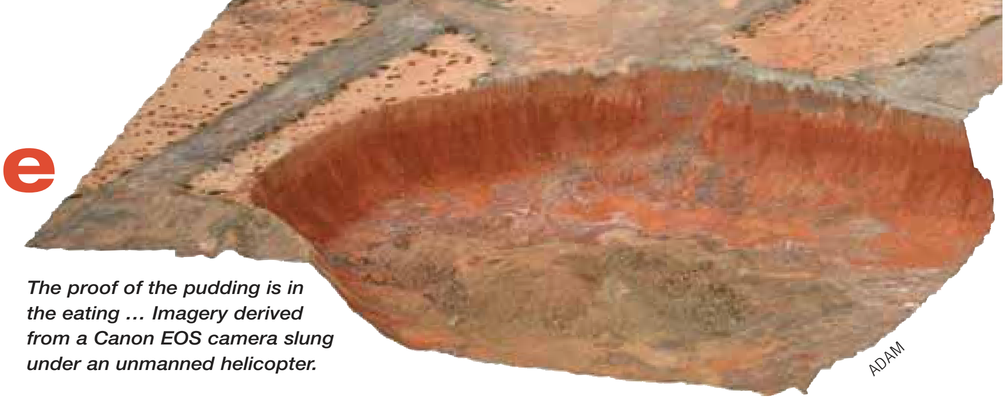
The UAV Experience



The proof of the pudding is in the eating ... Imagery derived from a Canon EOS camera slung under an unmanned helicopter.

ADAM

UAV technology is maturing rapidly. Several operators with established businesses are adopting them as a useful adjunct to gathering data. They have their limitation, however.

JASON BIRCH

Photogrammetry has benefited greatly from the advent of affordable, high-resolution and high quality digital cameras. The imagery from these cameras can be processed into digital terrain models with very little operator input. A process that used to take weeks or months can now be completed in days or hours.

Given that, it is a shame to wait days or even weeks for aerial image acquisition to be planned and executed. If we could do it almost as easily as capturing terrestrial images, it would allow the potentially enormous time and cost savings of digital workflow to be fully realised.

We believe that Unmanned Aerial Vehicles (UAV) go a long way to achieving this goal. They are as much a revolution in aerial photography as digital cameras have been to photography in general.

Because of this, we have become the Australian distributor and worldwide reseller for Rotomotion's range of UAVs, and have worked with Rotomotion to tailor the UAVs for this application. They cost around $25,000 and can be deployed in about 15 minutes.

Conceptually, the system has three components: the flight platform, the ground station and a safety controller.

In our case, the UAV is a helicopter. It has an onboard flight computer for control and navigation, GPS for positioning, and magnetometers for orientation. It also carries an onboard LAN that is bridged to the ground by a Wifi router.

The router allows any payload that can interface with an Ethernet network (e.g. IP video camera, infrared camera, etc.) to be connected to anything that can be interfaced to a normal Ethernet LAN. It can also carry a Canon digital SLR for high-resolution aerial images. This can be triggered from the ground or by the on board flight computer.

The ground station is nothing more than a standard Windows or Linux PC. It is plugged into the LAN and so connected to the UAV, via a Wifi router. This runs software for monitoring and controlling the UAV. The UAV can be flown semi-autonomously using a PlayStation-like controller if desired, or it can be instructed to follow a flight path and capture images completely autonomously.

If it exceeds the maximum safe level it will abort the landing ...

The safety controller is a pilot with a manual remote device that can take complete control of the UAV at any time. The pilot is responsible for ensuring safe operation of the UAV. Strictly speaking, the safety controller is not necessary for the operation of the UAV. However, the capability to take manual control is strongly recommended, especially in an environment where it could present a safety hazard.

Control is transferred via a toggle switch on the safety controller's remote control. In this mode, the UAV is flown just like any other remote control helicopter.

If communication is lost between the UAV and the ground station for a period of 60 seconds, by default the UAV will cancel its current flight plan. It will then fly to a pre-specified safe location and hover, waiting for communication to be restored. The safe location is typically set to 20 metres above the landing zone. If flying directly toward the safe location is undesirable, an alternative flight path back to the safe location can be specified.

The mid range model features dual electric motors and can fly for 60 seconds on one motor should the other fail. It also has redundant actuators, allowing flight to continue – with reduced performance – should one actuator fail.

Finally, the non-electric helicopters also feature a kill switch on a separate communications link to the safety controller and ground station. This ensures that the flight can be terminated manually at any time.

The aircraft is capable of nearly autonomous operation. It can take off without operator intervention, navigate to a waypoint and capture images. However, in its default configuration it cannot land autonomously. GPS is not accurate enough for the UAV to determine when it has reached the ground. Instead, the on board navigation system will bring it in to hover a few metres above the landing site. The ground controller brings it down by holding down one button to make it descend, and another to kill the engine.

In landing mode, the UAV keeps track of its horizontal velocity. If it exceeds the maximum safe level (due to a sudden cross-wind, for instance), it will abort the landing and return to an altitude of 20 metres. Fully automatic landing is available as an option.

The aircraft's endurance is between 15 minutes and two hours, depending on model and configuration. It can communicate with the base station over a distance between 500 and 1000 metres with the default systems installed. A range of 10+ kilometres is available as an option.

It can climb or descend at two metres a second. Maximum forward flight speed is 10 metres a second in the entry level SR-20 with a digital SLR attached. It is 18 metres/second in the more expensive models.

The software on these UAVs allows users to specify exactly where they want images to be captured. The UAV will fly to each location and carry out the specified assignment. Given the speed at which they can be deployed, only a small window of good weather is required to capture an area. Overcast days are not a problem, either. The UAVs will generally be flown at much lower altitudes than conventional aircraft.

A Case Study

In April 2007, we conducted a trial at St Ives Gold Mine in Kalgoorlie, using a Rotomotion SR-20 equipped with two 10Ah LiPo batteries that provided 15 minutes flying time. The aircraft was equipped with a Canon EOS 5D digital SLR with a 28 mm lens.

Four strips were flown at an altitude of 121 metres, mapping an area of 20 hectares with a ground pixel size of 3.6 cm. Strip lengths ranged from 375 metres to 530 metres. The UAV was programmed to hover for 15 seconds at each camera station and capture two images for redundancy. For two of the strips, images were captured with an 80 per cent overlap. In this scenario, four images in a sequence would need to be bad before there was a hole in the project.

This turned out to be far more cautious than necessary. Very few images had a problem. For the final two strips, a more conventional 60 per cent overlap was used.

The two longer strips were flown as separate flights. Each was captured in about six minutes. It took about four minutes to climb to operating altitude and about three minutes to return from the last station and land. On this basis, it would take an hour to capture 20 hectares.

However, it is not necessary to hover while capturing the images. On an overcast day, the shutter speed was 1/500 of a second at ISO 200. At that shutter speed and travelling at 5 m/s, the camera only travels 1 cm, or less than 0.3 pixels on the ground.

Using continuous flight, the same project could be completed with a single run in under 15 minutes. The same level of redundancy can be achieved by capturing images with a 90 per cent overlap, or about one image every three seconds.

Thirty-four 12.7 Mpixel images were processed in the 3DM Analyst mine mapping suite to generate the digital terrain models. It took 27 minutes to determine the absolute orientations of all images from scratch using a 2.4 GHz Intel Core 2 Duo PC. A further 46 minutes was needed to generate 6.3 million points – more than 30 points per square metre.

Clearly, this is far more detail and accuracy (~ 2 cm in plan, 3.5 cm in height) than required, so it would make sense to seek CASA approval to fly higher, especially over larger areas. Flying at an altitude of 170 metres, the ground pixel size would increase to 5 cm and the total flight time would decrease to about 12 minutes. This would also cut down on image processing time.


Rotomotion

Shorn of its fairing, a UAV is a serious piece of complex avionics.

There are some environmental restrictions, however. They cannot be used when it is raining or if the maximum wind gust exceeds 27 km/h; nor when light levels get too low. Apart from that, there are few limitations, apart from legal ones.

Not surprisingly, the air safety regulator, the Civil Air Safety Authority, keeps a close watch on UAV operators. If an operator wishes to use a UAV commercially over someone else's property – for example, a surveying and mapping company carrying out photography over a mine – a UAV Operator Certificate is required.

Only a small window of good weather is required to capture an area ...

Otherwise (e.g. if the mine itself owns and operates the UAV), the usage is considered private. Certification should not be necessary.

Obtaining an Operator Certificate is not a trivial exercise, but a number of operators in Australia already have these, allowing them to fly UAVs commercially.

If the operator wishes to fly above 400 feet – for example, to reduce the number of images required – approval must first be sought from CASA. The applicant will also need a radio and a radio operator's certificate to enable them to talk to any aircraft that happen to venture into the area.

Processing of the application takes a few days and costs a few hundred dollars. If the work is ongoing, it is possible to apply for an exclusion zone so that airspace can be allocated to the UAV. Many mines already have exclusion zones above them due to blasting, so it is worth approaching CASA to see if an application is necessary.

The primary application for these UAVs is in mapping small areas that need to be mapped fairly often, such as mine stockpiles. Pit mapping is a logical extension of this.

Cost and time advantages make UAVs a very compelling proposition. So far, the primary market for these machines has been the military. This remains the case.

We believe, however, that the technology has now reached a level of maturity and user-friendliness that makes it suitable for civilian mapping applications. The response we are receiving from the mining community confirms this view.

CASA

The use of small UAVs – all our UAVs are classified as small under the regulations – is governed by rules imposed by the Civil Aviation Safety Authority.

According to advisory 101-1, Section 7: 'Provided that a small UAV is operated not above 400ft AGL and remains clear of designated airspace, aerodromes and populous areas, there are no restrictions imposed upon the operation of a small UAV.'

However, the rules impose considerable responsibility on the operator: 'The operator is responsible for ensuring that the UAV is operated safely and remains clear of potential low level traffic, structures, powerlines, etc, except where operation in close proximity is part of an operation authorised on the operator's operating certificate.

'The operator should consider the benefit of a thorough reconnaissance of the proposed route beforehand.'

CASA regulation CASR Part 101 can be found at www.casa.gov.au/rules/1998casr/101/index.htm.

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