SHIFTING THE ROBOTIC AUV INTO OVERDRIVE

Advanced Navigation's Hydrus AUV is attracting considerable interest in the marine and subsea sectors since being unveiled at Oceanology International 2022. The goal of Hydrus is to offer a fully autonomous surveying solution that is game-changing in terms of affordability, versatility and ease of use. This has taken almost a decade of research and development, testing and refinement.

''We have seen a revolution occur in the aerial drone market, where smaller, easy to use drones have opened new opportunities in applications previously restricted by cost. Hydrus is intended to offer the same accessibility to the underwater world.'' says Xavier Orr, Advanced Navigation CEO.

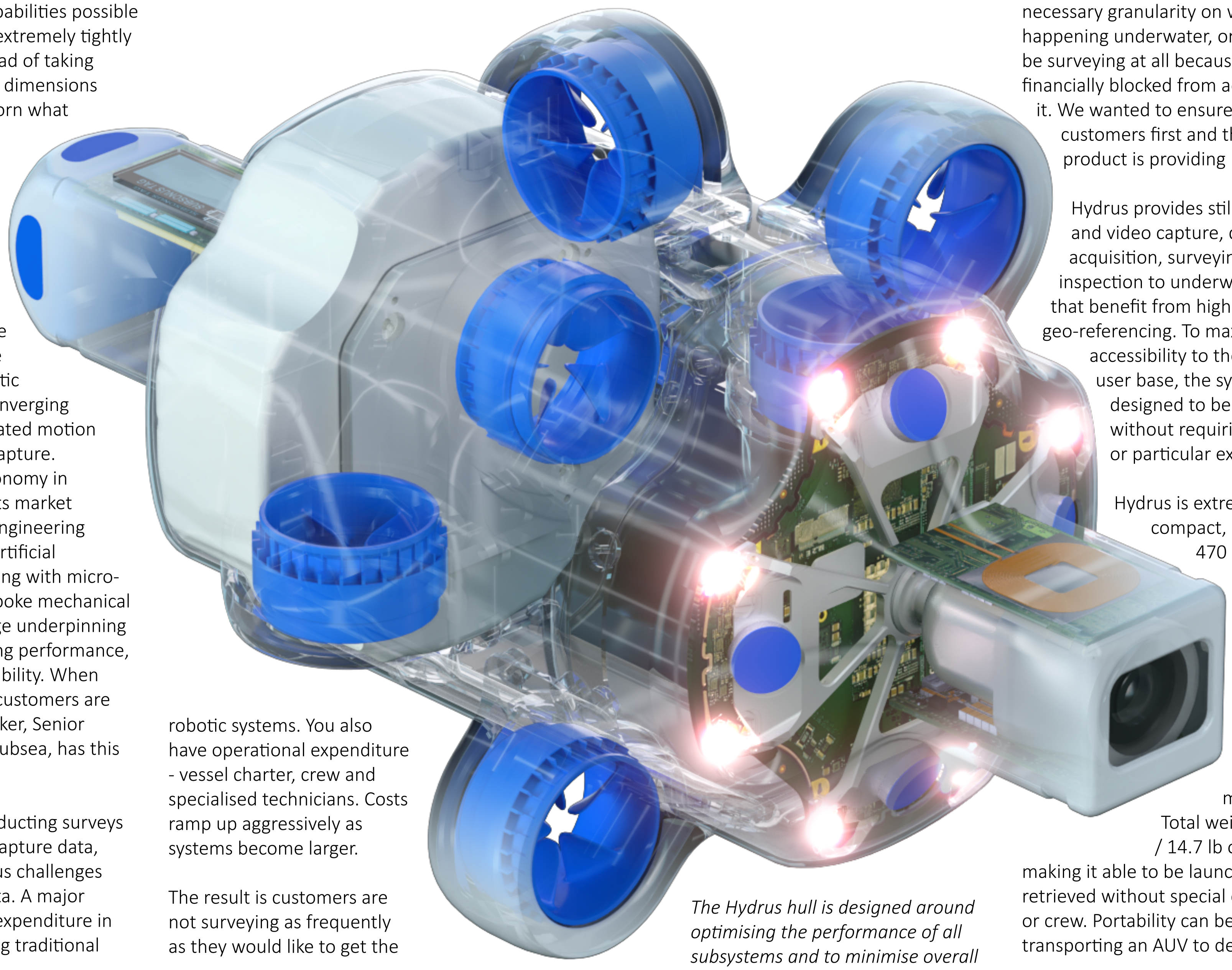
The analogy seems simple, however, designing a sophisticated underwater drone presents numerous challenges. Initial thoughts were a typical torpedo shaped hull and rear mounted propulsion system. This was rejected, though, as it became apparent that designing the hull around the robot subsystems would provide the greatest versatility and optimal system performance. Orr states;

"We wanted the most advanced sonar, navigation, and communications capabilities possible and for them to be extremely tightly integrated. So, instead of taking a cylinder with fixed dimensions and trying to shoehorn what we could inside, we designed the hull to optimise the subsystems, footprints and requirements."

Hydrus represents a leap in extending the company's expertise in inertial and acoustic technologies and converging them with sophisticated motion control and image capture. To achieve true autonomy in a package that meets market requirements, the engineering teams synthesised artificial intelligence processing with micro-electronics and bespoke mechanical design. The challenge underpinning the design is blending performance, capability, and portability. When asked what Hydrus customers are looking for, Peter Baker, Senior Product Manager- Subsea, has this to say;

"Customers are conducting surveys and inspections to capture data, but there are obvious challenges in obtaining that data. A major challenge is capital expenditure in purchasing or renting traditional robotic systems. You also have operational expenditure - vessel charter, crew and specialised technicians. Costs ramp up aggressively as systems become larger.

The result is customers are not surveying as frequently as they would like to get the necessary granularity on what is happening underwater, or they won't be surveying at all because they are financially blocked from access to it. We wanted to ensure we put customers first and that the product is providing real value."



The Hydrus hull is designed around optimising the performance of all subsystems and to minimise overall size and weight

Hydrus provides still image and video capture, data acquisition, surveying and inspection to underwater tasks that benefit from high accuracy geo-referencing. To maximise accessibility to the broadest user base, the system is designed to be operational without requiring training or particular experience.

Hydrus is extremely compact, measuring 470 mm in total length, with a main hull 170 mm diameter (260 mm including thrusters) and 310 mm long. Total weight is 6.7 kg / 14.7 lb out of water, making it able to be launched and retrieved without special equipment or crew. Portability can be critical to transporting an AUV to deployment sites, so Hydrus is certified flight safe to standard UN38.3 and can be shipped by air or carried in baggage.

SYSTEM ARCHITECTURE

In-house design and vertical integration manufacturing techniques were applied to reduce part count and provide full control over placement and material selection. This enabled creating material boundaries and separating components to minimise internal noise and de-conflict the system electrically and digitally. The hull is pressure tolerant, with fully encapsulated electronics and zero external bulkhead connectors. The external surfaces are smooth to minimise biofouling.

VISUAL DATA CAPTURE

The vision module contains the camera and ground sapphire optics. Image capture is optimised using AI in real-time and is capable of rapid movement capture and machine vision. Images are immediately evaluated for quality- any image that does not meet requirements is re-taken before the vehicle moves ahead. Still image resolution is 12MP, with 4k video- both can be captured simultaneously. A variable luminescence LED array compensates for turbidity and ambient light to provide optimised image capture.

ACOUSTIC TRANSDUCER DATA

Four acoustic transducers in a Janus configuration around the front face of the main hull provide a 130° FoV for determining physical surroundings and distances between seabed, objects and the camera/vehicle. The transducers have short minimum range capability, allowing very close tracking to objects and improved acoustic mapping resolution.

Acoustic data is used for collision avoidance and generating three-dimensional acoustic point clouds of the seabed. Point cloud data can be used for creating digital terrain models; for example, to locate points of minimum depth in a shipping channel, and be imported into mapping software. The transducers provide Doppler velocity from seabed and water-layer returns, greatly improving velocity estimates for the inertial navigation system.

INERTIAL NAVIGATION SYSTEM (INS)

A high accuracy INS, with 9-axis IMU, is used for primary navigation. The INS and DVL are fully integrated, with DVL data used to improve dead-reckoning performance for position, velocity, distance, heading and altitude. This subsystem coupling is also intrinsic to collision avoidance and enables rapid detection of hazards and taking avoidance measures.

The INS provides precise geo-referencing and timestamp data for each item of data being logged. A GNSS-based reference position is attained acoustically from the surface vessel. The INS is coupled to impeller control for navigation but also to detect and respond to current induced drift. The unit also has a GNSS antenna for establishing absolute position when at the water surface.

COMMUNICATIONS AND BATTERY CHARGING

Wifi is the primary means of uploading post-mission data and downloading missions and payload software. At the rear of the robot is a USBL module that can aid navigation and acoustic modem for status data messages and position updates, up to 1000 m distance between Hydrus and surface vessel.

Several charging options are available for the 100 Wh Li-ion battery pack. Charging is fully wireless and can be performed in or out of water. Hydrus can also provide power wirelessly to a payload carrier attached to the acoustic module.

PROPULSION

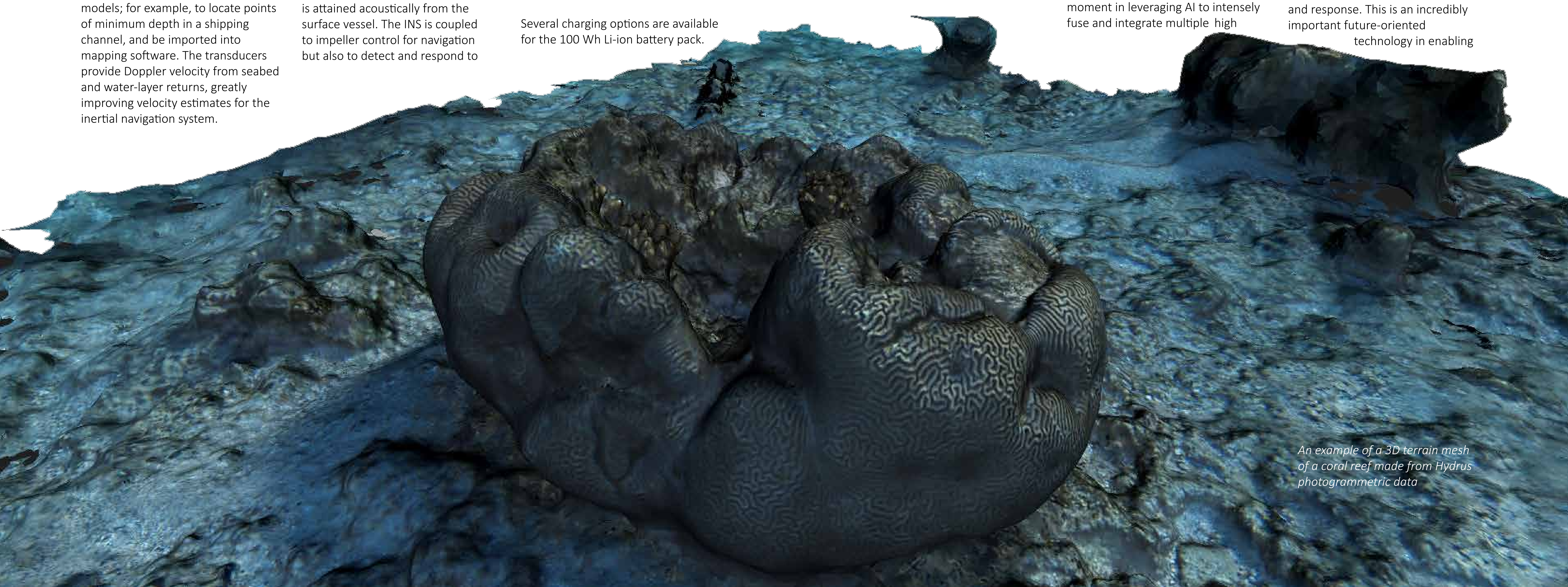
Two impeller arrays are mounted orthogonally to the hull to provide six degrees of freedom. The hull is pre-set for buoyancy to minimise burden on the propulsion system. The impellers feature contactless circumferential drives that negate axles and hubs, thus providing protection against jamming and obstruction. The impellers are used in various combinations, speeds and direction of rotation to maintain stability even in several knot currents. For efficient high-speed travel between survey locations, the robot travels horizontally.

ARTIFICIAL INTELLIGENCE AND HARDWARE

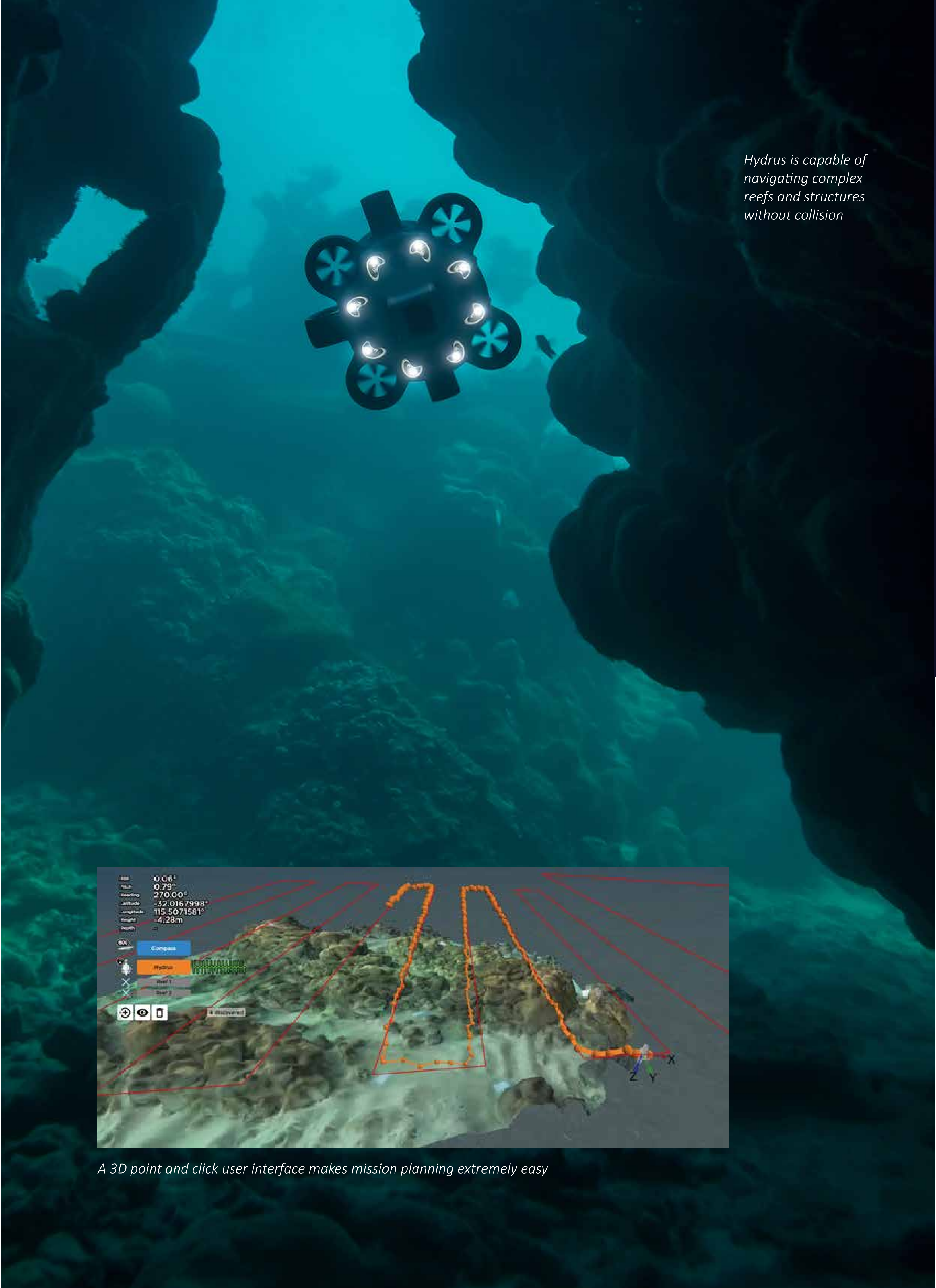
Advanced Navigation has long understood the benefits of artificial intelligence and machine learning, not only in its areas of expertise but the widespread adoption of this technology. Hydrus is a watershed moment in leveraging AI to intensely fuse and integrate multiple high complexity, interleaved systems.

"AI and artificial neural networks are fundamental parts of the technology that enables a deep fusion of data from different streams and subsystems used in our solutions. This allows our systems to be reactive to local and prevailing conditions in ways that cannot be anticipated or modelled by conventional algorithms.

From this reactive behaviour, our systems learn how to continue improving in self-analysis, guidance, and response. This is an incredibly important future-oriented technology in enabling



An example of a 3D terrain mesh of a coral reef made from Hydrus photogrammetric data



Hydrus is capable of navigating complex reefs and structures without collision

A 3D point and click user interface makes mission planning extremely easy

large-scale adoption of autonomous systems and advanced robotics." comments Baker.

Two PCBs are used- a motherboard and secondary PCB for acoustic communications and USBL. A FPGA that allows multiple systems with individual clocks to coexist and be separately synchronised ensures that data from each subsystem (INS, video, acoustic etc) is precise. The FPGA handles majority signal processing to help reduce CPU burden and minimise power consumption. The CPU is a 4-core 1.8GHz 8GB RAM unit with two cores running custom acceleration. A 1TB SSD provides data storage.

SIMPLIFIED STORAGE

The AI fused subsystems and miniaturisation of Hydrus are enabling technologies that offer simplified solutions to many complex underwater tasks. More importantly than ever to operators and clients of subsea services, the simplicity of the system and its versatility can help substantially reduce costs, environmental impacts and carbon emissions.

A 3D graphical software interface is used to create mission waypoints and set various operating parameters. Upon mission completion, the unit can be quickly retrieved for wireless data uploading and charging. Multiple missions can be stored in robot memory and automatically performed according to date and time or on demand.

Hydrus supports custom payload software and provides access to subsystem data. For example, machine vision software for classifying objects by shape, size and location via image and position data. This feature makes the system incredibly useful and able to be utilised for very complex visual detection tasks.

The versatility of the Hydrus system is immediately beneficial for shallow-mid depth survey and inspection; for example wrecks, bridge footings, pipelines and infrastructure. For large scale survey operations, such as off-shore wind farms, Hydrus deployments can vastly improve the speed and efficiency of inspection campaigns.

A small, manoeuvrable AUV that is capable of real-time decision making without human intervention can often supplant cumbersome, expensive systems while providing opportunity for more frequent, more affordable surveys.