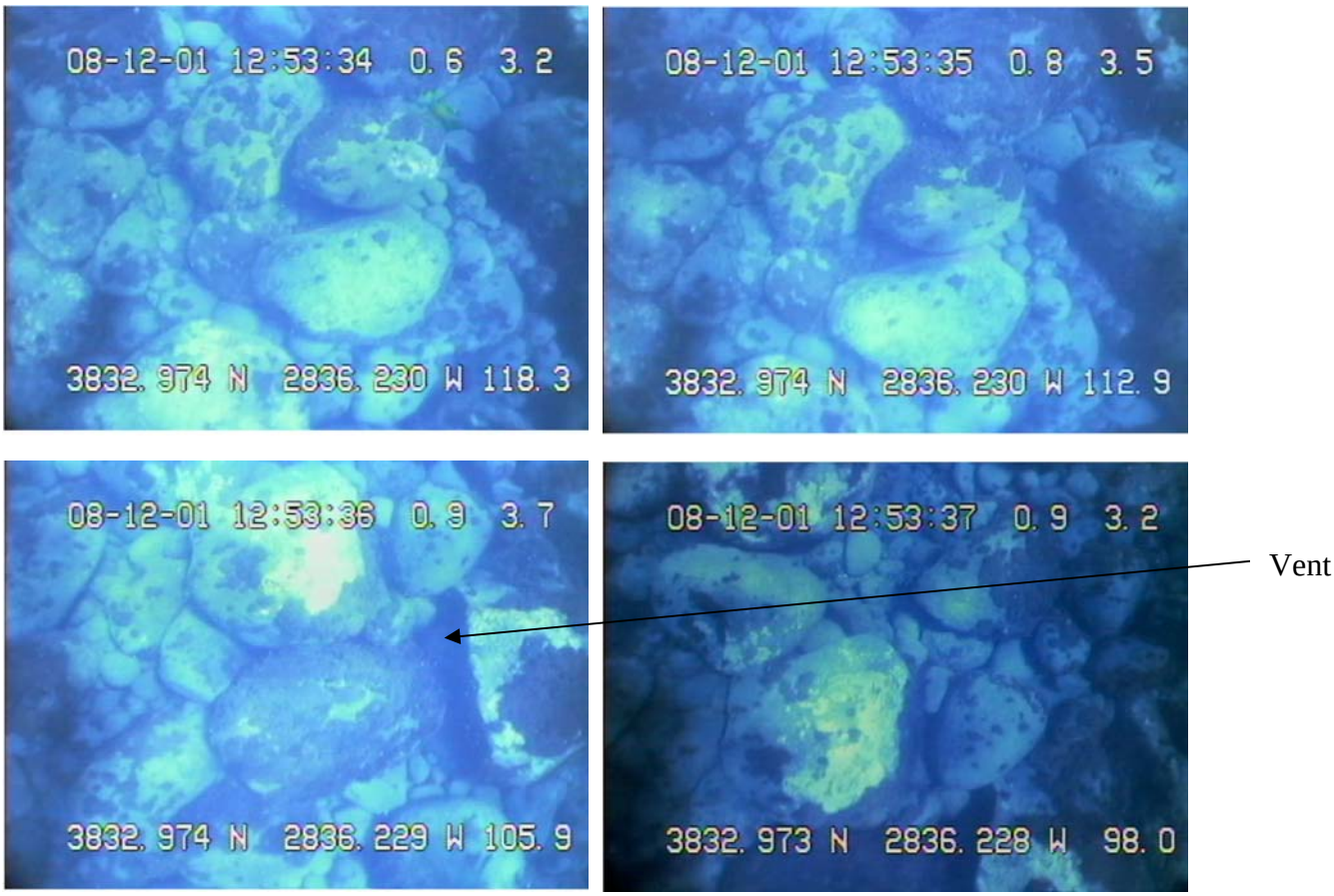


Figure 12 A sequence of frames from the Video Capture at *.34,35,36,37, seconds That show on close up bubbles from the Vent. The Bubble stream is not constant and intense

MPEG snippets of Segment around Vent Activity

A short MPEG movie of the bubble sequence is found at

http://www.cs.nps.navy.mil/research/auv/images/azores01/BUBBLE2.AVI

This will require at least WIN 98 and Windows Media Player viewer