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MARINE SURVEYING ASCENDS

One company's success reveals how work in offshore surveying is booming.

FLATDOG MEDIA

Airborne Research Australia brings unique capabilities—including powered gliders reported to be more economical than UAVs—to a wide range of research projects.

By Jeff Salmon

Airborne Research Australia (ARA) is Australia's National Research Aircraft Facility and is hosted within the School of the Environment at Flinders University in Adelaide, South Australia. ARA's capabilities are unique in terms of their aerial platforms and their all-in-one approach to airborne atmospheric science and airborne remote sensing. ARA's mission statement is "to carry out world leading research in airborne environmental sciences," and their website adds, "probing the environment using the least intrusive and most cost-efficient airborne technologies."

ARA's all-in-one approach to airborne research projects has several components. First, ARA owns its fleet of aircraft and has a small, five-person team. The multi-function team serves as scientists, technicians, data processors, and pilots. In addition to streamlining the process, this provides the advantage of first-hand observation of the target areas as well as a direct understanding of the possible inadequacies and advantages of particular data sets. This collaborative method makes the end-user an integral part of the team, either as part of the crew or through collaboration with the team.

One of the key factors in their all-in-one approach is ARA's cost-effective aerial platforms. The operating cost of their aircraft is so low that the number of flying hours needed to accomplish the tasks is virtually a non-issue. Additionally, they can carry multiple sensors at no additional cost. These can include Riegl Q560 full waveform lidar, SPECIM AisaEAGLE and AisaHAWK VNIR/SWIR hyperspectral scanners, active (InSAR) and passive ProSensing microwave scanners.

The ECO-Dimona, their main aircraft, is built by the Austrian-Canadian Diamond Aircraft Company and described as a "powered glider." The craft offers superb aerodynamics, including a 25-1 glide ratio, and very low operating costs,

ABOVE: ARA scientists Jorg Hacker (left) and Wolfgang Lieff set up the SPECIM AisaHAWK hyperspectral scanner mounted in a pod under the wing of the ECO-Dimona research aircraft.

Australian Aer

thanks to excellent fuel economy and its use of standard premium unleaded fuel. The latter contributes to ARA's claim that, in many cases, it is more economical than a UAV. What's more, the ECO-Dimona does not suffer from the typical airspace restrictions that UAVs are subject to. ARA owns two ECO-Dimonas, models VH-EOS and VH-OBS, and calls them both "magic carpets."

To get a feel for how ARA's unique capabilities and methodologies come into play in its projects, I interviewed Jorg Hacker, director and chief scientist of ARA.

ial Innovation

Turtle Reef

Professional Surveyor Magazine: I read your presentation from the Riegl Lidar 2013 conference and selected three of the many interesting projects for a deeper look. Let's start with your mission to Turtle Reef.

Jorg Hacker: Turtle Reef is a species-rich coral reef in a mud-dominated, macrotidal, virtually landlocked embayment within Talbot Bay in the Kimberley region of northwestern Australia. The area is located in one of the most remote areas in Australia and is all but inaccessible from land due to terrain and also restricted military areas directly to its south. Talbot Bay features the world's second-largest tidal variations of 11 meters, with Turtle Reef exposed in its entirety only during rare, very low tides. Apart from aerial and satellite photographs, there are few scientific observations of any kind available of the reef area and the surrounding waters.

The Turtle Reef project was the result of a coincidence. The ARA survey aircraft was on task to survey the waters and coastal features around Port Hedland in northwestern Australia, as well as some areas of the eastern and western sides of the Dampier Peninsula in collaboration with the Western Australian Marine Sciences Institute (WAMSI).

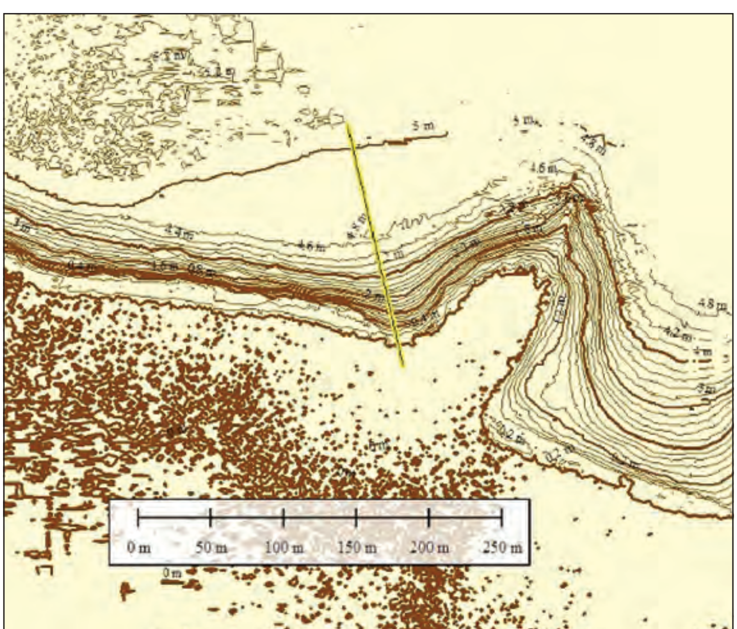
TOP: Aerial photograph of study area in Talbot Bay, Kimberley region, Australia—*courtesy of Shakti Chakravarty.*

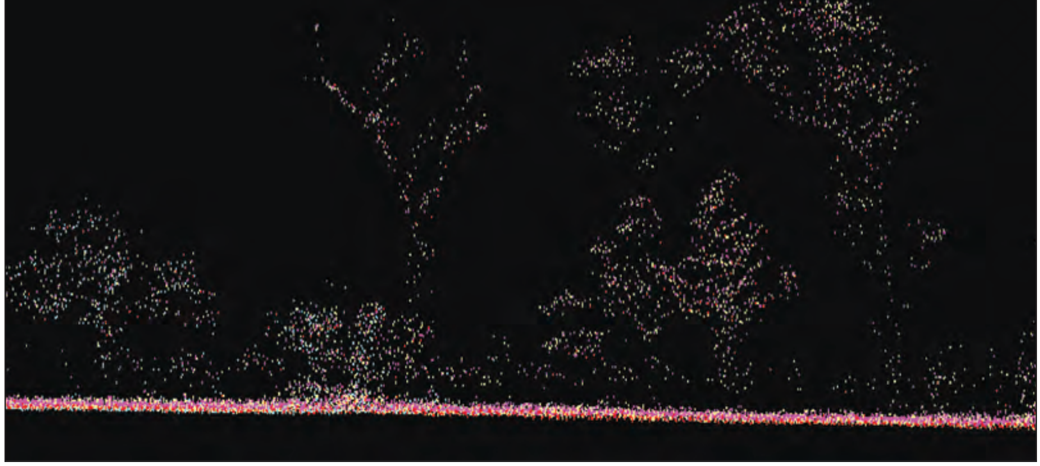
BACKGROUND: The ECO-Dimona is described as a "powered glider" offering superb aerodynamics, low operating costs, and the ability to carry a robust sensor package.

To do a first check of the collected airborne data, the survey team (my wife Shakti Chakravarty and I) stayed for a few days in a hotel in Broome. One afternoon, two scientists from the Western Australian Museum visited and told the crew that in two days' time a rare, very low tide would expose most of Turtle Reef—about 200km NE of Broome—and asked if it would by chance be possible to do some laser scans of that unique event, but that there was no funding available for this. Considering the low operating cost of the ARA "magic carpet," the survey team agreed and had a great six-hour flight two days later.

We had on-board the Riegl Q560 full waveform lidar, a SPECIM AISA Eagle VNIR hyperspectral scanner, the ARA/AWI high-resolution tri-spectral scanner, and a Canon EOS 1D digital camera, plus the associated ancillary sensors such as several high-accuracy GPS/IMU units.

BELOW: View of part of the edge of Turtle Reef showing data derived from measurements with the Riegl Q560 airborne laser scanner. Shown are elevation contours in meters above the lowest water surface point.





ABOVE: Cross section through a stand of Gamba grass in the savannah of the Northern Territory of Australia. Shown is a point cloud of individual laser returns as taken from the Riegl Q560 airborne laser scanner. The cross section is 5m wide and shows data from five individual overpasses flown at different altitudes (50m, 100m 200m AGL) and lidar pulse rates (240kHz, 120kHz).

All went very smoothly, resulting in a great and unprecedented data set for this area of the world. Together with the reef researchers, results were published in the Journal of the Royal Society of WA, and a compilation of the aerial images was put on VIMEO (www.vimeo.com/19011651). Data from this flight also formed the basis of an exhibition showing enhanced lidar and other airborne remote sensing images in an arts exhibition at the Adelaide Fringe Festival.

Gamba Grass

PSM: Australia, like the United States and many other countries, faces difficult issues with invasive, non-native species. Tell us about ARA's research project on the problem of Gamba grass.

JH: Gamba grass is an invasive species that was introduced from Africa into Northern Australia to augment the native grasses that form the basis for fattening cattle. That was the idea, but it turned out that Gamba grass is actually a very aggressive species that overwhelms just about all native vegetation and forms nearly impenetrable thickets. Furthermore, as it grows very tall (up to more than three meters) and dries out quickly, it changes the whole savannah fire regime. There are other effects which make it even worse, such as the root system into which the fire spreads, destroying grass and plant seeds in the ground that normally survive bushfires.

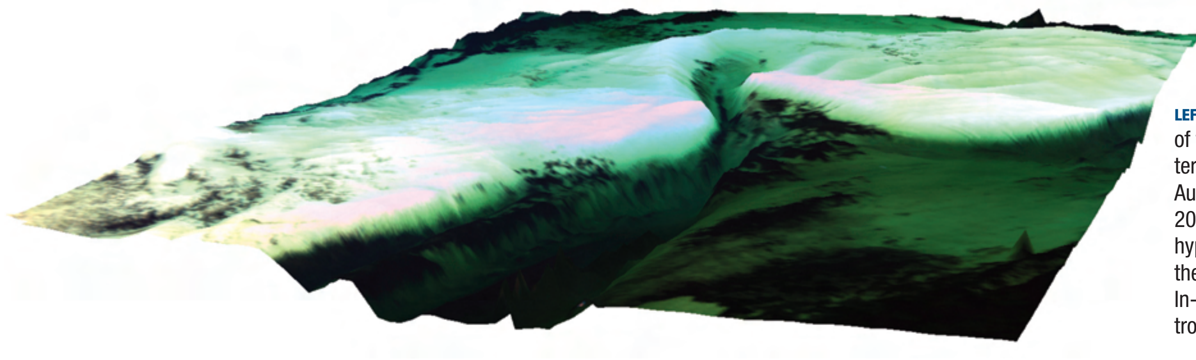
Intense attempts are underway to control these Gamba grass infestations. To determine the effects of the Gamba grass on the native savannah vegetation and to assess the effectiveness of mitigation strategies, aerial surveys are an immensely useful tool. However, so far nobody had tried to use airborne lidar for this because Gamba grass has very dense stands which make it difficult for lidar to "see" the ground.

To determine what airborne lidar can actually do, we teamed with scientists from Charles-Darwin University in Darwin and others who carried out ground-based surveys in parallel to our airborne ones. We also used special strategies to establish what method would give the most detailed structural information. For instance, we flew our small-footprint lidar at various heights, between just 50m AGL [above ground level] to 600m AGL, with different pulse rates, and in different directions over the same areas, overflying some of the areas up to six times and then combining the measurements.

This strategy obviously requires highly accurate measurements in terms of geo-location. First analysis showed clearly that we were able to achieve this. The next step will be to also use the full waveform data from the Riegl lidar to get even more details.

The ARA magic carpet (in this case, VH-OBS) was an ideal tool for this work due to its flexibility in terms of flying speed (25m/s to 50m/s), stability, and low noise pollution (not to scare the cattle).

The Gamba grass flights were made during a week-long deployment of the ARA magic carpet in the Northern Territory of Australia, together with a whole range of other surveys covering escarpment zones of Litchfield



LEFT: 3D surface showing bathymetry of the St. Kilda Channel, an underwater feature near Port Adelaide, South Australia. Data was captured in April 2009 using the SPECIM AisaEAGLE hyperspectral scanner mounted on the ARA research aircraft and the In-Situ Marine Optics DALEC3 spectrometer mounted on a small vessel.

National Park (for geo-morphology), timber plantations on Melville Island, a wildlife park, a WWII airstrip to locate historical features there, transects of the Adelaide River floodplains, and a 5-by-5km monitoring area on a plateau of the Litchfield National Park—together a very intense survey program.

And, on the way home to Adelaide (about 3,000km), another lidar survey was flown at night out of Alice Springs in Central Australia to support a Ph.D. project at ARA's host University, Flinders University.

An interesting challenge for the survey flights was that they took place in parallel with a large military exercise involving large numbers of fast jets (F-15s, F-18s, and others) from the Australian, United States, Singaporean, and other air forces with continually changing airspace restrictions. Another challenge was to cope with the large amounts of airborne data sampled and to make sure that everything is checked and backed up properly—in a tropical environment, staying in a small resort with few facilities, and using only notebook PCs—with a team consisting of just three individuals. But it was all worth it!

BELOW: Instrumentation for bathymetric measurements mounted on the wing of the ARA research aircraft (Diamond Aircraft HK36TTC-ECO Dimona). Left: the SPECIM AisaEAGLE Hyperspectral scanner (400-970nm) in the under-wing pod; right: the In-Situ Marine Optics DALEC3 spectrometer—*courtesy of Andrew McGrath.*

Shark Bay

PSM: The possibilities of bathymetric lidar is an interesting subject. Your presentation contains what you call an "ideal test case" in the form of your Shark Bay project.

JM: Shark Bay is a large, shallow estuary with a 30km-wide sandbar at its [northern] opening to the Indian Ocean. It's located at Australia's west coast about 650km north of Perth. It's also the home of the Stromatolites that provide the most ancient records of life on Earth by fossil remains that date from more than 3.5 billion years ago.

The direct purpose of the survey was to map the 150km-long coastline of Shark Bay as well as the mouth of the Wooramel River to assess the effect of sea level rise, but also to map the coastal vegetation. Using the hyperspectral sensor and lidar together, it was possible not only to determine the topography of the land, but also the bathymetry down to about 30 meters and also benthic parameters.

The ARA magic carpet carried the Riegl Q560 full waveform lidar, a SPECIM AISAEagle VNIR hyperspectral scanner, the ARA/AWI high-resolution Tri-Spectral scanner, and a Canon EOS 1D digital camera, plus the associated ancillary sensors such as several high-accuracy GPS/IMU units.

A special challenge of this survey was the weather, because deriving bathymetry and benthic data from airborne hyperspectral measurements requires clear skies. The survey took place in May, which is usually a time when there is minimal cloud cover, but in 2011 this was not the case. We had to wait more than a week to get the right conditions for the five-hour bathymetry flight over the 30km-wide sandbar, flown at 10,000ft. On the positive side, this gave us plenty of time to laser scan the coastline in great detail and to enjoy flying in this spectacular area, looking down at turtles, dolphins, and dugongs in the extremely clear waters.

Additional Projects

Although the projects here focus on ARA's work in Austrialia, the team travels the world to tackle projects such as the Mountain Wave Project, currently studying atmospheric conditions high in the Andes mountains in South America, as well as a project studying jetstream turbulence in the Sea of Japan and over Mount Fuji. Two projects planned for late 2013 and early 2014 involve studying mountain waves and turbulence in Nepal and documentation and visualization of dinosaur footprints on the coast of NW Australia. ARA welcomes the opportunity to collaborate with other researchers whose projects align with ARA's unique capabilities, including its cost-effective airborne "magic carpet" platforms, multiple sensor array packages, and all-in-one approach to airborne research projects.

Jeff Salmon is the editor of *Pangaea* newsletter and has served in various capacities at PSM since 2005. He lives in eastern Colorado with his family, where he helps his clients with land-use, marketing, and freelance writing projects.