Unmanned Aerial Systems for Field Scouting and Spraying

by Tanner Ehmke

Drones are widely thought of as weaponized tools used by the military for combat or spying. Farmers, Certified Crop Advisers (CCAs), and researchers though, are finding that this aerial technology could be their eyes and ears out in the field.

Officially known as unmanned aerial systems, or UAS, these small remote-controlled flying devices that are more widely known for their military use are making their way into farm fields across the U.S., as growers, CCAs, and researchers seek out faster and cheaper ways to scout crops and map fields from the air or apply chemicals.

Precision agriculture and UAS are a natural fit, according to Michael Toscano, president and CEO of the Association for Unmanned Vehicle Systems International (AUVSI) since UAS are the perfect technology for any job that falls under the 4D’s: Dirty, dangerous, difficult, and dull. “These systems lend themselves to do those types of jobs in agriculture,” Toscano says.

In their latest economic report on UAS, AUVSI predicted earlier this year that following the Federal Aviation Administration’s (FAA) integration of UAS into the national airspace by the September 2015 deadline mandated by Congress, UAS will have a $13.6 billion impact on the U.S. economy in the first three years of implementation. Most of that business, according to AUVSI, will come from growth in precision agriculture, particularly with small UAS used for remote sensing and precision aerial application of crop inputs.

With the remote-sensing capabilities that come with UAS, farmers, CCAs, and researchers will be able to more efficiently and cost effectively scan crops for health problems, monitor nutrient uptake and hydration, and locate disease or insect outbreaks, Toscano explains.

“Once the crops are growing, the farmer could monitor the crops throughout the photosynthesis process,” he says. “We have devices that can tell whether the plant is healthy, or whether part of the crop may be very healthy and part of the crop may not be. The farmer needs to know this because you don’t want to spray the whole crop if it doesn’t need it. This technology will be able to tell you.”

Tall crops like corn that are hard to inspect from the edge of the field are ideal for using a UAS for crop scouting, adds Jimmy Prouty, who builds and sells small
unmanned systems through his company, Hangar 18, in Wichita, KS.

It’s a win–win for farmers, Prouty notes, because if they hire a crop adviser to map their field with a UAS, they not only save on the cost of hiring a pilot with an airplane, but they also know how much fertilizer or chemical to apply to specific portions of the field rather than applying it to the entire crop, thereby trimming input costs. UAS also allow farmers to spray closer to the crop canopy, helping to reduce drift and waste.

“Because you’re using a quadcopter or a helicopter, you can fly just a few feet above the crop, which means more of the spray ends up on the plants and less on the ground,” Toscano says. “So, you have to buy less of it, and you can apply it in a more efficient and effective way.”

Farmers, CCAs, and researchers can also cut down on timeliness costs. Since UAS can fly in inclement weather when other forms of remote sensing like satellites or piloted airplanes and helicopters wouldn’t work, the user has the ability to acquire necessary information in a timely manner, adds Bruno Basso, ecosystem scientist at Michigan State University, who acquired a UAS this year for crop performance research.

“In the past, I’ve used remote-sensing technology on a larger scale, but you would depend on when the satellite goes by. If you had a cloudy day, it didn’t work for field applications,” recalls Basso, who uses a quadcopter equipped with GPS for the purpose of field scouting as part of the university’s Global Water Initiative. “I decided to overcome that issue by renting airplanes. I had more control, but they’re not too cheap. You still have to depend on the availability of the plane and the pilot, and the sensors may not be exactly what you need.”

Basso decided to invest in a fully automated quadcopter that takes off and lands on its own and can fly a pre-programmed route over a field, with virtually no manual operation from the ground. If the wind blows the quadcopter off course, the GPS system automatically brings it back into its programmed route.

Basso’s UAS also has a payload capacity of 3.3 lb and comes equipped with three sensors for crop evaluation: a high-resolution radiometer, a thermal camera to track plant temperature and hydration, and a laser scanner to measure plant height.

Vertical photography has especially become more popular with UAS devices, Prouty adds, because of the increasing demand for field mapping. But infrared photography is becoming more popular among growers and crop advisers for crop scouting.
“Our airplanes are set up where they do both digital visual spectrum and near infrared all in the same flight,” Prouty says. “One is for photo mapping just like a satellite map, and the other is for crop health studies. With near infrared, you can tell crop health, where you need to deploy more fertilizer or where you’ve got too much fertilizer.”

Skills and Cost

Even though a UAS system can be equipped to take off, fly, and land on autopilot, the operator will still need to acquire the technological know-how to operate it successfully in the field, Prouty says, which will require training and flight experience.

“I eventually would like to be able to sell directly to the end-user, so the farmer can do his own crop studies,” Prouty says. “That will require the farmer to develop a whole new set of skills.”

Basso also is hopeful that UAS technology will become widely available to farmers and ranchers someday. But, due to the complexity of processing the images on a computer screen, producers will initially require help putting that information to use on the farm.

“At this stage, you need to have people helping the farmers,” he says. “They can be CCAs or scientists through the extension service. Their role needs to be updated. They need to be trained on this.”

Basso uses the System Approach for Land-Use Sustainability (SALUS) model to process the data for forecasting crop, soil, water, and nutrient conditions across various climate scenarios. SALUS also can evaluate crop rotations, planting dates, irrigation and fertilizer use, and project crop yields and their impact on the land.

Cost can also be prohibitive for individual farmers who want to buy their own system, Basso adds. His system, which can cover 100 acres in about half an hour, costs about $85,000. But manufacturers like Prouty are already developing more affordable systems with his cheapest UAS priced at $14,000. While some may still consider that a big initial investment, Prouty says the cost is miniscule compared with manned technology like helicopters and airplanes.

“The manned technology is going to cost you hundreds to thousands of dollars an hour,” he says. “On ours, once you purchase the system, your cost is going to be just the manpower to fly it and then occasionally buy batteries for it. That’s it. You don’t have to pay for fuel, you don’t have to pay for a pilot.”

If the farmer or CCA lacks the capability to analyze the data, he adds, there are services that can be hired to process the images for the user affordably.

“There’s no comparison,” Prouty says. “It’s just so less expensive to do it unmanned.”

Evolving Technology

UAS technology has a ways to go before it can be adopted industry-wide, notes Basso, who had to go to Germany to buy the quadcopter that best fit his research needs.

Mike Sarton, CCA and senior agronomist at Landmark Services Cooperative in East
Troy, WI, agrees that the technology may require some evolving before it can be easily adopted at the producer level. This spring, Sarton acquired a small UAS quadcopter to implement into the coop’s crop-scouting program for farmers. But putting it to work wasn’t as easy as expected.

“We had envisioned using it for pinpointing problem areas and using it to judge nutrient deficiencies or insect problems,” he says. “Really, the way it’s turning out is that there were a lot of problems with it. There’s not enough duration, not enough time in the air, there’s not enough distance. You lose control when they get far out. The ones that we used did not have GPS, so you’re really guessing about its flight pattern.”

Sarton’s UAS was limited to traveling only about ¼ mile before the operator would lose control of the aircraft, leaving corners of the field unscanned by the quadcopter. The quality of the images taken from the UAS’s cameras was also not as useful as Sarton needed for crop scouting.

“Because of the weight limit, the cameras that we can use just really are not sufficient for any kind of an accurate analysis. It just doesn’t show you enough,” he explains. “You can’t tell what you’re looking at, except for blank spots in the field, skips, and drought spots.”

With any emerging technology, Toscano notes, growing pains are inevitable as the industry works out kinks. From a technical standpoint, he says, the two biggest challenges are power and secure wireless communications. Just as was seen with early generations of cell phones, UAS technology will evolve with time to overcome those challenges.

“If you have a small UAS that’s 55 pounds or less, it usually flies between 20 minutes and two hours because it runs on battery,” he says. “That is a technical limitation that is being worked on right now. Just like with anything else, until there is a big market for it, people aren’t going to spend as much money developing solutions for that problem. This is one of those things where what we know are difficulties today may not be what you’ll see in the next couple of generations.”

As the technology matures, he adds, it will not only become more capable, but it will be produced at a much lower cost. Most of the cost now, he says, is focused on human safety.

“Whenever you build anything that has a human being involved in it, 9 out of 10 times, the weak link in the system is the human being. And usually, 40 to 60% of the cost is to protect the human being.”

Privacy and Policy

UAS also have to overcome safety and legal issues, as well as their public image as “drones,” Toscano notes.

“The two biggest limiting factors right now for why we’re not seeing more of these things is safety and privacy. We have a concern from a public acceptance standpoint mainly because there’s a privacy issue that people have.”

But, those concerns become less of an issue in the open spaces of rural America where UAS will be employed for precision agriculture. And, privacy is less of a concern because corn...
Kevin Price is a rangelands ecologist and remote-sensing expert who spent 19 years in the University of Kansas Geography Department working with satellite images on projects funded by NASA. But Price also grew up on a farm, so he welcomed the chance to “get back to his ag roots” when the Kansas State University Agronomy Department offered him a remote-sensing professorship in 2008.

His agronomy colleagues were just as enthusiastic to have Price on board. Then he began showing them satellite images of cropland taken from 450 miles above the earth. “Most agronomists, at least in this department, are used to looking at individual plants on the ground,” Price says. “And when they can’t see an individual plant in a LANDSAT pixel that’s one-fifth of an acre in size, they don’t get very excited.”

Fortunately, one of Price’s graduate students approached him two years ago wanting to work on applying unmanned aerial systems (UAS) in agriculture. They soon assembled a larger team including the Kansas State–Salina Aviation Program, other agronomists, and a colleague in veterinary medicine, Deon van der Merwe, who also happens to be a UAS expert.

Today they’re wowing their colleagues with images snapped from UAS that can resolve individual crop plants and even single leaves. But getting there has meant grappling with a host of issues, including selecting the best airplanes and cameras, standardizing data collected under varying levels of cloud cover, stitching thousands of images seamlessly together, and navigating FAA regulations.

“There are a lot of components to this technology that I never dreamed of when I started this work,” Price says. “It’s a whole new area of research that’s blowing wide open.”

One of the thorniest questions is how to transform simple aerial images of fields that a farmer might use as “refrigerator door art” into information that can assist in management decisions, Price says. “That’s what we’re working really hard on.” For example, how much nitrogen should be applied? Does a certain section of a field need replanting? What are the projected yields?

In conjunction with a company called RoboFlight Systems, Inc., Price’s team has now developed a software program, AgPixel,
which allows users to easily convert the pixel data in images into a key measure of plant growth and vigor: the Normalized Difference Vegetation Index (NDVI). With “just a few clicks of the computer mouse,” Price says, farmers can then have AgPixel compare the NDVIs across an entire field to those in a reference strip that received all the nitrogen fertilizer the crop could handle.

The final output is a map of NDVI variation linked to crop nitrogen status that can be formatted for use in variable-rate applications of fertilizer. And unlike tractor-based or handheld instruments that do the same thing, a UAS can collect the needed image data from a 640-acre field in just 20 minutes, Price adds.

Even though there are still plenty of kinks to be worked out, more than 130 companies from 40 countries have shown interest in AgPixel since it first became available commercially in August 2013, Price says. “There’s really no other software out there that works well with the kind of imagery we’re collecting.”

To him, it’s a sign both of the great need for research in this burgeoning field, as well as the terrific promise UAS holds for the future of farming. “This is going to revolutionize the way work is done in agriculture,” he says.

“Precision ag will never be the same.”

doesn’t mind if you watch it, he says, making production agriculture a natural fit for UAS from a legal standpoint, he notes.

Integration into U.S. airspace is also a looming concern, Toscano continues.

In February 2012, Congress required the FAA to integrate unmanned aircraft for commercial use into national airspace by 30 Sept. 2015. However, the FAA does not have to fully integrate UAS, Toscano points out. How the FAA decides to regulate UAS might affect how they are implemented in agriculture.

“The FAA right now says you cannot fly an unmanned aircraft system in national airspace for commercial applications,” he says. “But the American Modelers Association, they’ve been flying for about 80 years. They fly below 400 feet and fly within line of sight. So, a farmer might be able to also, depending upon how that ruling goes. The FAA may come out with rulings for agriculture that specify certain conditions to fly UAS. That’s not outside the realm of possibility in the future. The worst that they can do, if you violate the law, is fine you $10,000.”

The legal hoops required for academia to acquire a UAS for research purposes are also needlessly burdensome in the U.S. compared with other countries, Basso says.

“The FAA makes things a little laborious,” he says. “As an institution, there’s a lot of paperwork. But there is no regulation whatsoever in Europe. You can just pick up a drone—university or private—and you can use it. Here, it’s more difficult because there are so many issues because [UAS] are used for spying in the military.”

Because of the open spaces and lower populations typical of farm country, it’s hoped the FAA will approach legal restrictions for UAS commercial use in agriculture less stringently, Toscano says. Future farmers will likely be more concerned with safety issues, such as their UAS blowing off course and hitting a driver on a nearby road. The consequences of mishandling a UAS and causing harm to another person are far greater than legal restrictions from the government, he points out.

“If I have a UAS and I crash it into a car, guess what? That person’s going to sue. They’re going to own my farm,” he warns. “It’s the fact that you’ve operated in a reckless or endangering way, or done something irrationally that endangers other people. Just like with any technology, if you misuse it, you are going to be held accountable. Period. The same thing is going to be true for UAS.”

The uncertainty on what the FAA decides by the 2015 deadline, meanwhile, is also keeping UAS manufacturers like Prouty from expanding their business.

Without a solid legal framework on how UAS will be integrated into airspace or restricted for commercial use, he says, the industry will fumble in the dark on how to move forward with technology advancement and marketing.

“I don’t want to go with a full-time store front until I know what the FAA is going to do,” says Prouty, adding that in markets like Canada, Europe, and Australia, UAS restrictions are less than what is widely speculated to be imposed in the U.S. in 2015.

Public skepticism and misinformation—thanks in part because of UAS history with the military—are sources of uncertainty in the U.S. that could create a more restrictive atmosphere for the UAS industry as the legal framework develops, Toscano adds.

The only way to effectively bring a useful, cost-saving technology like UAS to farmers, CCAs, and researchers, he says, is through education.

“There’s a lot of misinformation of what the capability of this technology is. This is no different than any other revolutionary technology that we’ve had in the past,” Toscano says. “It’s like when they asked the 100-year-old-man, ‘You must have seen a lot of changes in your life,’ and he says, ‘Yeah, and I was against all of them.’ That’s kind of what we’re up against.”

T. Ehmke, CSA News magazine contributing writer