Unmanned Systems Down on the Farm: *Dull, Dirty, Dangerous, Demanding*

By Gaea Honeycutt

One of the UAVs used to study the phytophthora infestans crop disease. Air collection sampling devices are closed underneath the wings.

Farming seems to present a perfect challenge for unmanned systems: The work is sometimes dull, often dirty and occasionally dangerous.

Not only is the vast area of land a concern, but different crops have respectively different planting, watering, fertilization and pest control needs.

The automated pivot was an early solution to some of these challenges. With some pivots stretching as long as half a mile, the spindly equipment can prevent water waste using controls that determine the amount, speed and flow of water. Steve Hodges, president of M2M Communications, a company that develops intelligence and remote control systems for pivots, notes their flexibility: "You can control speeds, directions and amounts from cell phones or other locations." Farmers simply log on the Internet and use interfaces designed for computers and mobile phones.

The incorporation of more complicated unmanned systems, including air vehicles, is a growing trend in agriculture, enabling precise crop management that can save farmers thousands of dollars in time and resources, and opening up new, innovative research that could blaze new trails in agriculture and agronomics.

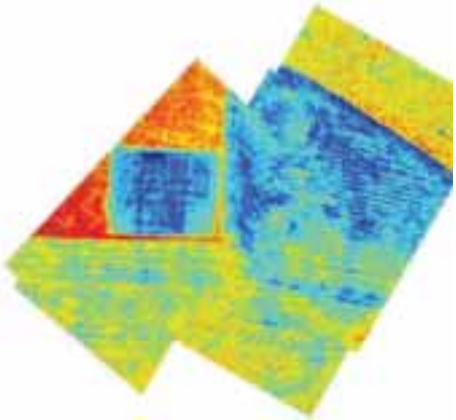
Crop Management

First to market, CropCam developed an affordable unmanned aerial system (UAS) aimed specifically at the agricultural market. Built by a division of Canada's MicroPilot, CropCam is a radio-controlled, hand-launched plane that provides digital images on demand, by-passing hit-or-miss satellite photography and costly manned airplane surveillance of crops.

Robert Blair, a farmer in Idaho, has seen the effectiveness of CropCam in precision farming firsthand. "Last year, the UAV helped tremendously on my farm," he says. The digital images helped him recover $120,000 in elk and chemical damages to his garbanzo beans, peas, wheat and barley.

Blair is so sold on the concept of applying unmanned systems to agriculture that he's launched his own business, Pine Creek Precision, and is developing a UAS of his own. However, there are significant barriers to entry in the industry. "If you're trying to do a business, you need a full blown pilot's license and a full-sized aircraft following behind it because the UAV isn't big enough for a commercial number," he says.

Just back from reseller training at CropCam's headquarters, Leasie Selderhoff of Queensland, Australia, has launched a similar enterprise there, Sky View Solutions. She plans to provide high-resolution imagery solutions for agricultural land management and natural resource clients. "We want to teach people how to fly the plane and deal with their images," Selderhoff says.



A near difference vegetation map from QinetiQ.

Indeed, not just anyone can operate a UAS, which is why CropCam requires resellers to complete training.

"You have to be pretty savvy on a computer and you to have some RC [radio control] skills," says CropCam project director Lisa Shaw.

Selderhoff admits to some disappointment at the UAS' constraints. Because of the lightweight airframe design, it's not well-suited to landings on hard surfaces.

"It's not a robust airframe. It's less adaptable for landing in tight areas," she says. "You have to be selective about where it's used." Still, she's happy with the resolution level and looks forward to growing her business.

On Demand Imagery Solutions (ODIS) in Canada has provided high-resolution multispectral imagery using CropCam since 2003.

"From my experience I see a huge application ... [Near infrared] along with color imagery allows for vegetation indices to be calculated," says Greg Lewis, founder and president of ODIS. "These can then be used as a way to monitor a crop and identify 'hot spots' before they become large problems."

In the United Kingdom, satellite imagery is particularly tough due to uncooperative weather and manned aerial imagery is expensive, so the UAS presents a viable solution. The British company QinetiQ recently announced development of a UAS that takes multispectral and, soon, hyperspectral images of agricultural and forest environments.

Assistant technical director Andy Tailby collaborated with Timothy Stewart, an agricultural economist at Aberystwyth University in Wales, to develop a vehicle that uses near difference vegetation index (NDVI) maps, which provide much richer data than conventional imaging applications. Tailby and Stewart combined off-the-shelf components and proprietary software with two complimentary NDVI cameras in the UAS.

In a test staged for July's ParcAberporth Unmanned Systems 2008 event in Wales, the team sowed a wheat crop in unseasonable May, spraying a message—"PAUS 2008"—in nitrogen fertilizer. Given the poor quality of the crop, they weren't expecting good results.

"Much of it was brown. We didn't think anything would come up. But, the message was quite clear in the image," Stewart says.

The multispectral video was able to distinguish between the treated plants and those growing without assistance. There are potential applications with other types of plants as well.

"NDVI is very useful for nitrogen management with grains," says Stewart, but already they're seeing more opportunities. "We're exploring use with grassland. There was more than we thought we'd be able to see."

QinetiQ has already begun testing the hyperspectral sensor, which provides a more accurate picture by looking at "many more slices of the spectrum." It opens the door to detecting diseases and pest damage, which is difficult to identify before it's too late to save a crop. Because of the amount of biodiversity data available through the sensor, there may be commercial applications. "Hypersectral imaging will enable more products in the market—for instance, different herbicides for different weeds that are tuned to the right spectrum," says Stewart.

Precision Planting

At the Centre of Excellence for Autonomous Systems in New South Wales, Australia, Jay Katupitiya's team has completed the operational tests of the Robotic Seeding Instrument, which is funded by Australia's Grain Research and Development Corporation.

The University of New South Wales' Robotic Seeding Instrument.

"What we're doing is targeting farming where large areas of land need to be planted in a short period of time," says Katupitiya, head of Mechantronic Engineering at the University of New South Wales. Farmers must plant seeds accurately according to a predefined pattern, and covering such a large area is tiring. The Robotic Seeding Instrument addresses both of these issues.

"The first challenge you face is that when the tractors travel on the field, they tend to slide laterally and they need to be brought back into line [to plant seeds accurately]," Katupitiya says. Using advanced sensors and actuators split into six different units, his team developed a system that rights itself.

However, although the tractor was following a precise path, implementation still presented a challenge. "Even though the tractor is going accurately, the implement can drift sideways, thereby not planting at the desired locations," Katupitiya says. The team designed additional controls to bring the implement back into line, given that "the deviation of even one inch is too much."

Katupitiya says that concerns about safety are misplaced, believing the only real concern is damage to the robot itself because there are no people involved in the process. "For example, when you're dealing with an unmanned factory, there are no questions about safety," he says.

Asked about other applications for the tractor, Katupitiva was hard put to identify other uses due to the unique nature of seeding, but he did note the similarities to mining. "The same technology can be used in mining if you have trailing equipment used in mining and a trailed implement, because mining is also a function that digs the ground," he says.

Averting Disaster

Last year, David Schmale, assistant professor of Pathology, Physiology and Weed Science at Virginia Tech's College of Agriculture and Life Sciences, was focused on testing the air above crops for pathogens and microorganisms. He plans to use the research to develop detection and warning systems that have both civil and military applications.

While that hasn't changed, the Schmale Lab has zeroed in on phytophthora infestans, the fungus-like microorganism behind the infamous Irish Potato Famine, which killed and displaced millions of people in the mid-19th century. Closely related to brown algae,

phytophthora infestans is a devastating disease in potatoes and tomatoes that literally melts them in only a few days.

Virginia's Eastern Shore experienced an outbreak in 1996, making the microorganism a very real concern in this century as well. "It can kill an entire crop quickly," Schmale says, "which makes it a bio-security threat."

Even though phytophthora infestans presents a security threat, the research is in the civilian sector. Funded by the U.S. Department of Agriculture, the $1 million project is collaboration with Elson Shields, professor of entomology at Cornell University, and Donald Ayor, distinguished scientist at the Connecticut Agricultural Experiment station.

The team equipped a UAS with samplers on the wings, systematically capturing air in collection plates as the planes move in repeated patterns over the University's Kentland Farm. Tracking the location of the sample collection using the Global Positioning System, the team studies the movements of the pathogens with the goal of developing a system that will enable farmers to address problems quickly.

Vegetable, Animal, Mineral

Some pieces of the agricultural puzzle fur unmanned systems are still missing. Research on animal farming hasn't yet caught up with plant farming, although there are some promising herd management applications under investigation at the Massachusetts Institute of Technology in the U.S. and the Commonwealth, Scientific and Industrial Research Organisation in Australia.

The MIT study is testing the use of sound cues to move cows using head harnesses. The CSIRO research uses collars that give off a humming sound when cows venture too close to land boundaries. However, both projects are in early phases and years away from completion.

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