New Surveyor's Tool Puts Everything UP IN THE AIR

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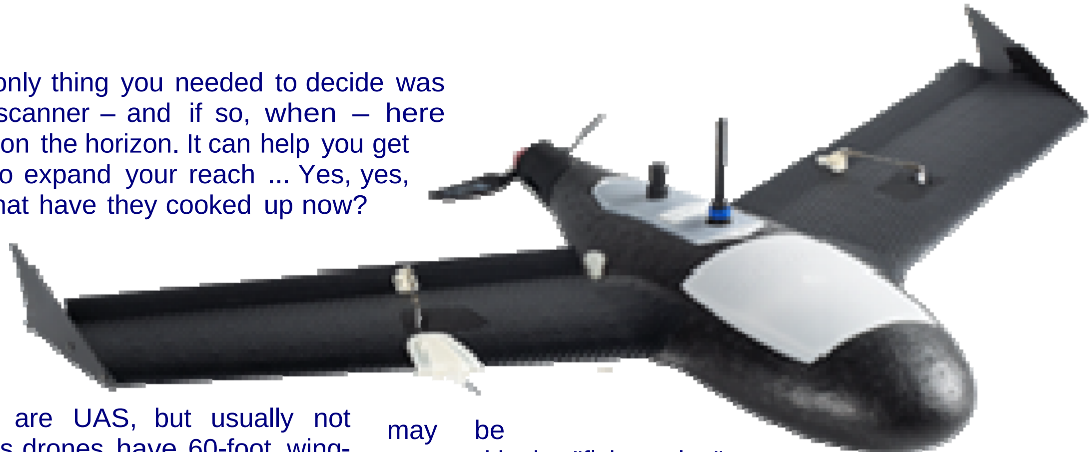

Just when you thought the only thing you needed to decide was whether to buy your laser scanner – and if so, when – here comes another technology on the horizon. It can help you get more done faster, it can also expand your reach ... Yes, yes, you've heard it all before. What have they cooked up now?

<u>The answer is sUAS.</u>

Small Unmanned Airborne Systems. Some people hear about them and say "drones." Drones are UAS, but usually not sUAS. Some of the military's drones have 60-foot wingspans, and even the smaller ones can weigh in at several hundred to a couple of thousand pounds. But sUAS' aren't anything like the Predators and Desert Hawks being used by the military, or the ones used for surveillance by the Border Patrol or various police agencies, or the ones that loiter overhead for a variety of reasons-atmospheric sampling, providing temporary communications links or doing some type of electronic monitoring.

A purpose-built sUAS for geomatics (or, if you prefer, surveying and mapping) is a mini-version of the systems you might be familiar with in conventional manned aerial photogrammetry. Yet while they are similar, they're definitely not the same. They differ in details of the benefits, drawbacks, costs, skills required, size, weight and power consumption, and so forth.

<u>What are the characteristics of sUAS?</u>

It is impossible to generalize too much about sUAS technology, but the greater majority of them can be described, as long as you realize that a particular sUAS you are discussing may not have all of these general characteristics.

We begin by first breaking them down into two classes: rotor wing and fixed wing. A rotor wing is often in the configuration of a helicopter, as most of us know. Many others designed for sUAS applications have multiple rotors, four, six or eight being relatively common. While rotor wing sUAS are extremely useful devices for certain applications-such as inspection of inaccessible parts of structures or the small sections of ground surface – they are generally not that great for photogrammetric mapping of larger areas. This is because their stability is questionable when the weather is not calm; flying them in a straight line is difficult; and most have extremely short flight range because of their extraordinary power consumption.

Fixed wing sUAS can be configured similar to most commercial aircraft we see, with a wing near the front and a vertical stabilizer and horizontal stabilizer in the back. However other designs may be seen, with the "flying wing" concept used quite a lot. Regardless of the details, fixed wing sUAS use the concept of an airfoil (the wing) to generate lift, which is only possible when the movement of air over the wing occurs.

While larger UAS may be powered using liquid fuels that are similar to gasoline, it is common for sUAS to be electrically powered. At minimum, there is an electric motor that drives a propeller, a battery, and some means of controlling the speed of the propeller to vary the thrust. Takeoff may be conventional, as in rolling down a runway on wheels, or the fixed wing sUAS may be thrown in the air or a mechanical device can be used to launch it. sUAS designers will pick the best system based on the aircraft's characteristics and the application for which it is designed. Landing may also be conventional, or devices such as parachutes or nets may be used. Some sUAS land conventionally but do not use wheels. Skid landing is a common technique so that the user is not limited to smooth paved surfaces required for wheeled landings.

The aircraft may be "pilot-in-the-loop," which means that the plane is under remote control of a pilot from the moment it starts its engine until it lands. Or it may be semi-autonomous, where takeoff and landing are manual, but part of the mission is automated. The aircraft may also be fully autonomous. This means that once the "takeoff" button is pressed, it executes a pre-programmed flight plan automatically and lands at a designated spot. Autonomous vehicles should have preprogrammed "fail safes" that handle abnormal or out-of-the-ordinary situations that may require mission suspension or termination. Autonomous vehicles are generally required by the civil aviation authorities (in the United States, the FAA) to have a radio link that allows the pilot to observe that conditions are abnormal (such as an imminent collision with a flock of birds) and either suspend or terminate the mission.

Almost all sUAS that are autonomous will have a speed sensor to determine airspeed, an altimeter, and GPS. Autonomous sUAS must also have some kind of attitude sensor to detect the three principal rotations of pitch (nose up or down), roll (right or left wing up), and yaw (orientation of nose or longitudinal axis of the aircraft in relation to the direction of travel).

What is a mapping sUAS?

A mapping system that is sUAS-based carries a camera payload, automatically flies a predetermined flight plan with correct forward and side overlap, takes pictures automatically, and has avionics that keep the plane flying as straight and level as possible. The avionics includes a three-axis gyro (usually a micro-device) and a three-axis accelerometer. Usually, like all well-designed craft that are created to be autonomous, it will have GPS on board so that it can navigate to the points designated on the flight plan that was uploaded into the aircraft before takeoff. The system will include software that allows the flight plan to be created before takeoff. This usually includes designation of landing and takeoff points, boundaries of the area to be flown, and usually, designation of the altitude above ground level at which the mission will be carried out.

The system will also include software for downloading the imagery once the craft is on the ground, viewing it, geocoding it (if it hasn't been geocoded in the air), and preparing for the process of converting the imagery into data products (usually orthomosaics, digital surface models – DSMs – and X, Y, Z point clouds).

Why are mapping sUAS being developed?

The sUAS has several operational benefits for surveying and mapping that cannot be ignored. Generally, they can fly in a wider array of weather conditions than is optimum for manned aerial photogrammetry. In fact, because flying height is usually 150m or so, cloudy weather is usually not a problem. It is lightweight and can be brought to a site without worry about the logistics of getting a large airplane near the site. Very often the system can be taken along as luggage on a commercial airplane flight. While acquisition costs can vary between the cost of a total station and a low-end

lidar scanner, the costs of operation are miniscule. While the sUAS cannot carry a large payload (a few hundred grams is the norm – usually far less than a pound), the cameras used, which are usually semiprofessional off-the -shelf systems, can capture images of exceptional clarity and resolution. At the 150m flying height, pixel resolution of 5 em is normal. This opens up a style of data capture and mapping that has not been feasible before.

Generally, conventional photogrammetry serves extremely well when the areas to be mapped are large (tens to hundreds to thousands of square miles). On the other hand, surveyors with on-the-ground systems such as total stations and RTK GPS become expensive timewise and cost-wise as areas to be mapped get larger than about 10 acres. With sUAS technology, a user can bridge the gap between these two well-developed and relied-upon systems. In addition to making mapping of areas larger than about 10 acres to about 10 square miles economically feasible, without the limitations of weather delays, sUAS mapping is sometimes the only solution when it is dangerous to fly over the area to be mapped with manned aircraft or even to approach the area on the ground. Examples of sUAS saving the day are already numerous, including levee surveying during floods, forest fires, and the recent Fukushima nuclear power plant accident in Japan.

Accuracy varies depending on how the imagery is used. Conventional photogrammetric processing techniques cannot be used together with sUAS technology. The principles of close range photogrammetry and vision software must be used instead. This requires, among other things, high overlap photography-usually a minimum of 75 percent forward and side overlap. When properly controlled with surveyed ground targets, accuracies at the 5 em level horizontally and 10-15 em vertically are feasible. Potential users see sUAS as the ideal data collection source for many applications, including volume mapping for construction projects, construction progress mapping, change detection in a variety of applications, forest and agricultural crop monitoring and management, and open cut mine management.

Caveats and full disclosure

Currently FAA regulations (the regulator of the use of our national airspace) do not allow the use of any unmanned system without a permit. Permits for most of the applications mentioned here are only available to government agencies and publicly owned universities. Commercial flights with sUAS are banned except for research or training purposes or for market surveys, when a special airworthiness certificate may be issued to a commercial company.

It is anticipated that the FAA will issue new regulations that open up the skies for sUAS ... but even the proposed regulations have yet to be released… 'Men there will be a comment period, and then a period for the FAA to modify the regulations based on legitimate comments they received. So, commercial flights may still be a year or two in the future for most of us. But there's no harm in dreaming ... and many public agencies have already started using sUAS for mapping for GIS, volume determinations, environmental assessment, resource mapping, etc.

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Photos by Gatewing (www.gatewing.com)
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