



UNMANNED AERIAL SYSTEMS IN AGRICULTURE: PART 1 (SYSTEMS)

UAS in AG Series

By

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FS194E

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Introduction

A vehicle is classified as an unmanned aerial system (UAS) when there is no person on board to guide controls, or decide direction or speed of the vehicle. UAS are equipped with on-board flight and navigation controls to be piloted remotely or through Global Positioning System (GPS) waypoints in autopilot mode. In general, the shape and size of the system governs classification of UAS into four different types (explained below). Proposed regulations from the Federal Aviation Administration (FAA) classify a UAS with gross weight of less than 55 lbs (25 kg) as a small UAS (sUAS). Most of the newer sUAS are controlled from ground stations using remote control, multi-channel bidirectional communication systems, which generally use a frequency of 2.4 GHz in the United States. Most systems also have autopilot and auto land capability. From an application standpoint, sUAS, which are the focus of this fact sheet, are integrated with sensing modules on board that appear to have a wide range of applications in agricultural production management when combined with soil, weather, and relevant crop growth information.

Types of Unmanned Aerial Systems

Shape, size, flight time, control type, and payload capabilities influence the selection of sUAS for agricultural applications. The sUAS can be classified into four types: parachute, blimp, rotocopter, and fixed-wing systems. Each type has favorable and unfavorable attributes, depending on application.

Motorized **parachutes** are easy to fly in no-wind conditions with varied payload, but are challenging to operate under windy conditions. They can be maneuvered at low speeds and offer longer flight time compared with the other three types discussed in this article. However, they cannot hover at a chosen point of interest and need a runway for take-off and landing.

Blimps commonly are used in commercial advertising and may be used in agricultural aerial imaging applications. Blimps can hover in place so it is possible to take clear images of selected areas. However, blimps may be difficult to fly in windy conditions and they are slow to move from one location to another.

The most utilized sUAS are rotocopter and fixed-wing systems (Figures 1 and 2). **Rotocopters** (also called multi-copter or multi-rotor) have highly flexible flight attributes and use anywhere from a few to many rotary propellers. Often, the name signifies the number of rotors used on the sUAS. For example, quad-, hexa-, and octo-copters respectively signify the use of 4, 6, and 8 rotors. Rotocopters offer several advantages as they can hover at a chosen point of interest for a pre-determined time, use GPS-based waypoint navigation, fly horizontally and vertically, and require very little space for takeoff and landing. The limitations include lower travel speed and shorter flight times, limiting coverage of larger fields.



Figure 1. Rotocopter type sUAS are commonly used in agriculture. (Photo by Lav Khot, WSU.)



Figure 2. Fixed-wing sUAS also are commonly used in agriculture. (Photo by Manoj Karkee, WSU.)

Fixed-wing sUAS also use horizontal rotary propellers (often one or two) for propulsion, and generally have longer flight and faster travel speeds than rotocopters, which is important depending on applications. Fixed-wing systems cannot hover in place and the travel speed can result in image blurring with slow camera shutter speeds. Image blurring can be fixed by using imaging sensors with improved capabilities including high shutter speeds.

For the multi-rotor and fixed-wing sUAS, flight time is limited by the battery capacity. Single or multiple lithium-polymer (LiPO) batteries can be used depending on the desired application and flight time. For example, a rotocopter (Model: Okto XL, HiSystems GmbH-Germany) powered by two 5000 mAh capacity LiPO batteries can hover for about 8 to 36 minutes depending on payload and wind conditions. Ongoing research to improve battery technology and solar power platforms may result in increased flight time capability. When a multi-rotor's flight length is critical, an sUAS could be secured to a cable that acts as a tether as well as a power supply.

Agricultural Applications

Agricultural applications of sUAS may vary widely based on the versatility of the sUAS and resourcefulness of the user. An sUAS can be used for imaging and non-imaging applications. Imaging applications primarily involve the use of multi-spectral sensors or cameras for crop scouting (Figures 3 and 4), irrigation assessment, pest and disease detection, crop inventory, and quality and yield estimation. For example, crop-scouting applications may include crop emergence assessment, winter survival and spring stand assessment of winter wheat, biotic and abiotic stress monitoring of row and specialty crops, weed distribution, insect spread monitoring, and more. Non-imaging applications include sampling for levels of air-borne pathogens, surgical or spot spraying, and bird deterrence. Non-imaging applications currently are limited by the payload an sUAS can carry with sufficient flight-time. Details on various types of imaging sensors and data management aspects will be covered in a future *Washington State University Extension Publication*.

Operational Regulations

Small UAS types currently are being integrated into airspace under FAA safety regulations similar to that of manned aircraft. Most of the sUAS operations are intended to be in uncontrolled airspace and within line of sight. Although operations below 1,200 feet above ground level (AGL) are considered uncontrolled (Class G) airspace, the FAA regulates sUAS operations below 400 feet AGL. A different set of guidelines applies for sUAS operations by recreational users, and by commercial and public entities. Detailed regulations and guidelines can be found at: <http://knowbeforeyoufly.org/>.

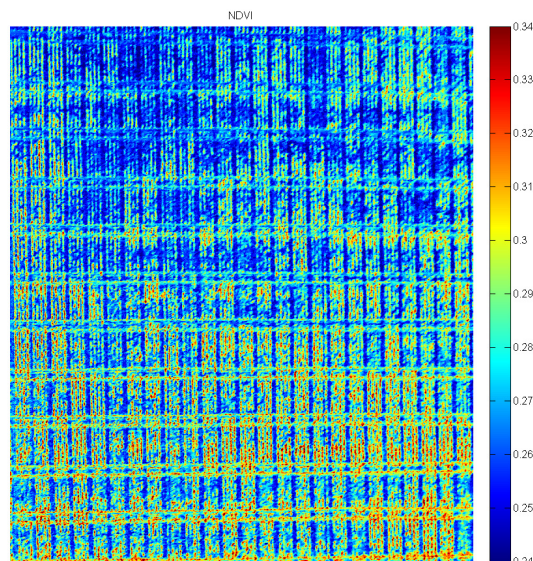


Figure 3. UAS integrated multi-spectral imagery based monitoring of winter wheat emergence. (Photo by Lav Khot, WSU.)

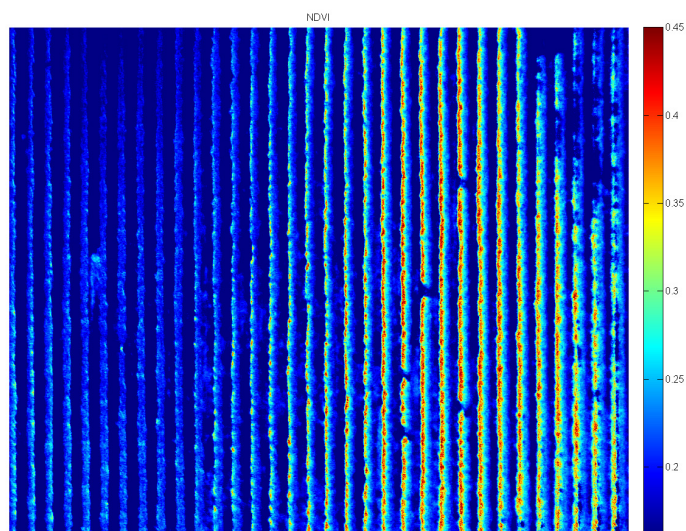


Figure 4. UAS integrated multi-spectral imagery based monitoring of grapevine vigor. (Photo by Lav Khot, WSU.)

Table 1 summarizes the minimum FAA guidelines for safe operation of sUAS. Growers, crop consultants, and agricultural service providers planning to use sUAS are considered commercial (civil) operations and hence need a pilot “ground school certification” from an FAA-approved pilot school and “third class airman” medical certification to be in compliance with existing FAA rules. Such certifications are necessary to educate sUAS pilots about airspace-sharing protocols and general aviation terminology. The pilot of an sUAS also needs to have hands-on operational and safety training with the type of sUAS to be used. Ideally, before actual field training and flying, one should practice flying the pertinent sUAS in a simulated flight environment using AeroSIM^{RC} or similar radio-controlled flight-training simulators. Per existing FAA regulations, the airframe of a chosen manufacturer of an sUAS must be registered and should have airworthiness certification prior to use for intended operation.

Table 1. Summary of FAA guidelines for small UAS operations in airspace.

Minimum guidelines (what is needed)	User		
	Recreational	Civil	Public
Who	Hobbyist	Non-government, commercial service providers, private entities	Federal, state government, law enforcement agencies, public colleges and universities
Section 333 exemption ^a	No	Yes	No
Certification of Authorization (COA)	No	Yes	Yes
Special Airworthiness Certificate (SAC)	No	Yes	No
Aircraft airworthiness certification/Registration	Yes	Yes	Yes
Pilot licensing needed			
(Ground school certification)	No	Yes	Yes
Observer	Recommended	Required	Recommended
Medical certification for pilot and observer	No	Third-class airman	Third-class airman
Operation restriction			
Horizontal ^b	Line of sight	Line of sight	Line of sight
Vertical	< 400 ft AGL	< 400 ft AGL	< 400 ft AGL

^a "Section 333 FAA Modernization and Reform Act of 2012 (FMRA) (PDF) grants the Secretary of Transportation the authority to determine whether an airworthiness certificate is required for a UAS to operate safely in the National Airspace System (NAS)." (Source: http://www.faa.gov/uas/legislative_programs/section_333/).

^b 5 miles away from airport

In 2012, the FAA was mandated to develop pertinent regulatory guidelines so that sUAS could be integrated into the airspace by September 2015. In response, FAA has proposed new regulations that will replace existing ones in the near future. The proposed guidelines can be found at: www.faa.gov/regulations_policies/rulemaking/media/021515_sUAS_Summary.pdf. This publication will be updated periodically to reflect the new FAA guidelines.

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[Know before you fly](#). 2015.



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