# GLIDERMAN

Steve Woodward is responsible for gliders within the Marine Autonomous and Robotics Systems group at the National Oceanography Centre in Southampton (NOCS).

Currently, the group maintains around 24 Slocum Gliders and 7 Seagliders, as part of the UK's National Marine Equipment Pool, available for use by the UK scientific community.

In addition, NOCS runs the European Slocum Glider Service Centre for service and repair. Teledyne's clients can call upon the facilities rather than having return their gliders to United States.

Steve discusses aspects of modern glider design and operation.

Gliders have come a long way since the first were developed in the 1960s. In the early days, scientists were delighted if they got data – or indeed, their vehicle – back after a month or two. Today, it is not even remarkable for multiple vehicles from different manufacturers to interact with each other using acoustic communications.

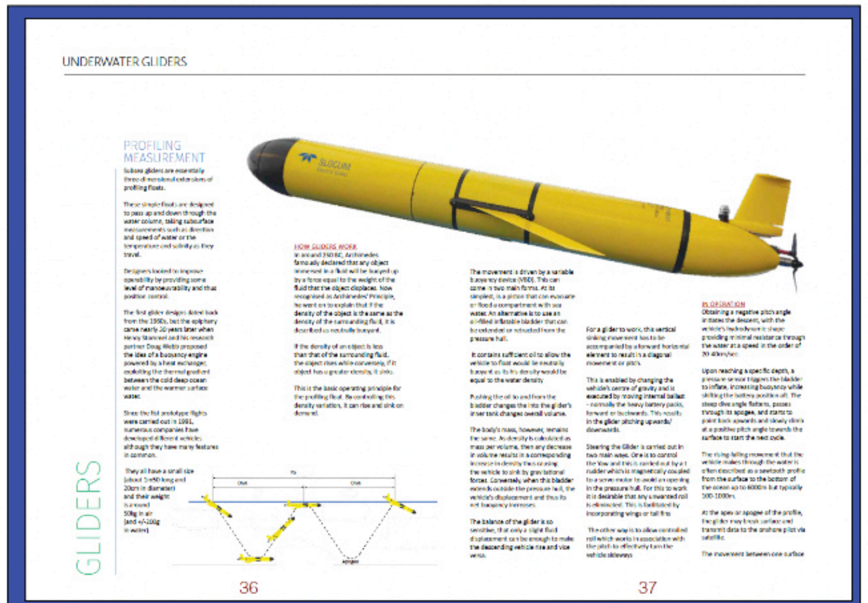
There is also a greater mix of vehicles in general. Gliders, AUVs, subsea vehicles and surface vessels can all cooperate on the same project to afford a more complete picture of the environment.

"Modern gliders can carry more sensors to produce more data," said Woodward. "While increasing onboard processing reduces overall endurance, we have looked for ways to improve operability. Our longest mission is now 240 days (although the longest we know about is greater than 400 days). Deployments of around 6-10 months are not uncommon and we are close to reaching the one-year mission mark."

Most gliders are long torpedo-shaped vehicles often incorporating wings and/or a tail for steering and stability. They all operate, however, using a similar buoyancy mechanism to travel across the water in the same classic saw-tooth motion. After diving to the target depth, a change in buoyancy and movement of an internal mass (a battery pack) causes the vehicle to rise to the surface with the nose tipped upwards .

Close to the surface, the nose is tipped down again, and once the tail breaks the water, it can transmit accumulated data to a satellite. It then repeats this cycle, all the time expending remarkably little energy.

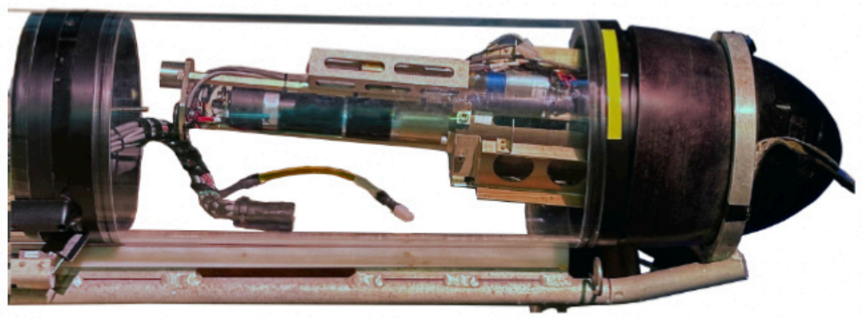

*Array of Gliders in storage*




HOW GLIDERS WORK
A previous issue, explaining how gliders operate, can be seen here.

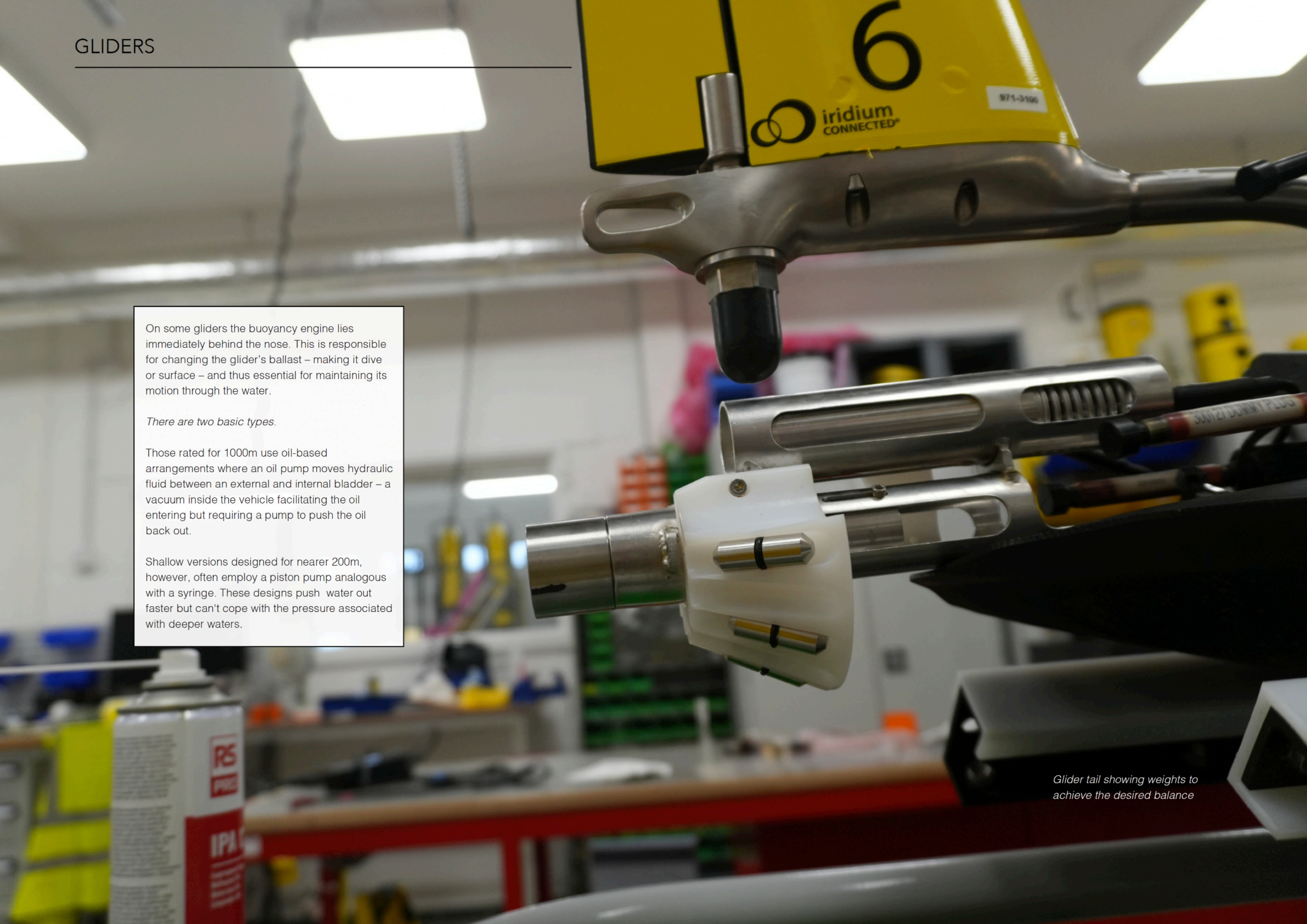
## ANATOMY OF A GLIDER

In some designs, to aid recovery, the nose (fabricated from syntactic foam within a tough external skin ) is remotely released to act like a drogue anchor. A 10 metre trailing line can then be snagged by a grapnel, allowing the glider to be recovered to the recovery vessel.



*Inside the nose is an altimeter to measure the vehicle position with regards to the seabed.*

# GLIDERS




On some gliders the buoyancy engine lies immediately behind the nose. This is responsible for changing the glider's ballast – making it dive or surface – and thus essential for maintaining its motion through the water.

*There are two basic types.*

Those rated for 1000m use oil-based arrangements where an oil pump moves hydraulic fluid between an external and internal bladder – a vacuum inside the vehicle facilitating the oil entering but requiring a pump to push the oil back out.

Shallow versions designed for nearer 200m, however, often employ a piston pump analogous with a syringe. These designs push water out faster but can't cope with the pressure associated with deeper waters.

*Glider tail showing weights to achieve the desired balance*

SENSING AND CONTROL

Every glider has a conductivity temperature depth (CTD) package which provides water density information.

“We've had just over two years of continuous operations for the UK Met Office taking temperature and conductivity measurements to validate their supercomputer climate models, as there are parts of the ocean where the model is not as accurate as others.

The data gets fed back and assimilated daily.

“They can run two versions of the model, one using the glider data and one ‘control version’ without, to assess the benefit of the extra in-situ data source. In the first year, our gliders took 35 million data points for temperature and 35 million for conductivity.

However, the central module houses the glider's interchangeable payload that can be modified according to the project needs.

“One recent project has been to look at carbon cycle organisms in the water column,” said Woodward. “In deep waters, we employed optical sensors able to detect backscatter to see how much light of a certain wavelength was reflected. Other sensors measure light and oxygen levels from the top of the water column down to full depth.”

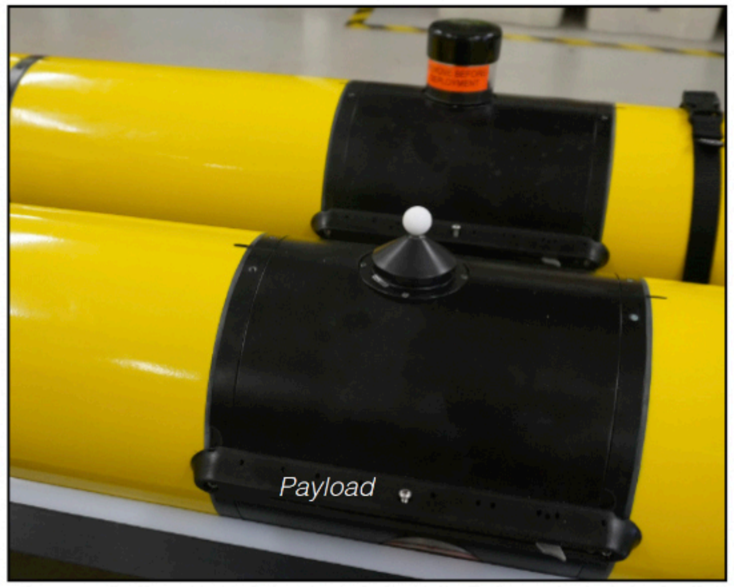
HYBRID

Some manufacturers advertise gliders as being Hybrid Capable. This translates as them having a rear propeller.

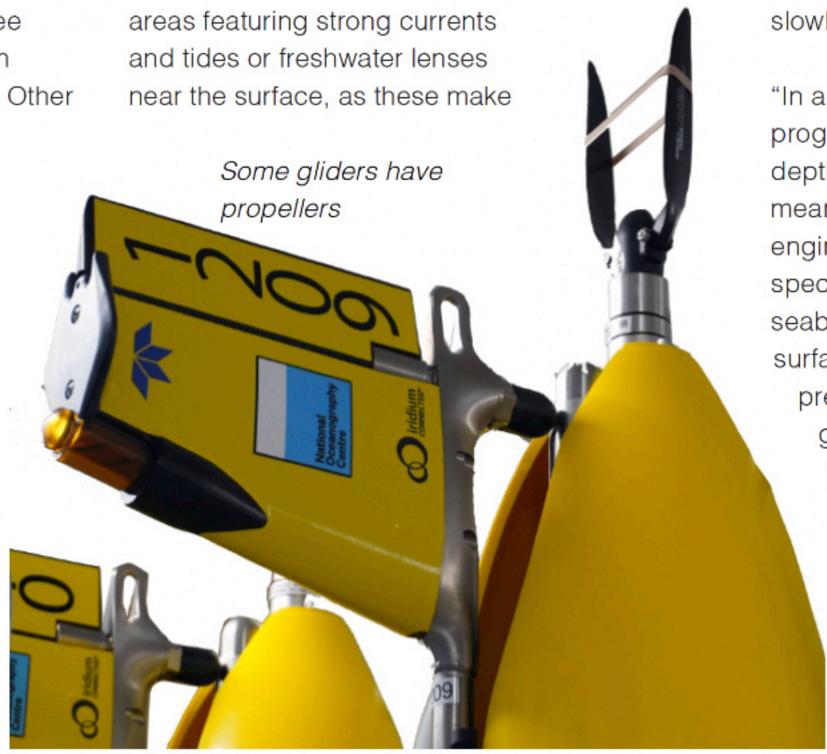
“We try to never use thrusters for propulsion, instead solely relying on the more efficient buoyancy engine,” said Woodward.

“It can be useful, however, in areas featuring strong currents and tides or freshwater lenses near the surface, as these make it hard for the buoyancy glider to pass through without stalling. In such cases, therefore, the glider can be set up in such a way that it will autonomously engage the propeller for extra thrust.

“Our ascent speed is typically 0.1m/sec, so we might set the thruster to engage if the speed drops below0.05 m/sec as it approaches the surface.



Payload



*Some gliders have propellers*

AUTONOMY

“Glider autonomy is still limited. Currently, the vehicles are only able to make decisions based on a limited number of parameters, such as if they reach a particular depth or suddenly detect the seabed and need to turnaround. This is slowly changing.

“In a typical mission, the glider is pre-programmed to follow a path to a specific depth and start to begin the turn. This means pre-programming the buoyancy engine to change once it reaches a specific depth or altitude above the seabed. When the glider reaches to the surface, the operators will have preprogrammed how much data the glider will send and what actions the glider should take when something goes wrong.

“We have some development projects ongoing that could improve the way we operate,” said Woodward. “At present, the Slocum glider has two processors. The main flight processor is used for navigation and control while the science processor controls all of the payload sensors and data.” The group are now adding a third processor, a backseat driver.

“It can effectively take inputs from the other two and conducts some internal processing before relaying information back to the onboard flight processor to modify the way the glider behaves underwater. This occurs without receiving

*Central payload section*

## Shallow vs Deep Water

What are the differences between shallow water and deep water glider designs?

"One factor is the type of pump and how the vehicle is set up to achieve a balance between speed and operation," said Woodward.

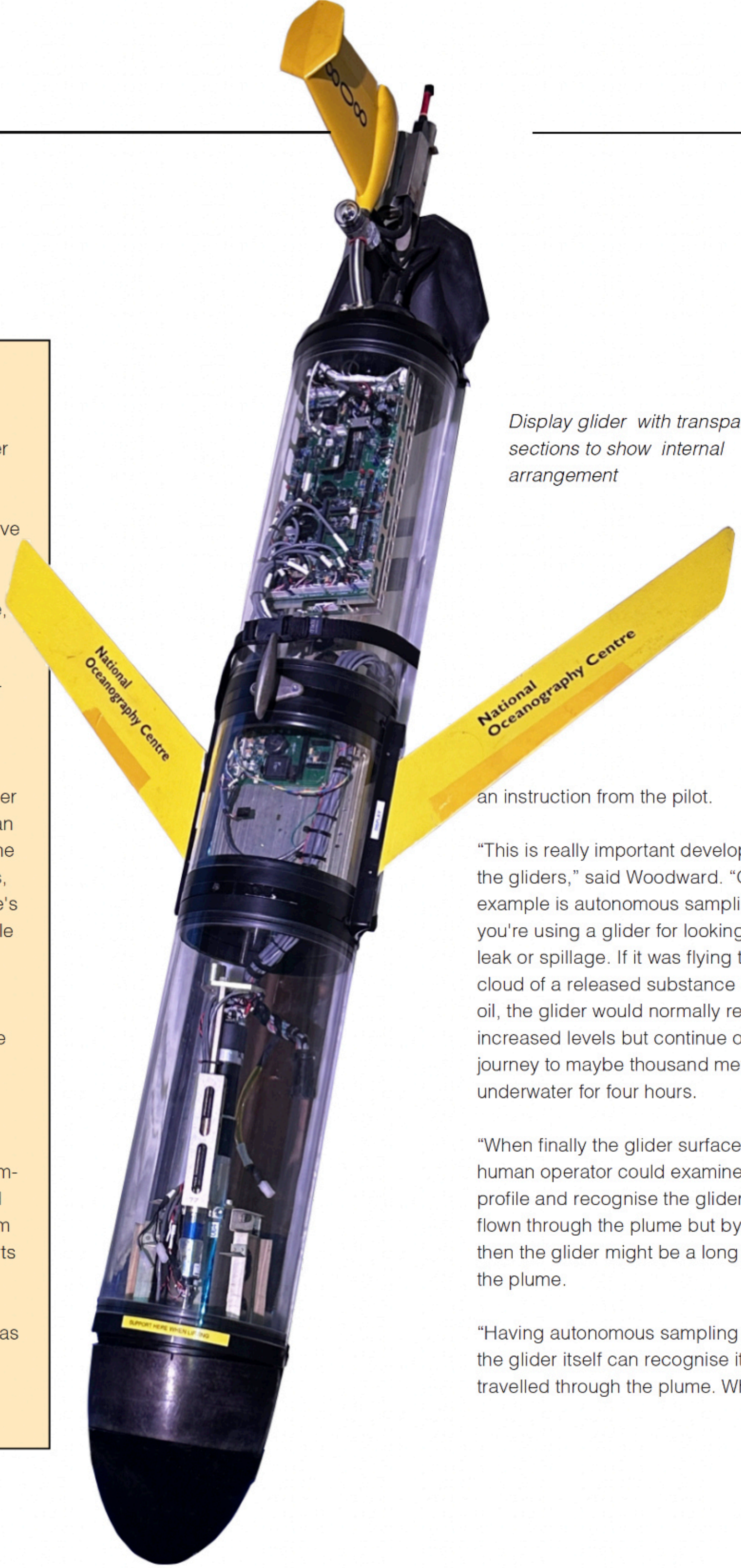
"In shallow water, you don't need a pump that can cope with pressure, but you do need one that can run quickly. That is because a proportionally greater amount of time is spent making the turn at apogee, so you need to be able to have a pump that makes the glider turn quickly and get back to stable flight where we can collect good data.

"Regardless of the depth rating, gliders are always more efficient closer to their maximum depth: a 1000m glider is more efficient at 1000m than it is at 500m. This means, that in theory, it would be possible to tune the engine to the exact maximum depth simply by changing gearing. This, however, disregards the fact that when operating in 200m water, there's a pretty good chance that you're going to be operating for quite a while in 100m of water, for example when making transects back and forth across a slope.

"Instead, the designers offer a range of pumps. As operators, we have to look at the science requests and understand the locations in which they want to operate. That will determine whether we buy deep or shallow pumps.

"NOC has a range of 1000m and 200m-rated gliders as well as a 350m-rated glider. In theory, we could also buy even shallower pumps rated to 100m, but that would mean that the only people who could use them are those interested in studying water shallower than 100 meters - parts of the North Sea, for example.

"As such, we try and keep as much modularity as we can in the fleet, as we don't really know what the science drivers will be in three or four years' time."




*Display glider with transparent sections to show internal arrangement*

an instruction from the pilot.

"This is really important development for the gliders," said Woodward. "One example is autonomous sampling. Say you're using a glider for looking at an oil leak or spillage. If it was flying through a cloud of a released substance such as oil, the glider would normally recognise increased levels but continue on its journey to maybe thousand meters underwater for four hours.

"When finally the glider surfaces, a human operator could examine the profile and recognise the glider had flown through the plume but by then, then the glider might be a long way from the plume.

"Having autonomous sampling means the glider itself can recognise it has travelled through the plume. When it

## BATTERIES

Today, we use more rechargeable batteries than we have previously," said Woodward. "Of course the downside of rechargeables is that the endurance reduces quite considerably."

The research vessels are typically away at sea for four to seven weeks. The endurance for a glider with secondary batteries is about six weeks, but they can be recharged on the host vessel. An underwater station that can employ wireless charging systems can be used for larger AUVs, but gliders are not particularly manoeuvrable and this is not currently an option.

There is still a call for primary Lithium batteries, as these greatly increase the endurance, but this comes at a financial cost. They may, however, be the only answer for inaccessible operations such as those under ice, etc.

reaches the surface, or even before, rather than waiting for new instructions from the pilot, it can instruct the flight computer to turn around, fly back towards the plume, resolve its extent and possibly return to the surface instead of continuing down to the seabed. It becomes a really useful tool for science, as well as commercial applications.

“We could also use adaptive sampling, where, if it detects (for example) temperature changes that might indicate an ocean front, the glider can either start sampling in that area or follow that body of water.

This, therefore, does some of the pilot’s work for them and means it is not necessary for the operator to wait - potentially hours - until the glider surfaces to instruct the glider to follow the temperature change.

“Another benefit of autonomy is when working under ice. The glider will want to climb to the surface, but sometimes ice cover prevents this and can damage the vehicle. It also cannot receive new instructions. We need to add extra processes so that the glider can also detect what’s above it such as an ice sheet and automatically know to turn around or change heading.

“A backseat driver allows for processing that extra information. Is there ice above the glider? What's the water temperature? What's the salinity of the water above? Is the glider likely to be able to get to the surface? In such case, the vehicle can turn 20m, maybe, 30m below where it perceives ice is, and then start to dive again, possibly changing heading, and steering somewhere else.

“One of the projects we are currently working on, and intending to start trials in the spring, is to use acoustic underwater navigation to keep the glider within a certain area without ever going to the surface.

“When combining the extended endurance of the glider with the ability to operate under ice, it might be able to carry out the sort of work that is currently the domain of much larger vehicles. Being able to use these vehicles, instead of larger autonomous vehicles, also reduces the transportation and logistics issues involved in moving these types of vehicles around.”

## VEHICLE REPAIR

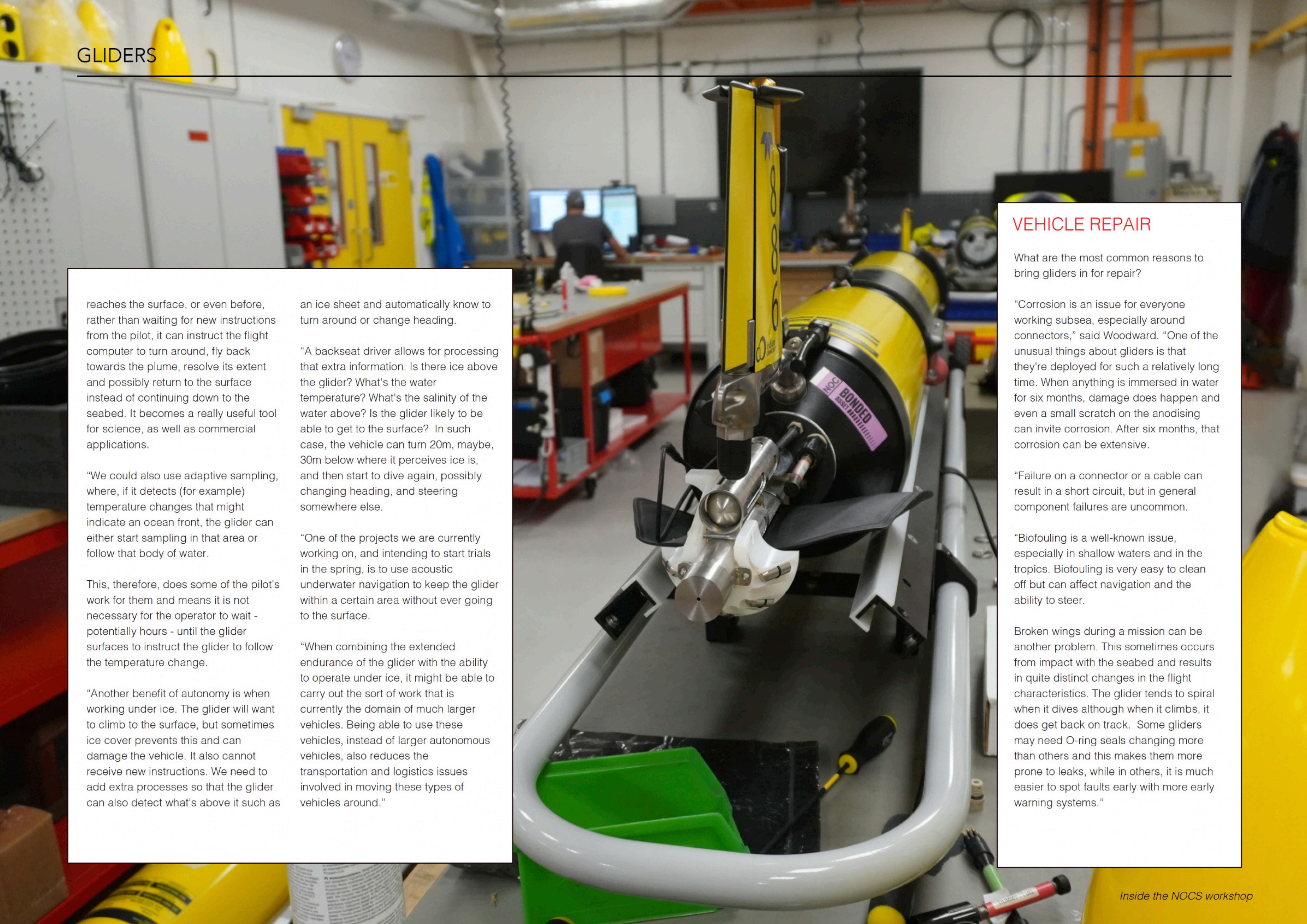
What are the most common reasons to bring gliders in for repair?

“Corrosion is an issue for everyone working subsea, especially around connectors,” said Woodward. “One of the unusual things about gliders is that they're deployed for such a relatively long time. When anything is immersed in water for six months, damage does happen and even a small scratch on the anodising can invite corrosion. After six months, that corrosion can be extensive.

“Failure on a connector or a cable can result in a short circuit, but in general component failures are uncommon.

“Biofouling is a well-known issue, especially in shallow waters and in the tropics. Biofouling is very easy to clean off but can affect navigation and the ability to steer.

Broken wings during a mission can be another problem. This sometimes occurs from impact with the seabed and results in quite distinct changes in the flight characteristics. The glider tends to spiral when it dives although when it climbs, it does get back on track. Some gliders may need O-ring seals changing more than others and this makes them more prone to leaks, while in others, it is much easier to spot faults early with more early warning systems.”




*Inside the NOCS workshop*