Cruise Plan

Project PHAEDRA:
Partnership for Hellenic/American Exploration in the Deep Regions of the Aegean

June 25 – July 4, 2006
Research Vessel *Aegeao*
Greece

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2. **Cruise Overview:**
   a. Chief scientist contact information

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USA
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email: bfoley@whoi.edu

During the cruise Brendan can be contacted through Cathy Offinger - (30) 694 869 2230 (Greek Cell Phone)

   b. Vessel identification and cruise number :

This project will involve land-based scientists on Santorini, and aboard the Greek Research Vessel *Aegaeo*. R/V *Aegaeo* specs can be viewed at: http://www.ncmr.gr/frame/facilitiesB.html

   c. Study areas:

Focus sites offshore of Milos and Santorini in the Cycladic Islands.

   d. Goals and objectives

The scientific goals of Project PHAEDRA 2006 are three-fold, and fit the general categories of archaeology, earth science, and engineering. For the archaeological component, under the direction of archaeologists from the Hellenic Ministry of Culture's Ephorate [Department] of Underwater Antiquities (EUA), the team will survey shipwreck sites selected by EUA.

The archaeological objectives are to determine the dates of the vessels as closely as possible; the dimensions of the wreck sites; and the nature of their cargoes. Interpretation of these data will help determine the cultural identity of the sailors and the vessels' possible origins, intermediate port calls, and suspected ultimate destinations. We also will investigate and seek to characterize the environmental and preservative characteristics of the water and sediments around the wreck, and will experiment with novel methods for chemical analysis; for instance, regressive carbonate analyses may allow the team to derive information regarding the nature of original organic cargo elements. We will interpret all of this information within the larger context of the period and cultures in question once those basic questions have been answered. These will be the first surveys of these sites; therefore, we anticipate that many new research questions and opportunities for scholarly inquiry will arise during this expedition.

A secondary goal is to develop new techniques and data products for archaeology. The team will deploy a suite of in-situ sensors mounted aboard a precision navigated robotic Autonomous Underwater Vehicle. Many of these sensors have never before been utilized by archaeologists. The AUV's sensors include a multibeam mapping sonar; high resolution digital cameras for photomosaic and site detail imaging. On board chemical sensors, including the Gemini mass spectrometer, will quantitatively map concentrations of trace chemical components and their isotopes, including dissolved biogeochemical gases (i.e. oxygen, nitrogen, methane, carbon dioxide, hydrogen, hydrogen sulfide, argon) dissolved organic matter, chlorophyll, and petroleum hydrocarbons. Additionally, the team will deploy an experimental 150 kHz subbottom profiling sonar to image acoustically objects under the sediments. Precise and accurate navigation of the AUV will be achieved through a combination of Doppler Velocity Log, PHINS fiber optic gyro, attitude sensors, Paroscientific depth sensor, and 200 kHz SHARPS2 acoustic long baseline transponder navigation system.

In addition to surveying shipwrecks, the team will investigate the Columbo submarine volcano off the island of Santorini. Precise bathymetric and chemical mapping of this volcano will provide geologists and vulcanologists with a

better understanding of its structure and activity. Data will be collected with the *Gemini* mass spectrometer mounted on *Thetis*. *Gemini* will determine the chemical signature of water seeping from different points on the volcano. These data will be used as baseline measurements for future surveys, and will also provide information about structural and chemical features of the volcano. The data will be compared with other active sites in the Hellenic Volcanic Arc system, and other volcanoes throughout the world.

The investigation of these archaeological remains and geological features can only be accomplished with deep submergence technology. A critically important but easily overlooked aspect of this technology is navigation – the capability of the robots and submersibles to determine where they are on the seafloor. Proper navigation makes possible the documentation and quantification that transforms exploration into scientific inquiry. Because GPS signals are not available underwater, the engineers on the PHAEDRA team will navigate the underwater vehicles by merging information from a mix of sensors: acoustic transponder systems, Doppler Velocity Log, flux gate compass, and ring laser gyro. Combining these sensors' data allows the team to place into context all of the information gathered by the on-board scientific instruments, and to situate those measurements within globally referenced coordinates. This spatially fixed reference will allow scientists revisiting these sites to document changes over time – important for observing archaeological preservation and capturing the slow dynamics of geological processes. To accomplish this, the PHAEDRA engineers will employ new navigation techniques that eliminate much of the cost and complexity of previous methods.

Factors such as weather, sea state, and unforeseen technical difficulties (such as hardware damage, etc.) invariably disrupt any plan. Given the nature of operations in the deep sea, detailed hour-by-hour plans of work are impractical. Therefore, short term operational decisions will evolve as necessary while at sea. The WHOI and Hellenic Centre for Marine Research (HCMR) investigators each have extensive experience with deep sea operations and are well prepared to handle the inherent uncertainties of mission planning for this expedition.

3. Description of operations:

a. Submersible (HOV, ROV, AUV)

This year the PHAEDRA team is using a combination of deep submergence technologies including the WHOI *SeaBED* Autonomous Underwater Vehicle (AUV), the HCMR *Super Achilles* Remotely Operated Vehicle (ROV), the HCMR *Thetis* Human Occupied Vehicle (HOV), and towed side scan sonar and subbottom profiling sonar. *Thetis* can go as deep as 610 meters. SeaBED can go to 2000 m. A key part of our technology is precise, accurate navigation of underwater vehicles. In addition to precision navigation equipment, the underwater vehicles carry a suite of scientific sensors and instruments: digital cameras, multibeam mapping sonar, and environmental and chemical sensors such as the *Gemini* in situ mass spectrometer.

b. Video recording – wiring diagram if necessary

Video collected during the cruise will consist of topside HD (NTSC HD DVCAM) and MiniDV footage, in addition to a handheld MiniDV camera that will be taken down by an observer in the HOV *Thetis*.

c. Small boat operations

A small boat will be used daily to transport additional members of the science team from ship to shore.

d. Visits - education and outreach events

Kelley Elliott will arrange all NOAA – OE related outreach events. An event is scheduled on July 1st at the home of a private sponsor on Santorini for officials and members of the science team.

e. Other

4. Itinerary:

Team arrives in Greece on various days during the week of June 19th. Shipment of vehicles and sensors should clear Greek Customs Tuesday 6/20 or Wednesday 6/21, and be delivered to HCMR.

06/22/2006 - 06/24/2006: Team to assemble AUV and make modifications to Thetis.
06/25/2006: Mobilize aboard R/V AEGAEO 6/25.
06/25/2006: Depart Piraeus. Transit to Milos.
06/26/2006: 100 meter check-out ops on hydrothermal.
06/27/3006: 07/01/2006: Transit to Columbo. Conduct operations.
07/01/2006: Transit Santorini for cruise reception at Nomikos Conference Center.
07/01/2006 (evening): Transit to kythnos, conduct survey of shipwreck (?).
07/04/2006: Transit Piraeus, demobilize.
07/05/2006: Pack WHOI equipment for shipping to USA.

5. Personnel

a. List, roles/responsibilities

Matthew Barton (Shore)
Videographer?
Woods Hole Oceanographic Institution

Brian Bingham (Boat)
Professor
Olin College

Team Member: Brian S. Bingham is an expert in precision underwater navigation and underwater vehicle operations. During the 2006 cruise, Bingham will be jointly responsible for systems engineering, and for precision navigation of the AUV and other vehicles.

Ballard Blair (SHORE - shuttle out / swap with Vikrant Shah - they "share" one bunk space)
Doctorate Student
Applied Ocean Physics & Engineering
WHOI - MIT Joint Program

Dr. Richard Camilli (Boat)
Assistant Scientist
Woods Hole Oceanographic Institution

Team Member: Richard Camilli designed and built the Gemini mass spectrometer. His expertise and responsibilities lie in deep water in-situ chemical sensing, environmental sensor/data integration, and underwater vehicle operations.

Greek Archaeologist (Boat)
Ephorate of Underwater Antiquities
Hellenic Ministry of Culture

Katerina is the chief underwater archaeologist for the Greek state. She will be responsible for issuance of all archaeological permits, coordinating the Ministry of Culture funding for time on the R/V Aegaeo, coordination of all publicity within Greece, dissemination of archaeological results, and generation of initial scientific publications (with Foley and Sakellariou).

Kelley Elliott (Shore)
Web Coordinator
NOAA Office of Ocean Exploration/MPSC
Shoreside

Dr. Ryan Eustice (Boat)
Autonomous Navigation and Mapping
Johns Hopkins University
Team Member: Ryan Eustice is an expert in Visually Augmented Navigation techniques for underwater vehicles, AUV operations, and three-dimensional photomosaicing and mapping. With Singh and others, he designed and built the SeaBED AUV.

Dr. Brendan Foley (Boat)
Chief Scientist
Woods Hole Oceanographic Institution

Team Leader Brendan Foley is expert in methods and techniques for deep water archaeological survey, archaeological analysis of shipwrecks, and the history of technology. He is responsible for overall project management and is the primary liaison between the Greek and American partners, as well as the primary liaison between the technical/engineering teams and the archaeological community. He is responsible for post-cruise coordination, including processing and dissemination of data products, generation of initial scientific publications (with Katerina Delaporta and Dimitris Sakellariou), and arranging conference presentations. He is responsible for coordinating the team's public outreach, including overseeing press releases and authoring project web pages.

Vicki Lynn Ferrini (Shore – boat if possible)
Chemical Samples and Sonar Data Processing
Woods Hole Oceanographic Institution

Joanne E. Goudreau (Shore)
Chemical Samples and Sonar Data Processing
Woods Hole Oceanographic Institution

Matthew Grund (Boat)
Software/Vehicle Systems Engineer
Woods Hole Oceanographic Institution

Konstantinos Katsaros (Boat)
Chief HOV Pilot
Hellenic Center for Marine Research

Aggelos Malios (Boat)
Chief ROV Pilot and Electrical Engineer
Hellenic Center for Marine Research

Justin E. Manley (Boat)
Data Manager
NOAA Office of Ocean Exploration/Battelle

David Mindell (Shore)
Michigan Institute of Technology

Team Member: David Mindell is an electrical engineer and historian of technology. He is the inventor of the EXACT and SHARPS II precision acoustic navigation systems, two forms of transponder-based precision LBL underwater navigation. Mindell will be jointly responsible for systems engineering, and for precision navigation of the AUV and other vehicles.

Catherine A. Offinger (Shore)
Operations Manager / Logistics Coordinator
Deep Submergence Laboratory
Woods Hole Oceanographic Institution

Dimitris Sakellariou (Boat)
Greek Chief Scientist
Hellenic Center for Marine Research

Dimitris is a geologist and oceanographer and the Hellenic Center for Marine Research. He will be the Greek team's Chief Scientist, the primary liaison between the science team and the technical team operating the Greek ship and underwater assets. He will also be responsible for coordinating collection and interpretation of environmental data, the

R/V Aegaeo's hull-mounted multibeam sonar data, and in-situ chemical data. In consultation with Foley, Delaporta, and the caption of R/V Aegaeo, Sakellariou will be responsible for all major decisions regarding ship schedules and operations. This will include the pace, location, and over-the-side vehicle operations of all phases of the research cruise. He will also be responsible for generation of initial scientific publications (with Foley and Delaporta).

Vikrant Shah (Shore - shuttle / swap with Ballard Blair - they "share" one bunk space)
Graduate Student
WHOI – MIT Joint Program

During the PHAEDRA 2006 cruise, Vikrant will be working with both the Seabed and the newly built Jaguar deepwater AUVs. He will also be in charge of the water sampler that will be used to collect water samples from sites of interests for further analysis.

Hanumant Singh (Boat)
Co-Principal Investigator
Woods Hole Oceanographic Institution

Co-PI: Hanumant Singh and his former PhD students (including Co-PI Ryan Eustice) designed and built the SeaBED AUV, a vehicle optimized for underwater imaging. During the 2006 project, Singh will be responsible for high-resolution underwater imaging, two-dimensional photomosaicing, systems engineering, and general AUV operations.

6. Equipment lists:

Some info in appendix C.

7. Emergency information:

Several members of the science team (Cathy Offinger, Joanne Godreau, Vicki Ferrini, Kelley Elliott) we be based shoreside at: http://www.santorini.gr-santorini.com/hotels/thira/

Hotel Thira & Apartments
Fira Santorini 847 00 Greece
Tel: +30 22860 22863
Tel/Fax: +30 22860 24113

Cathy Offinger, the team's logistics coordinator, can be reached at (30) 694 869 2230 (Greek Cell Phone). Justin Manley can be reached via satellite phone at 8816-3144-0814.

8. Communications

Communication between the science party aboard the vessel and the shore side team will take place using Greek cell phones.

9. Miscellaneous:

a. HAZMAT inventory
b. Meals

Appendices:

A. Primary operating area maps

This cruise will take place offshore in the Cycladic Islands. Two focus areas are offshore of Milos, and the Columbo submarine volcano offshore of Santorini Island. Due to sensitivities with the Greek government, precise sites are still yet to be determined.

B. Permits and certifications

1. The pressure test certifications for all of the instruments and implodable volumes (pressure housings) that will be mounted on the Thetis submersible are located here as pdfs: ftp://ftp.whoi.edu/pub/users/bfoley/Thetis_Bureau_Veritas

2. Greek permits: WHOI has an established and long term formal relationship with the Hellenic Centre for Marine Research. WHOI and HCMR have in place a Memorandum of Understanding to facilitate cooperation over a range of oceanographic research topics. Archaeology in deep water is specifically itemized as one of the areas of collaboration between WHOI and HCMR. To comply with NOAA OE directions, we requested on 8 March 2006 a formal letter of collaboration from HCMR's Dr. Dimtris Sakellariou, a Principal Investigator on this proposal. That letter of collaboration is appended here, dated 9 March 2006, under the signature of HCMR Director of Oceanography Dr. Evangellos Papathanasiou.

Furthermore, with the full support of the U.S. State Department and U.S. Ambassador to Greece Charles Ries, WHOI has established a close working relationship with the Hellenic Ministry of Culture, Ephorate of Underwater Antiquities (EUA). The EUA is the Greek governmental body that issues archaeological survey and excavation permits for underwater sites; EUA Director Ms. Katerina Delaporta is a Principal Investigator on this proposal. Our archaeological surveys are planned and undertaken jointly by WHOI, HCMR, and EUA personnel, and incorporated into the annual research program of the EUA. To comply with NOAA OE directions, we requested on 8 March 2006 a formal letter of collaboration from Ms. Delaporta; she is currently traveling, and we anticipate receiving that letter upon her return to Athens.

C.

MINISTRY OF DEVELOPMENT GENERAL SECRETARIAT FOR RESEARCH AND TECHNOLOGY

HELLENIC CENTRE FOR MARINE RESEARCH

Institute of Oceanography

P.O.Box 712, GR 190 13, Anavyssos Greece, Tel.: +30 22910 76352, Fax: +30 22910 76323

Anavyssos, March 9th, 2006

CONFIRMATION OF COOPERATION

This is to confirm the collaboration of the Institute of Oceanography of the Hellenic Centre for Marine Research (HCMR) with the Woodshole Oceanographic Institution (WHOI) in the frame of the project 'Autonomous Rapid High resolution Mapping of Ancient Shipwrecks and Geologic Features', submitted to NOAA by Fr. B. Foley (WHOI).

The Institute of Oceanography of HCMR will participate to the project with a highly qualified research team which will perform seafloor survey and will operate the diving vehicles. The foreseen cruise will take place onboard the research vessel Aegaeo between June 21st - July 4th with the aim of surveying two ancient shipwrecks and the caldera of the active, submarine Columbo volcano.

Dr. Evangellos Papathanasiou

Director of the Inst. of Oceanography of HCMR

C. Equipment Specs

NavComms System Description

This document contains the information necessary to maintain the Bureau Veritas certification of the Greek submersible *Thetis*. The information pertains to the NavComms System to be installed on *Thetis* during the upcoming scientific expedition.

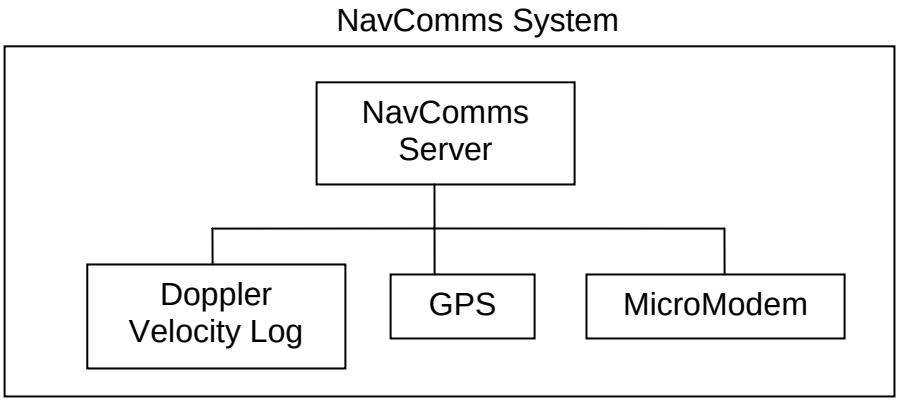

Figure 1: System diagram for the overall NavComms System consisting of four subsystems.

The NavComms System contains the following four subsystems:

1. NavComms Server
2. GPS: Garmin GPS-16HVS GPS antenna for time-synchronization and surface navigation.
3. MicroModem: WHOI MicroModem for acoustic communications and LBL navigation
4. Doppler Velocity Log: RDI 1200kHz Doppler Velocity Log (this unit is currently installed on *Thetis* and owned by HCMR. It will simply be connected through wet-cabling to the NavComms Bottle).

The first three subsystems are documented below. The Doppler Velocity Log (DVL) is currently installed on the submersible and needs no further documentation.

Subsystem 1: NavComms Server

For this purpose, it functionality consists of:

- Provide DC-DC power conversion from sub voltage of 150 Vdc to sensor payloads (12 Vdc and 24 Vdc).
- Act as a communication multiplexer by providing Ethernet-to-Serial conversion to a suite of sensor payloads.

Table 1: Certification Specification for NavComms Server

1. Technical Specifications of All Systems	
manufacturer	Woods Hole Oceanographic Institution
purpose/operation (a brief description)	The purpose of the NavComms bottle is to act as a host for precision navigation sensor payloads.
physical dimensions	Cylinder Length = 15 inches Diameter = 8 inches
construction materials	Aluminum
depth rating	2000 meters
weight out/in the water	Weight: In air - In water -
power consumptions (including max and nominal working elect. load/voltage - current)	Voltage In = 150 Vdc Power peak = 45 watts Power continuous = 35 watts
output/input electrical resistance	
engineering and electrical drawings (including the electrical connections)	see appendix
cables and connectors (if possible with DIN No. or equivalent)	see appendix
Individual frequencies or freq. spectrum of the acoustic transmitters/receivers (passive and active)	None
2. Verifications of the following:	
pressure tests/results for all the pressure proof housings (safe at least up to 9.3 MPa)	Certified to 1000 m at WHOI on 2 June 2006
EMI/EMC study (where it is applicable or necessary) e.x. effects on the vital systems of the submarine like electronics, computing control or navigational system, underwater and surface communications.	N/A
Free of toxic, radiation, nuclear, chemical or explosive devices/materials.	Yes

Subsystem 2: MicroModem

Table 2: Certification Specification for MicroModem

1. Technical Specifications of All Systems	
manufacturer	Woods Hole Oceanographic Institution
purpose/operation (a brief description)	Through-water acoustic communication
physical dimensions	Cylinder Length = 12.475 inches Diameter =2.5 inches
construction materials	Aluminum
depth rating	4000 meters
weight out/in the water	Weight: In air - In water -
power consumptions (including max and nominal working elect. load/voltage - current)	Internally powered, Li-ion battery pack
output/input electrical resistance	
engineering and electrical drawings (including the electrical connections)	
cables and connectors (if possible with DIN No. or equivalent)	Impulse MSAJ-7-CCP see appendix
Individual frequencies or freq. spectrum of the acoustic transmitters/receivers (passive and active)	9760 Hz center frequency with 5120 Hz bandwidth
2. Verifications of the following:	
pressure tests/results for all the pressure proof housings (safe at least up to 9.3 MPa)	Certified to 1000 m at WHOI on 2 June 2006
EMI/EMC study (where it is applicable or necessary) e.x. effects on the vital systems of the submarine like electronics, computing control or navigational system, underwater and surface communications.	N/A
Free of toxic, radiation, nuclear, chemical or explosive devices/materials.	Yes

Subsystem 3: GPS

Table 3: Certification Specification for GPS

1. Technical Specifications of All Systems	
manufacturer	WHOI/Garmin
purpose/operation (a brief description)	Accurate time synchronization and surface navigation
physical dimensions	Overall Dimensions Length = 1.61 inches Diameter = 3.58 inches
construction materials	Plastic shell, internally potted with epoxy resin
weight out/in the water	Weight In air 332g In water TBD
power consumptions (including max and nominal working elect. load/voltage - current)	Power peak = 1 watts Power continuous = 1 watts Voltage in =12 Vdc
output/input electrical resistance	
engineering and electrical drawings (including the electrical connections)	
cables and connectors (if possible with DIN No. or equivalent)	Impulse MSAJ-7-BCR
Individual frequencies or freq. spectrum of the acoustic transmitters/receivers (passive and active)	N/A
2. Verifications of the following:	
pressure tests/results for all the pressure proof housings (safe at least up to 9.3 MPa)	Certified to 1000 m at WHOI on 8 June 2006
EMI/EMC study (where it is applicable or necessary) e.x. effects on the vital systems of the submarine like electronics, computing control or navigational system, underwater and surface communications.	N/A
Free of toxic, radiation, nuclear, chemical or explosive devices/materials.	Yes