ECOSUB

Surrey-based ecoSUB Robotics, a division of Planet Ocean Ltd is currently embarking on a £2 million Innovate UK project focused on employing its pocket AUV in swarms. The vehicles will be used in association a range of autonomous platforms under a centralised planning, monitoring and fleet management autonomy engine.

The original ecoSUB AUV concept dates back to 2015 when a group of robotics engineers from Planet Ocean & the National Oceanography Centre MARS Group began to consider the autonomous vehicle market and discuss what they would do differently.

At the time, AUVs were largely the preserve of institutes and companies with both large budgets and access to infrastructure. Instead of large vehicles, however, ecoSUB's vision was to develop micro-sized units that could be used individually to either execute smaller individual projects or alternatively, could be deployed in large numbers, closely interacting with each other.

"We didn't set out to maintain the status quo," said Iain Vincent (business development manager), "We wanted to democratise the AUV and enable its use by the wider marine science community. We saw larger vehicles on the market costing £2 million, not to mention the need for sophisticated infrastructure necessary to launch and recover these assets, and we wanted to increase the number of people that could practically enjoy the benefits of these vehicles.

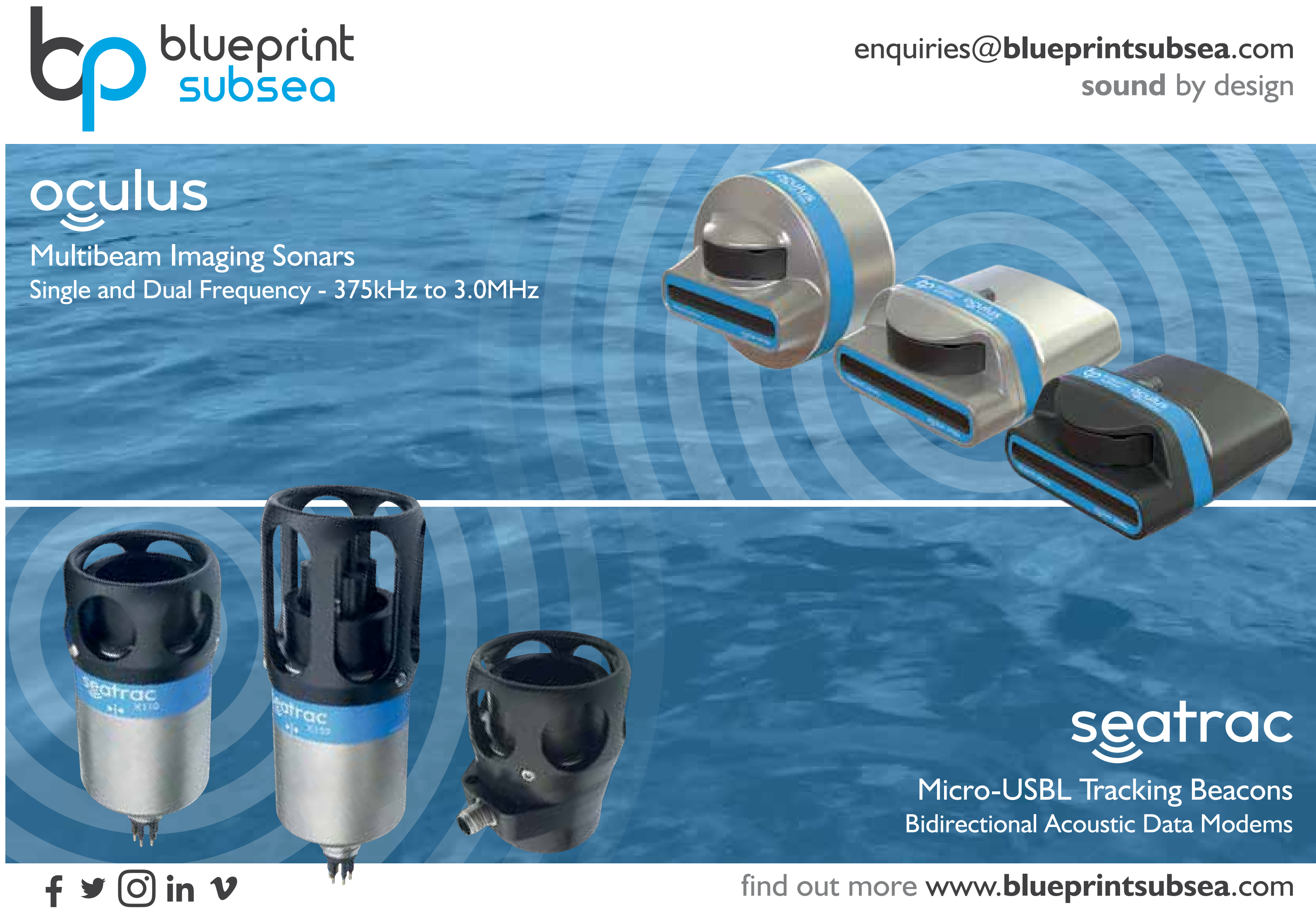
Fundamentally, it would demand a disruptive low cost vehicle design, small enough to be physically placed into the water by a single person. Its dimensions meant that it could be transported to site in cars or aircraft and could be piloted locally or remotely."

In an early iteration, the ecoSUB was to be launched through a tube and the company worked closely with ASV, (now L3 Harris) to install such launch tubes to its C-Worker autonomous surface vehicle. Tube launching meant that a vital vehicle design feature was a smooth cylindrical hull of a maximum 111mm diameter, importantly avoiding appendages such as fins protruding outwards. This also enabled launch from A Size Sonobuoy tubes.

"Designing an underwater vehicle without fins for steering or stabilisation is challenging," said Vincent. " We inserted a rudder in the Kort Nozzle just behind the propeller for lateral movement but satisfied the greater issue of pitch control by incorporating a 'moving-mass' arrangement to modify the vehicle's pitch. This manifests as a battery carriage that is able to drive itself forward along the inside of the hull. As this gradually passes across the centre of buoyancy, the nose becomes heavier and the vehicle slowly starts to dive. Conversely, moving the mass backwards causes the vehicle to rise to the surface."

In many AUVs, the comms antenna often stands within a tower arrangement, proud of main hull. In the ecoSUB-µ, however, the antenna is raked backwards along the axis of the vehicle to effectively form a tail. The antenna incorporates a GPS system as well as WiFi for short range communications transfer. It also has Iridium SBD for full global coverage. In addition, the antennas incorporate an LED visible & infra-red strobe to make them visible using infra-red cameras.

ecoSUBm



Like some underwater gliders, when the AUV reaches the surface, it can float on station with its antenna protruding upwards out of the water. ecoSUB can be fitted with acoustic nanomodems within each vehicle to enable the ecoSUBs to act as surface nodes in a Long Base Line (LBL) positioning system. This enables them to triangulate and localise themselves, position fixing with + 5 to 10 metres accuracy. Especially around the UK, the tides and currents are quite adept at moving vehicles and the position fixes ensure that the vehicles & user knows where the ecoSUBs are at all times.

"Being able to use a GPS signal and broadcast underwater using the modem allows the AUV to be used as a fairly undetectable gateway node, able to pass messages from satellite to underwater and even daisy chain vehicles for passing information," said Vincent

"Ironically, at the start, we thought that we didn't need this small AUV to be particularly intelligent in terms of its navigation as we mainly envisaged it being used for operations such as following a transect and collecting data such as, say, detecting a thermocline by measuring sound velocity. In this instance, it wouldn't be vital that the transect line wasn't exactly straight as we accepted that currents would move the small vehicle.

"Things started to change, however, when we began to engage more with users requiring geo referenced data such as side scan sonar and cameras. The later addition of a DVL, further enhanced the navigation accuracy and reduced the reliance on the LBL system.

"The original was called the micro, ecoSUB-µ5. This weighs about 4kg, is rated to 500m and is designed for relatively simple science missions, typically with single sensors suites. It is capable of measuring parameters such as conductivity, temperature, dissolved oxygen or pH. The units may incorporate devices such as a fluorometer altimeter or even a hydrophone.

"It soon became clear that there was demand for a more feature-rich single-person portable vessel with a greater payload capacity and more sensors, possibly for use in deeper waters. The result was the design of the milli- or m series, being the next size up from the original micro. It would have roughly the same length of around 1m, but a larger diameter of 146mm increasing the weight to around 12kg- still quite portable."

There are two different types of ecoSUB-m- a 500m rated version and also a 2500m model, virtually identical except for the internal ribs within the pressure hull. The extra size of the micro series gives a greater payload capacity which not only allows multiple sensors, but they can also incorporate heavier duty, more power-hungry devices such as a sidescan sonar and DVL.

“The micro AUV has a typical endurance of 8–10hrs,” said Vincent “but we are seeing a continual improvement in this as the internal technology and battery management improves.” The Larger milli has endurances of around 30 hours, o 5-8 hours with side scan and DVL, providing full working days use.

“The power comes from a hot swappable battery systems which can be replaced in minutes.

We normally use primary alkaline cells which cost around £20 a set which are ideal with small loads but as soon as a larger consumers such as a sidescan or DVL are connected, instead of getting 8hrs out of the vehicle during trials, we started getting nearer 9 mins because it drained the voltage down in the battery cells.

“The alternative is nickel metal hydride rechargeable cells. These cost nearer £100 for a set but it is possible to get around 1000 recharges from them. These hold the voltage much better given the way we take the energy.

“We did look at Lithium batteries and found that the energy density was great, giving achieve ranges up to 100km and endurances of up to 30 hours, but the amount of current profile didn’t always sit set very well when we got payloads onboard. Additionally, they were not so transportable.”

ecoSUB-µ,

SENSORS

Over the years, sensors have become a lot smaller and easier to incorporate in limited spaces. Multiple sensor heads are often ideally located in the nose section, and these can be 3D printed to accommodate complex shapes.

“We use a front seat /back seat architecture,” said Vincent “The front seat contains all of the system management and embedded controls while the back seat allows anybody else to incorporate their own algorithms control systems or third party payloads.

Altimeters can tell you how high off the bottom whilst a precision pressure sensor informs about depth. When exploring unknown areas, it is possible to define a particular depth or altitude in the mission planner and the vehicle will maintain this.

This can provides some level of collision avoidance with the bottom but not with obstacles in front and at present, sonar systems that provide this are either too big for the vehicle or take too much power from the available budget.

“We are potentially looking at locating altimeters in the nose and that would give us some level of forward looking ability but if we are going to bump into something, the ecoSUB is such a low mass system, that it is not likely to result in damage.”

“We can already integrate cameras – we have a simple GoPro in a 300m housing but we are looking at fully integrating a camera to the full 2500m and beyond. We are working with universities to use the cameras for navigation. The problem is the lighting because it consumes power quickly

During the course of the ecoSUB development it was recognised that it was not sufficient to produce the vehicle in isolation.

This led to the development of the HERMES C3 Command, Control and Communications system, which allows direct communication with the vehicles via WiFi, Iridium and acoustics in internet denied locations as well as very comprehensive mission planning, diagnostic, recovery and data processing software package.