

# Engineering & Computational Research

## 1. Hybrid Underwater Vehicle

A hybrid underwater vehicle (i.e. having the attributes of both a remotely operated and autonomous vehicle) will be developed that meets the critical technical challenges facing the incorporation of a submersible vehicle with a node on the overall NEPTUNE cabled observatory. The project will address key tasks generic to a broad spectrum of observatory experiments that will require both a locally mobile platform (ROV operating within a 3km radius of a node) and a roving platform (AUV capable of working within bigger radii or traveling between nodes placed about 100km apart). A suite of sensors, suitable for use on the hybrid vehicle, were identified at the May workshop and will be further defined in the period leading up to the September workshop.

The development of this vehicle will build on and extend the research capacity of the proposed NEPTUNE observatories in the following ways:

- The proposed hybrid vehicle will provide the ability to carry a suite of sensors and gather data in various spatial/temporal combinations.
- The nodes and instrumentation will be subject to bio-fouling, corrosion, electronic/mechanical failure and damage from slope failures, volcanic eruptions and, in shallower waters, of trawling. The hybrid vehicle will allow for inspection and maintenance of the sensor packages attached to each node.
- Sensor deployment and retrieval up to 3 km away from the node. These sensors may also need to be re-positioned periodically.
- Nodes will be positioned in the most scientifically important zones. Important events occurring in the vicinity of a node will be detected by different sensor packages (e.g. hydrophones). If important enough, the hybrid vehicle can be programmed, via the high bandwidth link, and dispatched in AUV mode to gather more data from the location of the event.
- Surface to node transport – periodic replacement of the vehicle on the order of months (to a year) will be necessary. This also provides to opportunity to retrieve and replace sensor packages.

The following research themes were also developed during the course of the workshop:

- Ship-to-node vehicle travel (and vice versa).
  - Tracking, guidance (underwater GPS) and control of vehicle to node.
- Hybrid vehicle docking.
  - Close proximity guidance and control of vehicle to docking system.
    - Acoustic guidance.
    - Range finders.
    - Video camera.
    - Integration of functions between operator, camera/sensor at the docking system, and the vehicle.
- Tether connection and disengagement.
- ROV mode missions:
  - Tracking, guidance and control of vehicle in vicinity of node.

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- Carrying and retrieving instruments.
- Node-to-node travel in AUV mode

Further interaction is essential with scientists to refine the specification of all the above and to further seek engineering expertise.

### 2. Integrated Acoustics System

An acoustics system for science, navigation, and communications is proposed for the Endeavor hot vent site. The navigation and communications infrastructure would support mobile platforms (AUVs, ROVs, bottom rovers, floats, gliders, etc) and autonomous acoustically communicating instrumentation, each with a scientific mission. In addition, the same infrastructure would support acoustic tomography (temperature and velocity), geodesy, and ambient sound (wind, rain, bubbles, seismic, marine mammals, shipping, etc.). Management of the acoustic spectrum to be used at an Observatory site is essential to avoid interference between experiments and between experiments and communications and control.

Some of the science topics that will be addressed in the integrated acoustics experiment are:

- Tracking floats, gliders, AUVs, ROVs, and marine animals.
- Tomography for ocean circulation (west wind drift bifurcation, eastern boundary currents, local flows and heat content around ridge).
- Inferring information about ocean fluctuations (e.g., internal waves) from acoustic fluctuations.
- Geodesy.
- Earthquake location.
- Air-sea interaction (wind, rain, bubbles, marine mammals, shipping, etc.).

Given the relative opaqueness of the ocean to electromagnetic radiation (e.g., radio and light), acoustics are one of the few ways to sense the interior of the ocean and to transmit information through it. Acoustics-based instrumentation is some of the most robust in the oceanographic tool box. This will be very important to assure success in the short term as well as in the long term. There are direct analogies between the Global Positioning System (GPS) and the proposed acoustic system, aka underwater GPS (UGPS).

The first proposed experiment for an integrated acoustics system should take place over a small area. A 15 km x 15 km area centered on the Endeavour hot vent field is proposed. There are several reasons for starting with a relatively small spatial scale: shorter range in deep water is easier from the acoustics point of view, because multi-path and scattering is minimal; a shorter range, higher frequency system is less expensive; there are expected to be many science payoffs at Endeavor, with many users of the provided navigation and communications infrastructure. The probability of success is simply higher.