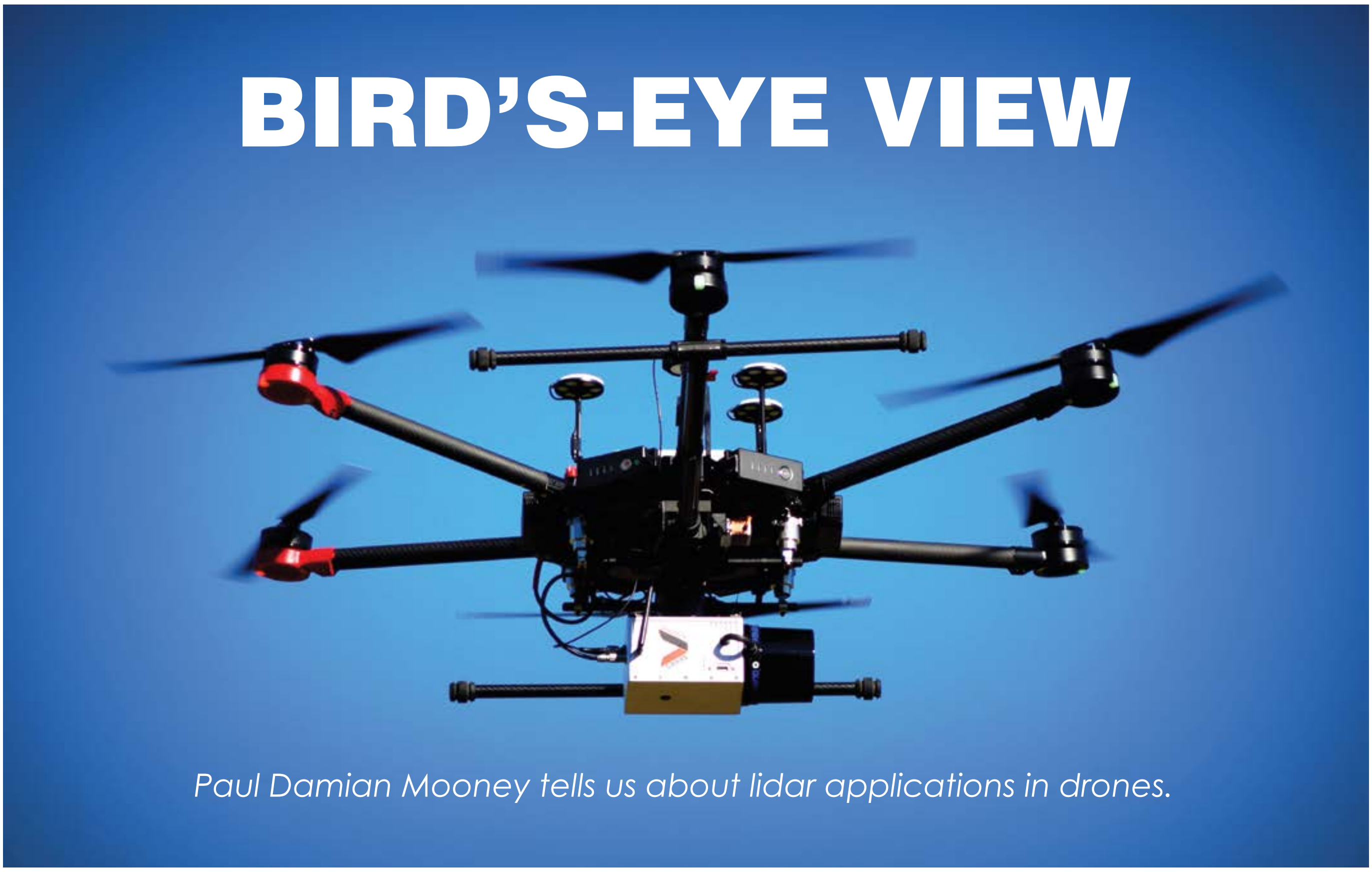
BIRD'S-EYE VIEW



Paul Damian Mooney tells us about lidar applications in drones.

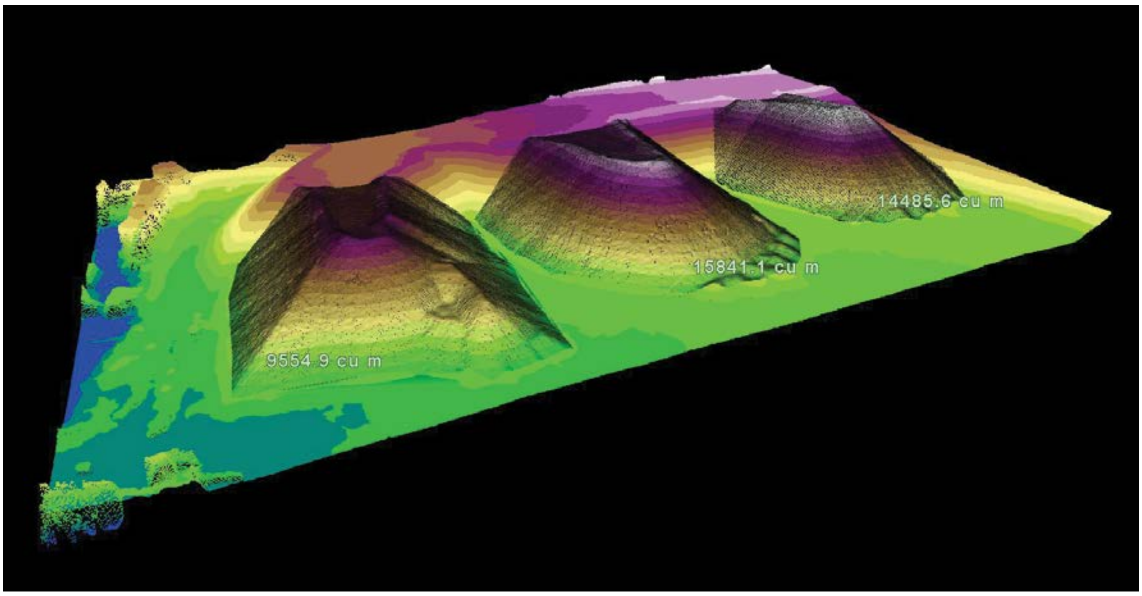
In stark contrast to 15 years ago when they were associated mainly with high-end military equipment, drones have now become readily available must-have gadgets that we might find in our Christmas stocking. Most of these drones are used as flying toys, and their ability to be easily controlled and make users feel like a professional helicopter pilot is their main aim and appeal.

The commercial drone, on the other hand, has an entirely different purpose in life. Once people realised that drones could carry some form of payload, even if only a few grams in early models, the drone itself was no longer the main point of interest. Instead, it was relegated to a tool that could carry other items with the potential to generate revenue, once in the air.

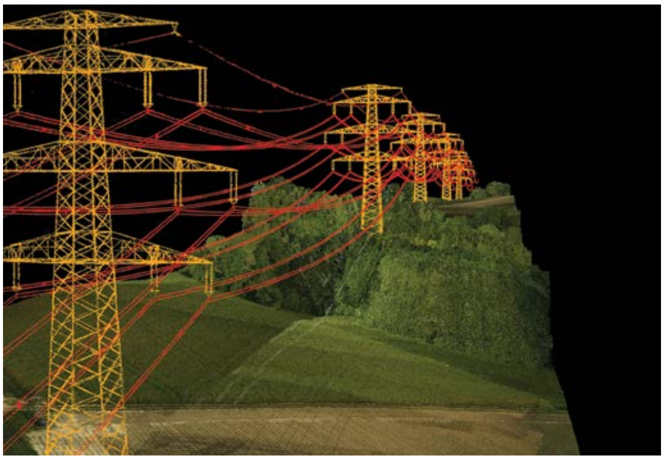
Although many commercial operators refer to drones as UAVs – an acronym for unmanned aerial vehicles – they are now officially classified in terms of the International Civil Aviation Organisation as remotely piloted aircraft systems, or RPAS.

The list of airborne equipment mated to an RPAS is very long, and growing every day. Cameras with RGB, thermal and multispectral sensors, sonar, lidar, air-samplers, loudhailers, floodlights, emergency Wi-Fi and GSM repeaters, receivers for tracking radio-tagged wildlife, weapons and – conversely – cargo bays for life-saving blood deliveries are just a few of the items that are airborne on thousands of RPAS around the world daily.

Cameras are by far the most common sensor on an RPAS, not only for the obvious benefit of having a bird's-eye



Drone-based lidar is widely used in the mining industry for volumetric measurements of ore stockpiles.



Siemens AG

Inspection of power lines has been taken to a new level with the Siemens SIEAERO service, which relies on drones equipped with highly sensitive lidar sensors, together with smart analytics software that uses artificial intelligence (AI) and machine learning. The service allows for rapid and precise automated detection and assessment of faults and issues along the lines.

view of a feature on the ground, but also for their use in photogrammetry – the science of making measurements from photographs, particularly useful for mapping and 3D surveying. If numerous images of an object of interest are taken from various angles as an RPAS traverses overhead, the different views of the object can be interpolated to determine both its horizontal and vertical dimensions, in a similar way to how human eyes determine depth of view by having two slightly different views. A high-quality camera can attain 1 cm horizontal accuracy and 2–3 cm vertical accuracy, which is very sought-after in the mining industries for volumetric analysis of ore stacks.

Recently, as technology has improved and sensor size has been miniaturised, lidar has become the new method of choice for high-accuracy airborne surveying. By recording the time taken for a laser pulse emitted from a lidar sensor on the RPAS to be reflected back, the distance that the pulse has travelled can be calculated to sub-centimetre accuracy. When the lidar is used in conjunction with tiny oscillating mirrors, the laser pulses leave the sensor in many directions per second, generating a line of data points across the ground as the RPAS moves forward. The high-speed mirrors give the lidar sensor up to 500 accurate point readings per square metre as the RPAS performs its survey. The resultant high-resolution data is capable of showing not only the structure of electrical power pylons but the thin power cables between them.

Mechatronics master's student Jacques Welgemoed was awarded joint second place at the online BRICS Future Skills Drone Operating Challenge 2020, which involved 85 participants from 12 countries.

The lidar sensor is only one part of the system needed for a high-accuracy survey. In order for the lidar to pinpoint a reference point on the ground, the sensor must also have extremely accurate readings as to its own position in space. This positioning data is obtained from high-precision satellite positioning systems in conjunction with inertial measurement units to determine the inclination of the lidar at any given microsecond as the RPAS 'bounces' through the air. The combination of lidar and supporting positioning systems can make lidar nearly double the price of a photogrammetry system, in the region of R500 000.

In the teaching and research arena, the high cost makes it difficult to provide students with lidar systems for individual projects, and we often have to use entry-level versions in the form of laser rangefinders. These units – weighing just a few grams – have recently become available for as little as R500. The VL53L1X is a state-of-the-art, time-of-flight (ToF), laser-ranging sensor, with accurate ranging up to 4 m and a fast ranging frequency up to 50 Hz. By combining a number of these sensors at various angles underneath an RPAS, students are able to mimic the line of points that high-end oscillating mirror lidar sensors generate, at a fraction of the cost although at a much lower resolution per square metre.

With the low costs of small RPAS, laser rangefinders and small-factor computers like the Raspberry Pi or Odroid, students from all over the world are competing in events to see what they can achieve with an RPAS and lidar system. Events include hackathons where students are given free rein to develop any project they feel will benefit humanity. An example of this is an RPAS that autonomously uses its lidar to keep a safe distance from a human while spiralling around the subject, in order to generate an accurate 3D model for clothes sizing.

Other events are structured competitions where students have to use lidar to navigate their drone through an indoor factory environment with no access to GPS, while measuring the size and shapes of containers to simulate an automated stock-taking sequence in a factory. Due to COVID restrictions, one of the events in 2020 became an online remote-controlling demonstration. Competitors were tasked with writing code in their home country that was then uploaded to physical drones waiting in a warehouse in Russia to perform the tasked flights. Competitors had the surreal experience of watching live YouTube footage of their drones flying autonomously on the other side of the world, using lidar sensors and the code they had just written.
The South African team from Nelson Mandela University, consisting of Jacques Welgemoed with me as his mentor, achieved the silver medal at the event.

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