SAMS

First **solid hydrogen drone** takes to skies

The first drone powered by solid hydrogen made its maiden flight in February – the fruit of a long-term collaboration between the private sector and scientists at the Scottish Association for Marine Science (SAMS).

It flew for just ten minutes and stayed below a height of around 80 metres, but it proved the new power system works. The team are now planning another flight this summer, lasting an hour or two.

The hydrogen engine emits nothing but water, bringing both environmental and scientific benefits – particularly if you're trying to sample the atmosphere and not your own exhaust gases.

There have been many attempts to build aircraft that run on hydrogen. But if it's stored as a gas, to carry enough to be a useful fuel source you have to keep it at very high pressures. This means the piping and containment systems have to be strong and heavy, limiting how much the aircraft can carry and how long it can stay aloft.

'The problem with storing hydrogen is that it's a gas unless cooled below -238°C,' says Dr Phil Anderson, head of the Marine Technology group at SAMS. 'To get enough on board, one method is pressure, but you need to crank it up to around 700 atmospheres. That needs some heavy-duty engineering and it's a challenge just to build something light enough to fly.' And if something goes wrong, it goes very wrong indeed – a high-pressure system has the potential to explode.

The system on the new drone operates at low pressure by using a solid form of hydrogen. This gets round the pressure problem, though it poses challenges of its own. The drone uses a system developed by UK firm Cella Energy, which stores hydrogen as solid pellets that are gently heated to release it as a gas. A fuel cell devised by Arcola Energy then turns this hydrogen stream into electricity, which powers an electric motor. The partners were initially brought together by Innovate UK – then known as the Technology Strategy Board – to help accelerate the development of this exciting new technology.

The power system is light, powerful and clean. What's the catch? At the moment the pellets are expensive. The developers hope that economies of scale will mean costs fall as the system becomes more widely used.

Once that happens, it could start being used in all kinds of situations. One clear target is the inner city electric car; hydrogen would replace the batteries and eliminate the need for lengthy recharging. In this context the solid fuel system is inherently safer than one using high-pressure hydrogen.

For scientists, Anderson says hydrogen-fuelled drones' lack of gaseous emissions will create new possibilities. 'It opens up a whole new style of atmospheric observation,' he says. 'With a large piloted plane you generally fly in quickly, taking measurements and leaving your pollution behind, but with a hydrogen-powered drone you can loiter over a small area for up to an hour, taking repeated measurements without ending up in a cloud of your own pollution. So you can get much better data on the composition of the atmosphere.'

Unlike internal combustion engines, the electric motors on most UAVs are unfazed by a dunking in the sea, lending themselves to operations over the oceans. Hydrogen storage also copes better with cold temperatures than equivalent battery-powered systems or even internal combustion engines, which would make life easier for scientists working with drones at the poles.

In the meantime, this shows that collaboration between scientists and business is good for everyone. The researchers get involved in developing next-generation technology that can help them with their work; the companies get practical input from expert users who can test their work in demanding situations and suggest possible improvements.

Anderson's now focused on cutting the drone's weight ahead of the next test flight. This should let the team do some real science along the way – perhaps examining the way the water leaving a sea loch as the tide goes out mixes with the open water.

Drones to brave volcanic plumes

Scientists are preparing to use unmanned aerial vehicles (UAVs) to sample the gases in volcanic plumes – places too risky for research planes to venture into. They hope to shed light on how these plumes develop over time. This should avoid economic costs by helping authorities avoid closing airspace unnecessarily, and benefit people's health.

The researchers are looking to recruit a PhD student to the NERC Doctoral Training Partnership at the universities of Leeds and York who'll develop the new drone and its sensors to measure a plume's composition.

They'll have to deal with some of the toughest conditions for drone flight yet attempted. 'It's going to be very difficult,' says Dr Barbara Brooks, a researcher at Leeds and head of the Atmospheric Measurement Facility at NERC's National Centre for Atmospheric Science. 'A volcanic plume is an extremely aggressive environment, with a mix of ash particles and hot, corrosive gases that means you can't risk sending a research aircraft into one.'

The project comes out of a NERC-funded project that was set up in response to the 2010 Eyjafjallajökull eruption in Iceland, aiming to improve our ability to model and predict the behaviour of volcanic plumes. It's a collaboration between academic researchers and partners including the UK Met Office and its Icelandic equivalent, the UK Civil Aviation Authority and the aviation industry.

Brooks says using UAVs can bridge the gap between research aircraft and ground-based measurements. Monitoring the 2014 eruption of Bárdarbunga involved lots of people driving around Iceland with hand-held instruments; in future, swarms of lightweight drones may be able to gather that data, and much else besides.

Understanding the composition of volcanic plumes and how they develop over time will help manage the economic damage they cause, and the harm they do to people's health through their effects on air quality.

Modelling our landscape in 3D

3D model of the cliff face at Aldbrough.

UAVs are helping NERC's British Geological Survey (BGS) understand and monitor areas that are susceptible to landslides around the UK, allowing the authorities to manage risks to the public more effectively. BGS researchers use a range of UAVs including a six-rotor model known as the Hexakopter, which flies slowly around the landslide, taking many overlapping photos from different angles. They then use a computer to stitch these images together into a 3D model of the cliff face.

The Hexakopter can carry heavier instruments and fly in nastier weather than more common four-rotor models. 'Wind's a big issue for us,' says Dr Colm Jordan, who leads the BGS Earth and Planetary Observation and Monitoring team. 'If you're going out in the immediate aftermath of a landslide, the weather's usually not ideal. So you need a platform that can handle the conditions.'

UAVs can respond quickly when a major new landslide is reported. The team doesn't only visit landslides right after they've happened, though; by returning regularly, they can build up a picture of how an area is changing over time. The 3D data is combined with analysis of the area's geology, and with readings from other on-site instruments like soil moisture meters and GPS sensors. For instance, the team keep a close eye on the cliffs at Aldbrough in Yorkshire, which are receding quickly and have already destroyed several buildings. Much of this can be done in other ways, but that would take longer. 'Having the drone lets us use the people on the ground in a more focused way; they don't have to do the basic work of creating a model of the whole hillside,' says Jordan. 'So they can concentrate on hotspots of activity where things are changing particularly fast.'

BGS drones don't only work on landslides; they're involved in projects that range from monitoring for gas that's leaking into the atmosphere from the ground to understanding how Icelandic glaciers are responding to climate change.