COOPERATIVE EXTENSION SERVICE
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The Use of Unmanned Aircraft Systems in Agriculture

Dr. Tim Stombaugh, Biosystems and Agricultural Engineering
Dr. Suzanne Smith, Mechanical Engineering
Michael Thamann, Mechanical Engineering

Unmanned Aircraft Systems (UAS) show promise as a valuable tool for agricultural production. They have also been the source of much controversy because of their origination in military use, potential interference with manned aircraft in the national airspace, and privacy concerns. Additionally, there is a lot of uncertainty today about who can legally use them and how they can be used. The purpose of this factsheet is to outline the state-of-the art and current regulations regarding the use of UAS in agriculture.

What is in a name?

When the terms UAV (Unmanned Aerial Vehicle) or UAS (Unmanned Aircraft System) or Drone are used, people might have very different images of the technology. In agriculture, natural resource management, entertainment, disaster response and other emerging applications, these terms are used to refer to relatively small aerial platforms ranging from 5 to 50 lbs.

The term "unmanned" is somewhat of a misnomer. Obviously because of size, there is no human onboard the UAS, but in all situations humans are involved in the operation and monitoring of their use. Some distinguish two broad categories by how they are controlled. The first is directly and only controlled by a human through some kind of wireless remote and are referred to as Remote Control (RC) or Remotely Piloted Vehicles (RPV). Systems in the second category will have some level of autonomous control, which means that for at least part of the operation, the vehicle is able to control itself to follow a planned flight path based on data from onboard GPS or other position sensors. The terms UAV and UAS are commonly used to refer to this class of more sophisticated aerial system. In all cases, though, humans are intimately involved in the planning and operation of these "unmanned" systems.

Figure 1. Researchers learning about a large UAS capable of applying liquid chemicals.

What can they be used for?

A UAS is kind of like an agricultural tractor. By itself it cannot do any useful field work - it must be coupled with some kind of implement. To be useful for agriculture, the UAS must carry some kind of tool. The most common application for UAS is collection of aerial imagery with platform mounted cameras. This imagery can be simple visible-light photographs or more scientific multi-spectral imagery that can be used to assess different aspects of plant health. With larger more sophisticated UAS, there is the possibility of actually applying agricultural inputs such as seeds, fertilizers or chemicals (Fig. 1).

Be aware that the UAS will help with data collection, but the data interpretation is left to the user. It's easy to imagine using aerial photographs or video of an agricultural field to visually scout for areas with problems and then go visit in person to diagnose the cause of the problem. Further interpretation, though, such as direct diagnosis of problems is one of the biggest challenges with using any aerial technology. It is possible to collect many different kinds of potentially useful data, but how do you get useful information from that data - information that can be used to make management decisions? There are a number of different universities, companies and services working to develop methods to provide interpretation and management tools, but it is not a trivial task.

What is special about UAS?

When considered as an alternative to manned aircraft or satellites, UAS can provide several distinct advantages. They can be deployed at almost any time and in most any location. They can operate at lower altitudes, which can eliminate cloud interference and increase resolution of imagery. The data collected by the UAS are immediately available to the user as soon as the vehicle returns to the base, or even earlier if some kind of wireless data transfer is used. They can be small and easily transportable.

What do they look like?

There are many different kinds of UAS platforms broadly categorized as fixed wing, rotary wing, lighter-than-air (LTA), or tethered.

As the name implies, *fixed wing* platforms have some form of a non-movable wing and a propeller or other propulsion device that provides forward movement (Fig. 2). They can be relatively simple to control with very basic electronics. The platform can often be recovered by gliding in case of loss of propulsion. However, they must always be moving relative to the air around them to stay aloft, and their performance can be greatly affected by high wind speeds. Larger fixed wing platforms will require some kind of runway for deployment and retrieval; smaller ones can often be hand launched and retrieved by landing on a soft surface such as tall grass or standing crop.

Figure 2. Researchers preparing to hand launch a fixed wing UAS.

Rotary wing platforms are the fastest growing technology in UAS applications. They include what are traditionally called helicopters as well as many unique multi-rotor configurations. As the name implies, the wing, or lift generating surface, is rotating. Rotary wing platforms often have the ability to hover, which can help improve the quality of collected images. They can be vertically deployed and retrieved, so special runways or launch areas are generally not needed. They are more difficult to control, but recent developments in electronics for rotary wing UAS have made many of them relatively simple to use. For equal payload capacity, they are generally smaller than fixed wing platforms making them more transportable, but they do not typically have as long of a flight time. They are less forgiving of mechanical failure since they have very limited if any gliding capabilities.

Figure 3. Example of multi-rotor UAS

Currently the most popular UAS platforms have multiple rotors - typically 4 to 8 (Fig. 3). These configurations lend nicely to carrying a sensor payload directly on the bottom center of the vehicle. Most of the control packages will control the direction and tilt of the vehicle based on the relative speed of the different propellers. With more than 4 rotors on a vehicle, it may be possible to recover from a partial failure of the propulsion system. One downside is that these systems are limited in how much weight they can carry – so the battery life, and therefore flight time - is limited. While advanced control systems will allow flights in gusty or higher-wind conditions, flight time will be even more limited. Typical flight times may be 15 minutes or less. Consequently, multiple batteries are often utilized for practical/field use, and multiple battery chargers are needed to expedite turnaround.

Figure 4. Tethered LTA craft being used to collect imagery over test plots

LTA and *tethered* systems are rarely used in agriculture. LTA systems include dirigibles (blimps) and other typically helium-filled craft (Fig. 4). They are usually difficult to transport when inflated because of size, and they cannot tolerate even moderate wind speeds. Tethered platforms include balloons and kites. Again, they are adversely affected by wind (either too much or too little) and the management of the tethers around trees, electric lines, and other obstructions is troublesome.

How much does a UAS cost?

The price of UAS will vary greatly depending on size and capabilities. While some small hobby RPV can be purchased for less than $100, the minimum price for a UAS with enough payload capacity to carry a digital camera and basic GPS-based navigation capabilities will be around $1500-$2000. From there, prices could easily reach 6 figures for larger systems with advanced guidance or input application capabilities.

Who can fly a UAS?

The primary governing body for the national airspace, which includes UAS and all other aircraft, is the Federal Aviation Administration (FAA). The Federal Communications Commission (FCC) also has some jurisdiction over UAS operation in that they regulate the radio frequencies used to communicate with the UAS. The FAA is in the process of developing specific regulations and policies for integration of UAS into the federal airspace. Until those are finalized and released, there are currently four ways that UAS can be legally flown in the United States: 1) for military purposes in Military Special Use Airspace, 2) as a hobbyist without any commercial purpose, 3) as a public entity such as a university or first responder with a Certificate of Authorization, and 4) as a private entity such as a business or person with a "333" Exemption.

Definition of a Hobbyist

Current FAA commercial restrictions do not affect the recreational use of UAS as long as they adhere the following long-established guidelines:

- The UAS must be operated safely and in accordance with policies of a community (hobbyist organization), yielding to manned aircraft under all circumstances.
- The UAS can weigh no more than 55 lb.
- The maximum flight altitude is 400 ft.
- Maximum vehicle speed is 70 mph.
- The operator must maintain visual contact with the UAS at all times; use of first-person viewing aids or binoculars is not permitted.
- The operator must be able to assume manual control of an autonomously flying UAS at any time during the mission.
- The UAS may not be operated within 5 miles of an airport without first contacting the air traffic control operator for that airport. Please note that this is inclusive of all airports and not just major commercial facilities. In 2015, the FAA will release a smart-phone App called B4UFly that can be used to determine if recreational flying is permitted at a given location.
- It cannot be used for any commercial venture.

What is Commercial Use?

Commercial use of a UAS is currently prohibited by the FAA. The interpretation of commercial use is any use that is tied to a commercial venture. In agriculture, this clearly means that it is illegal for a company or individual to charge a fee to use a UAS to collect data and provide it to their customer. The FAA has also taken this a step further to say that a producer cannot use their own UAS on their own farm if any data or information collected with the UAS is used to affect a management decision on a crop or product that will be sold. Research by universities or other public or private entities is also considered commercial use and is prohibited.

Permits for Commercial UAS Use

There are several ways that waivers to the FAA restriction can be obtained allowing UAS commercial use. Commercial and public entities, which include public university research groups and government agencies, can obtain permits for UAS use. These are called an Experimental Airworthiness Certificates (commercial entity) or Certificates of Authorization (COA) (public entity) and allow the entities to conduct aeronautics research and development work with UAS. Unfortunately the process of obtaining the permits is very arduous - it takes many months, and it requires detailed descriptions of the exact time and location of each UAS mission, operator team identification and qualifications, airworthiness certification, and more.

A new avenue for commercial use in the national airspace emerged in 2014 with the “333” exemption by the FAA of certain businesses for narrowly-specified uses under highly-controlled situations. For example, exemptions were granted for two commercial systems for use in Alaska for remote pipeline infrastructure inspection. Also, movie production companies were granted exemptions for use in filming on closed sets. Since then, almost 300 have been granted out of over 1500 requests filed, including exemptions granted to entities working in precision agriculture. Therefore, a limited number of companies are now able to operate legally, but with restrictions including only operations by a certified operator, in daylight, within visible line-of-sight, and away from airport proximity.

What is the Status of Permanent UAS Regulations?

The exemptions provide a temporary bridge for UAS advancement while the FAA continues to move toward permanent regulations. On February 15, 2015, the FAA released a proposed set of regulations for commercial use of small UAS. The regulations were subject to public comment for a period of time, then the FAA must review comments, and adjust the regulations as they deem necessary before issuing the final regulations. More than 4,000 comments were received on the draft regulations, so the anticipation is that it may be 2016 or later before the final version is released.

Some of the key points of the proposed rules for small (<55 lb.) UAS are as follows:

- UAS operators must be at least 17 years of age and obtain a special unmanned aircraft operator certification that will require a renewal every 2 years. This certification process will not be as extensive as required for commercial pilots, but will require knowledge of the laws as well as aerial platform systems.
- Altitude is limited to 500 feet.
- Speed is limited to 100 mph.
- Minimum of 3 mile weather visibility from control station.
- Must maintain Visual Line of Sight (VLOS) at all times.
- First person cameras can be used but cannot replace the VLOS observer.
- No operation in airport flight paths or restricted airspace.
- No operation over people except those responsible for operation of the UAS.
- The operator is responsible for pre-flight checks and assurance of air worthiness.

Again, these regulations are just a proposal. The final set may deviate from this proposal, but the anticipation is that there will not be large deviations. This document will be updated when the final regulations are released by the FAA.

Here are a few links to find more information about UAS and associated regulations.

- UK Unmanned Systems Research Consortium: http://usrc.engineering.uky.edu
- FAA Unmanned Aircraft Systems page: http://www.faa.gov/uas/

- Association for Unmanned Vehicle Systems International: http://www.auvsi.org