# Elements of Sensor Network Infrastructure: Moorings, Mobile Platforms and Integrated Acoustics

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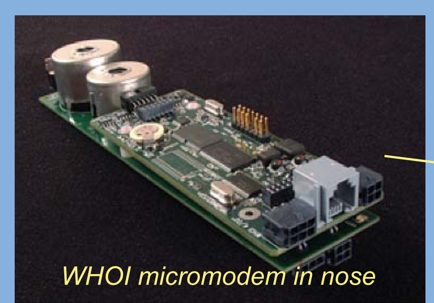
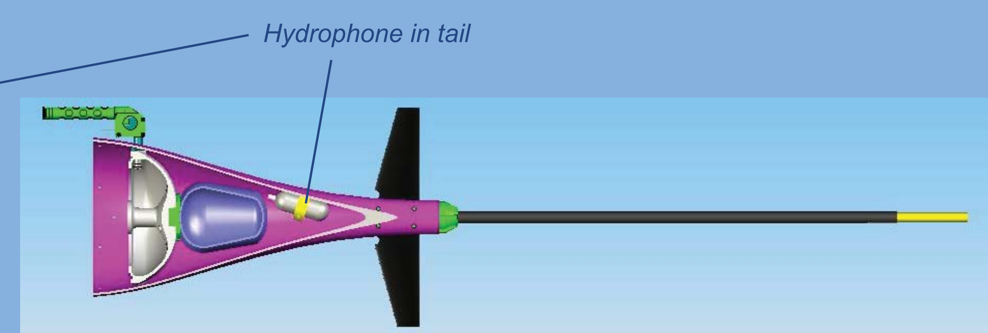
## I. ABSTRACT

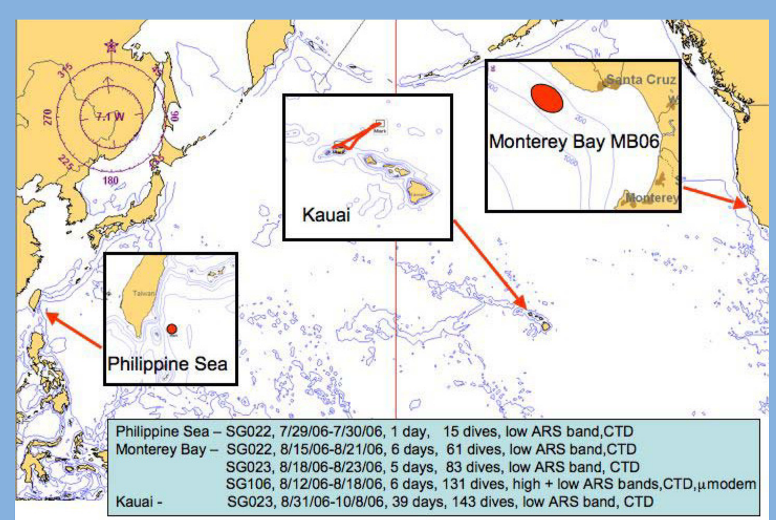
Much of the cost and effort of new ocean observatories will be in the infrastructure that directly supports sensors, such as moorings and mobile platforms, which in turn connect to a "backbone" infrastructure, such as will be provided by the ORION ocean observatories. Three elements of this sensor network infrastructure are in various stages of development, presented here: a cable-connected mooring system with a profiler under real-time control with inductive battery charging; a glider with integrated acoustic communications and broadband receiving capability; and integrated acoustic navigation, communications, tomography, and ambient sound on various scales.

## II. GLIDERS

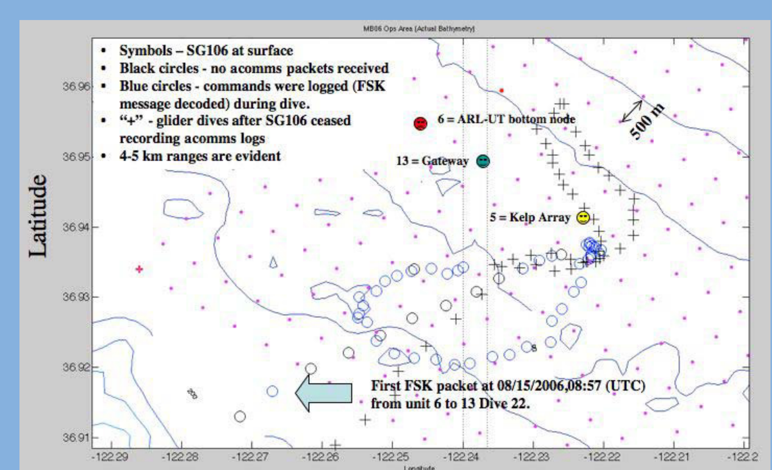


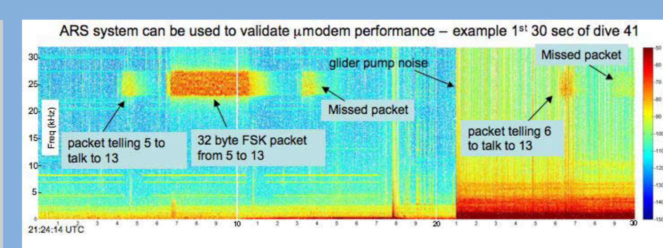

Seagliders equipped with passive receiving hydrophones and acoustic modems (WHOI micromodems) were deployed in three areas in summer 2007 to demonstrate these capabilities. Preliminary results are shown here. The hydrophone systems have up to 30 kHz bandwidth, 60 GB storage, and can perform simple real-time processing (e.g., power spectra) and send these via the glider Iridium link to shore. The micromodem can send commands to subsea units and receive data files to return to shore via Iridium. The present data rate used was 80 bps with ranges to 4 km, but higher data rates will be possible with hardware upgrade.



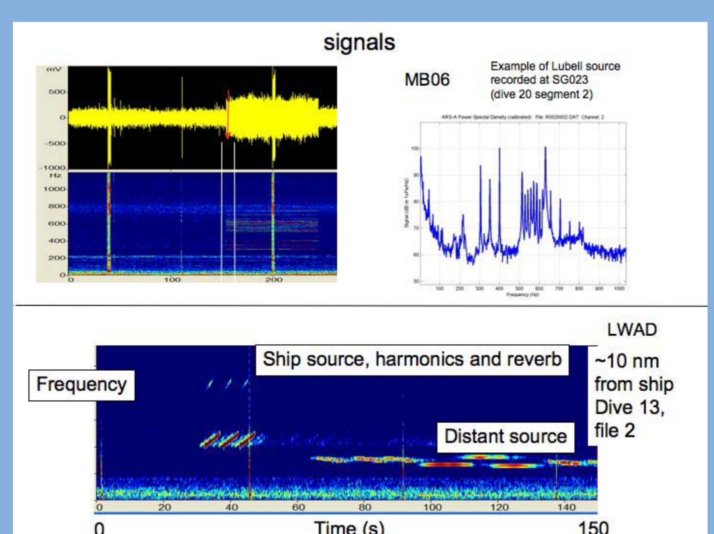

*Acoustic Seaglider Operations — Summer 2006*




*Positions during first mission where SG106 was able to read micro-modem FSK packets during MB06.*



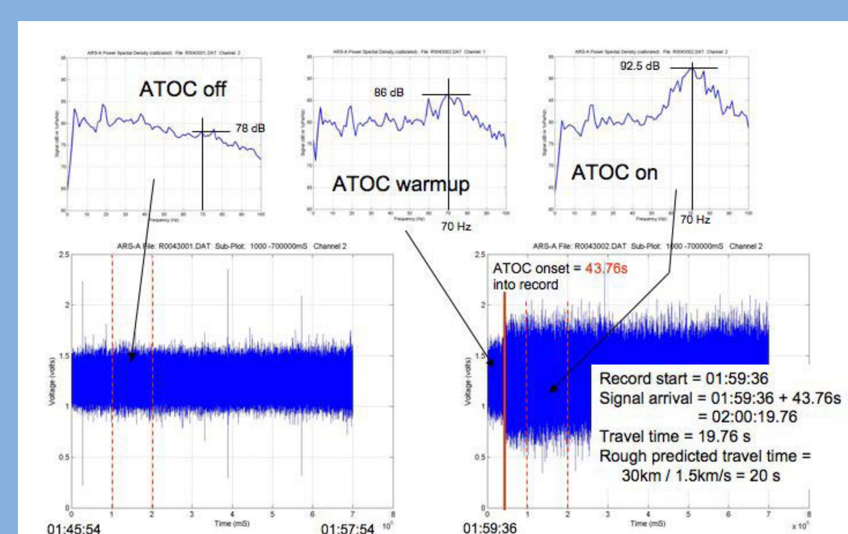

*Spectrogram showing micro-modem signals between gateway (13) and ARL-UT bottom array (6) and Kelp array (5).*



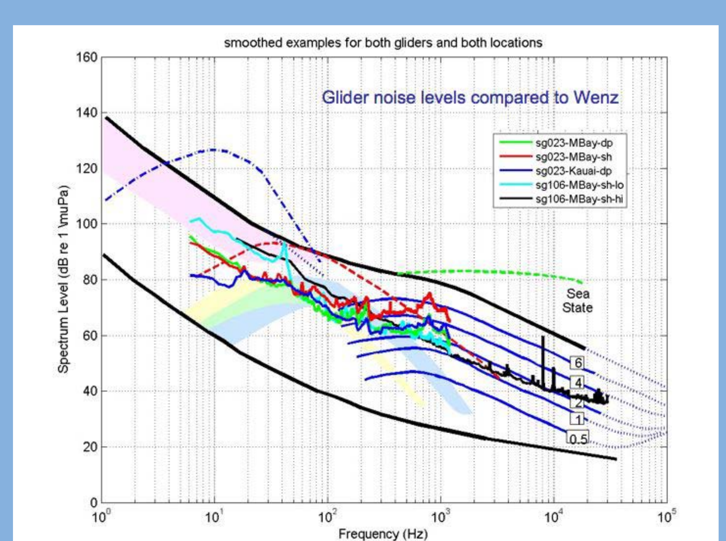

*Controlled source signals.*

*(TOP) MB06 "Lubell" source transmissions recorded on SG023.*

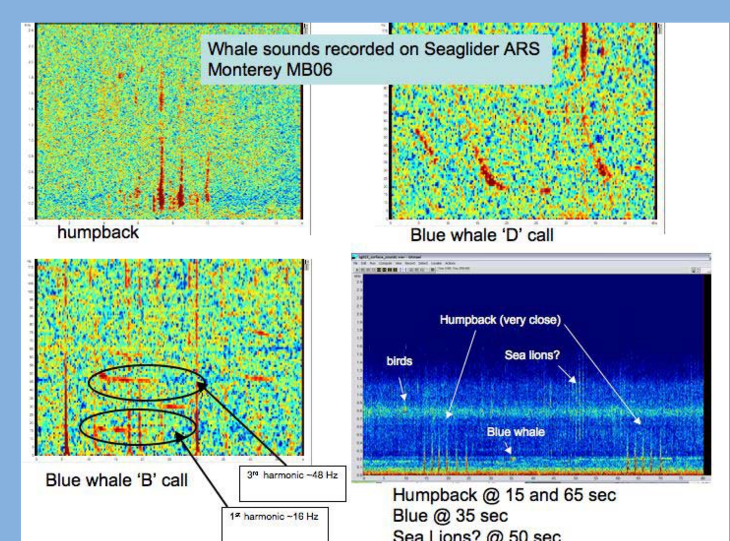
*(BOTTOM) Controlled sources in the Philippine Sea recorded on SG022.*




*SG023 recorded the last 2 weeks of signals from the ATOC source off Kauai. This example shows the reception of the ATOC signal by SG023 on dive 43 (~30 km from source). The transmitted signal ramps up to full power over ~5 minutes prior to 02:00:00 (full power starts at 01:59:32.72).*



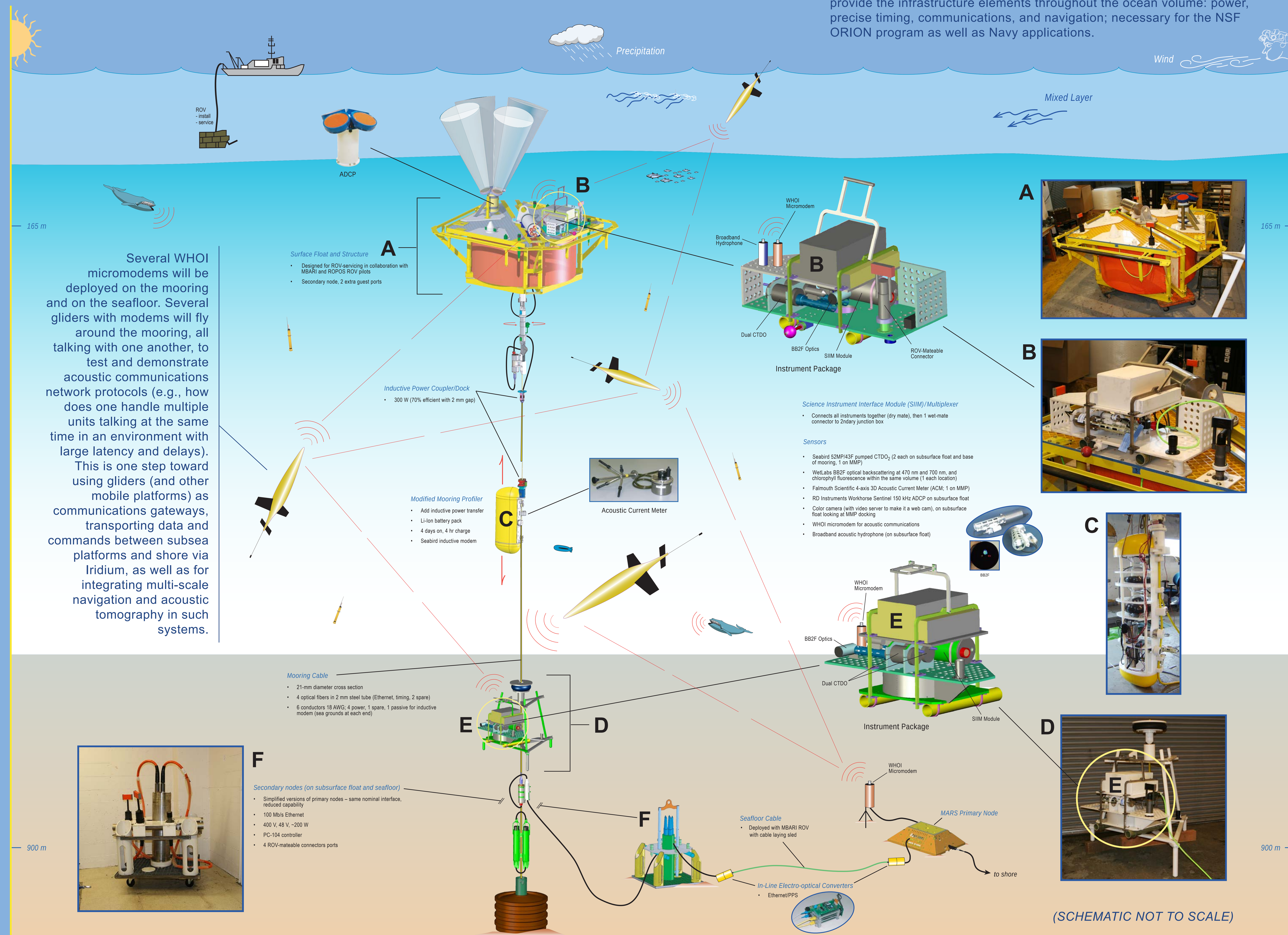

*Representative noise curves for SG023 and SG106 in Monterey Bay (shallow and deep) and Kauai (deep), compared to Wenz.*




*A wide variety of noises were heard in Monterey Bay. The Kauai data has not been processed for whale calls yet.*

## III. MOORED PROFILER SYSTEM

To enable better vertical sampling of the ocean, we are developing a moored profiler system to be connected to a cabled observatory node, thereby removing power as the major constraining factor. A profiler docking station with an inductive coupler will transfer power from the cabled node moored profiler. Further, two-way inductive communications will be used to offload profiler data at modest rates in real time as well as transfer adaptive sampling commands. Secondary junction boxes on the subsurface float and on the seafloor will provide several hundred watts, 100 Mb/s Ethernet, and precise time to users, and be ROV-serviceable. Instrument packages can be added on the subsurface float, such as a winched profiling system to carry in-situ and point and remote sensors through the mixed layer to the surface. This mooring will be tested in early 2007 in Puget Sound and deployed on the MARS cabled observatory system in Monterey Bay, California, in 900 m of water in November 2007.




Several WHOI micromodems will be deployed on the mooring and on the seafloor. Several gliders with modems will fly around the mooring, all talking with one another, to test and demonstrate acoustic communications network protocols (e.g., how does one handle multiple units talking at the same time in an environment with large latency and delays). This is one step toward using gliders (and other mobile platforms) as communications gateways, transporting data and commands between subsea platforms and shore via Iridium, as well as for integrating multi-scale navigation and acoustic tomography in such systems.

## IV. FUTURE

These sensor network infrastructure developments enable a wide range of new sensing modalities with fixed and mobile systems. On the mooring, one can put easily-serviced winch systems to sample the upper ocean, as well as complex instruments such as mass spectrometers, environmental sampling processors, acoustic imaging and tomography systems, etc. In addition to conventional ocean sampling, the mobile platforms can serve as data trucks, launched from a pier, going to remote areas (e.g., Southern Ocean) to retrieve data from long-lasting robust instrumentation. This work continues efforts to provide the infrastructure elements throughout the ocean volume: power, precise timing, communications, and navigation; necessary for the NSF ORION program as well as Navy applications.