

# Surface Detection For Recovery of UUVs

## Using Beacons to Locate a UUV on the Surface

By Kevin Hardy • Brock Rosenthal

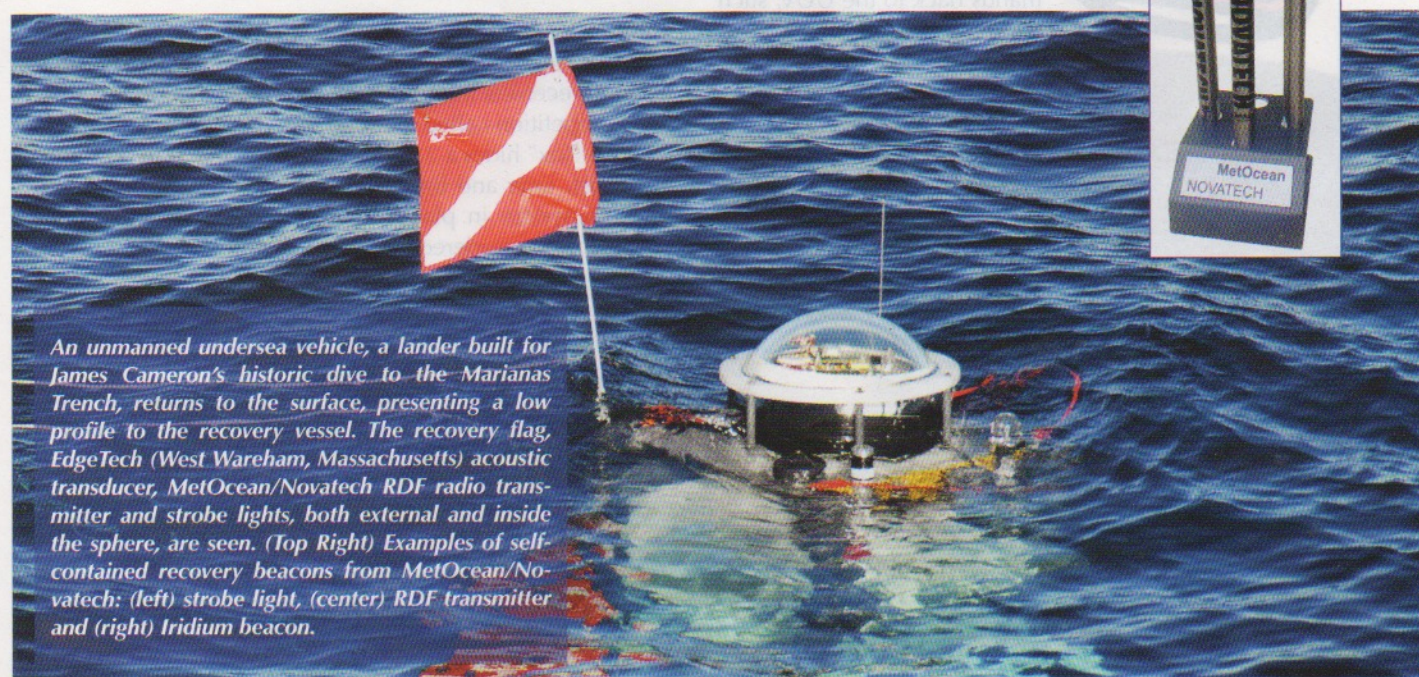
It was only in the middle of the 20th century that untethered free vehicles became possible with advances in flotation materials. Free vehicles operate independently from any surface vessel and, more recently, have been referred to as UUVs. These include AUVs, midwater floats, gliders and benthic landers. UUVs operate by managed control of their buoyancy. A positive buoyancy (flotation) is overcome by larger negative buoyancy (ballast weight), making the vehicle's net density greater than seawater and, therefore, able to sink to a position at mid-depth or on the seafloor. For recovery, the ballast weight is released from the flotation, or displacement increased, making the UUV less dense than seawater. It floats to the surface, carrying with it physical samples, recorded data or both.

Because of ocean currents and waves, its own propulsion or imperfect streamline, the UUV may have moved some distance from its initial drop point. Add limited visibility due to darkness, fog or storms, a low surface profile,

and problems locating the small, but expensive, UUV start to compound. Biological samples carried from the depths may be sterilized by the warm surface waters in a matter of 30 minutes or less. Ship costs can run more than \$40,000 per day, making search patterns expensive. Weather may change, and the sun will certainly set. It is mandatory to locate and recover the UUV in the shortest period of time possible. While the UUV does not present a large target in itself, there are ways to amplify its presence on the surface to facilitate location and recovery.

### Onboard Beacons

Selecting the most appropriate recovery beacons requires assessment of ship proximity to the UUV, overall system cost and complexity, depth and duration. Ship proximity determines if the beacon is to aid a ship on site or alert a



An unmanned undersea vehicle, a lander built for James Cameron's historic dive to the Marianas Trench, returns to the surface, presenting a low profile to the recovery vessel. The recovery flag, EdgeTech (West Wareham, Massachusetts) acoustic transducer, MetOcean/Novatech RDF radio transmitter and strobe lights, both external and inside the sphere, are seen. (Top Right) Examples of self-contained recovery beacons from MetOcean/Novatech: (left) strobe light, (center) RDF transmitter and (right) Iridium beacon.

shore-based operator after the ship has left station. A UUV may have been deployed for a long period of time, and the ship left station. The UUV's ballast weight, however, may become dislodged due to any number of reasons, including damage from a bottom trawl, a defective corrosive link or an incorrectly programmed timer.

Onboard beacons utilizing satellite communication networks, such as Argos or Iridium, can alert a shore-based operator of the unexpected surface arrival. Manufacturers of these beacons include MetOcean (Dartmouth, Canada), Telonics Wildlife (Mesa, Arizona) and Xeos (Dartmouth).

A promising addition to the field is the SPOT 3 satellite GPS messenger. It appears this could be adapted for UUV recovery inside a glass sphere. It's coverage includes large areas of northern oceans. Like the Iridium beacons, the unit determines its position using GPS satellites, sending its position back through a satellite network to ground stations that deliver the beacon ID and position through cellphone or email. We are giving this system a try in the coming months with a nearshore research project.

Beacons are generally activated by an integral pressure-sensitive switch or capacitive sensor. A pressure-activated switch, such as the Nautilus Marine (Buxtehude, Germany)/Global Ocean Design (San Diego, California) model, can be used with glass spheres or pressure cases. When satellite-based beacons are turned on at the surface, they begin a preprogrammed routine of locating their position and sending that data through a data network. There are costs for the beacon, the satellite communication, the data network and possibly an Iridium phone for remote locations of the operator. Alert times vary, but can be as fast as under five minutes. Once alerted, the operator is left with the decision of considering a recovery operation. Some systems, such as Argos, allow the operator to send limited commands back to the UUV, such as turning a strobe light on or

off. This could save battery power until a recovery vessel is near at hand.

### Surface Detection, Recovery

On-station methods of identifying a surface vehicle include passive/reflective, such as radar reflectors, flags, light-reflective tape and brightly colored fairings. Smoke bombs and surface water dyes have also been used.

Electronic beacon methods include strobe lights and radio direction finding (RDF) transmitters, such as those made by MetOcean/Novatech, Xeos and others. Similar to the previously mentioned satellite beacons, these are switched on at the surface using pressure-activated switches or capacitive sensors. Some manufacturers use a light sensor to turn off the strobes during bright daylight hours, saving power. MetOcean provides a remote antenna option with their RDF and a remote strobe head with their flasher. The RDF beacons can be located from a surface vessel using Yagi directional antennas, which amplify the signal within a narrow angle centered on the signal source, null meters, shrunk quad antennas or a dual-element switched array antenna, such as the MetOcean/Novatech DF-500N. These receivers determine approximate direction, while range is approximated by signal strength. Operator skill is required in interpreting the readings as the true direction and a secondary peak may be out by 180°. A ship could be sent directly away from the surfaced UUV due to the ambiguity.

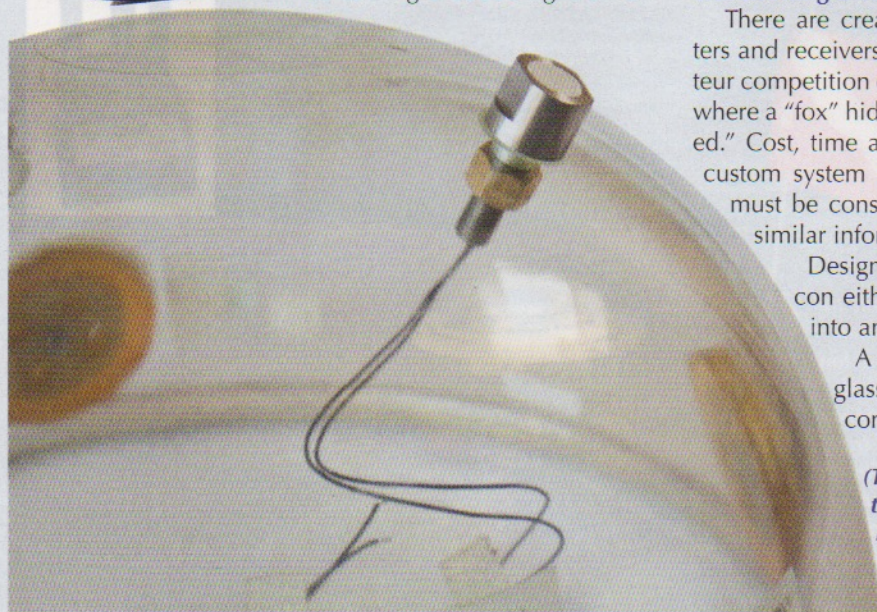
Teledyne Benthos (North Falmouth, Massachusetts) TR-6001 transponders employ a method of near surface acoustics to locate the sphere on return to the surface. The TR-6001 is ballasted for transducer "up" at the seafloor and transducer "down" after anchor release. When the sphere reaches the surface, the transducer remains in the water. A three- or four-element hydrophone array on the ship, either hull mounted or towed, can be used to determine time of first reception of the signal in two axes, port-starboard and fore-aft. The first hydrophone in a pair to receive the signal is the direction to the transponder. The sphere flip can be used to trigger a tilt switch that would also energize an internal RDF transmitter and xenon strobe light.

### Transmitting Data, Receiving Location

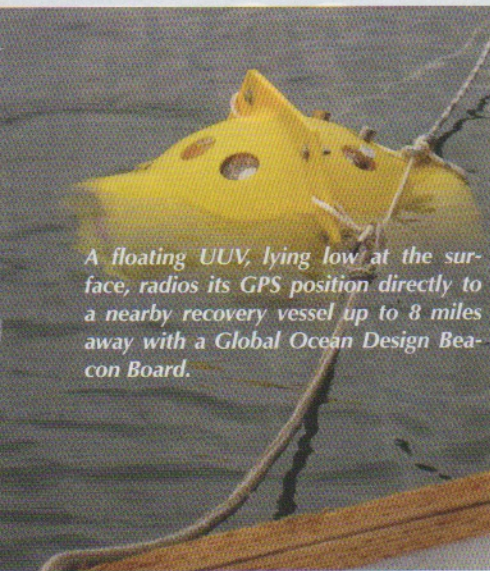
There are creative ideas for building 2-meter transmitters and receivers found on websites dedicated to the amateur competition called the "foxhunt," or radio-orienteeing, where a "fox" hides a 2-meter transmitter that is to be "hunted." Cost, time and limitations associated with building a custom system in place of commercially available units must be considered. Animal tracking websites provide similar information.

Designers have the option of housings. The beacon either has its own housing, or it is integrated into an existing housing.

A new option for 10-inch-diameter or larger glass sphere housings is the Beacon Board, a combination GPS receiver and VHF transmit-



(Top) A SPOT 3 satellite GPS messenger. (Bottom) A pressure-activated switch (Nautilus Marine/Global Ocean Design) may be used directly through a glass sphere or through a pressure case end cap.



A floating UUV, lying low at the surface, radios its GPS position directly to a nearby recovery vessel up to 8 miles away with a Global Ocean Design Beacon Board.

ter, made by Global Ocean Design. The Beacon Board utilizes a GPS receiver inside the UUV glass housing that transmits its position by VHF directly to a handheld device on the surface ship. An onboard operator is shown a precise range and bearing to the target up to an 8-mile distance, depending on line-of-sight placement of the antenna pair.

The UUV antenna may be located inside the glass sphere or external on a flag mast. This method is especially useful in the dark, fog, rain or other limited-visibility conditions. The system is a closed loop between the UUV and the ship: The Beacon Board uses multiuse radio service (MURS), an unlicensed, two-way radio, to transmit its location directly to a receiver on a ship. The shipboard receiver has its own GPS receiver to accurately locate its position. Circuitry inside the receiver decodes the position of the floating UUV, computes the bearing and range from its known position, and displays a compass dial and digital distance read-out to the UUV. A ship's captain can then steer a direct-recovery course. The

navigation graphics make clear sense to every mariner and are especially helpful to field teams operating out of a foreign port where the ship crew's first language may not be their own. The addition of an LED strobe provides a visual reference when the ship nears the floating UUV. The handheld receiver unit can track up to 10 surface targets at one time, logging their transmitted positions for later download to a PC. The handheld receiver can also accept navigational charts. Tests of multiple configurations have been made offshore San Diego with good result.

### Conclusion

Several means for determining position of a low-profile UUV on the surface are available to designers. Some are passive, others alert shore stations, while a third group functions to communicate with the surface support vessel and dynamically aid in the location of the UUV. Each beacon has comparative strengths and weaknesses, and a designer can select the options that best match his mission profile. ■

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*Kevin Hardy founded Global Ocean Design in 2011, following retirement from the Scripps Institution of Oceanography, where he developed and deployed deep-ocean landers around the world, including numerous ocean trenches. He was personally recruited by James Cameron to join his DEEPSEA CHALLENGE Expedition to the Marianas Trench. Hardy is a fellow in the Marine Technology Society. He can be reached at [kevin@globaloceanandesign.com](mailto:kevin@globaloceanandesign.com).*

*Brock Rosenthal founded Ocean Innovations (La Jolla, California) in 1993 to help guide customers through the sometimes bewildering array of marine technology products. He enjoys the challenge of finding the optimal solution for every technical problem, given the temporal and fiscal constraints. Rosenthal is a fellow in the Marine Technology Society. He can be reached at [brock@oceaninnovations.com](mailto:brock@oceaninnovations.com).*

# SEA TECHNOLOGY

The Worldwide Information Leader for Marine Business, Science & Engineering

March 2015, Volume 56, No. 3

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**COVER**—A surface model of a combined multibeam bathymetric and aerial survey. The site is a 1-square-kilometer coastal inlet situated in the north of Scotland. The survey was carried out utilizing a R2Sonic (Austin, Texas) 2024 MBES and a Trimble (Sunnyvale, California) UX5 drone. The survey was processed within Hypack (Middletown, Connecticut) HYSWEEP software and surveyed by Gordon Campbell from Aspect Land & Hydrographic Surveys Ltd. (Irvine, U.K.). (Photo Credit: Hypack Inc.)

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