

Unmanned Aerial Systems (Drones) for Ozarks Agriculture

by
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for
Christian County Livestock and Forage Conference
Clever, MO
March 26, 2018



UNIVERSITY OF MISSOURI
 Extension

*Farming looks mighty easy
when your plow is a pencil
and you're a thousand
miles from a corn field.*

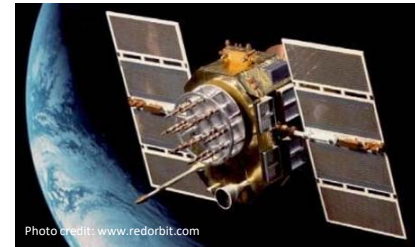
— Dwight Eisenhower



Agricultural Progress



What is agriculture to you?



Agricultural Challenges

- FAO predicts need to feed 9.6 billion people on planet Earth by 2050
- Food production must increase by 70% by 2050, in spite of:
 - Limited availability of arable lands
 - Increasing need for fresh water
 - Agriculture consumes 70% of the world's fresh water supply
 - Impact of climate change affecting seasonal events in the life cycle of plants and animals
- Future of agriculture = smart farming

Economic Impact of UAS

- **Precision agriculture** and **public safety** are the most promising commercial and civil markets
= 90% of the known potential markets for UAS
- Agriculture in U.S. anticipated to provide:
 - \$65 billion of \$82 billion UAS business from 2015-2025
 - 103,700+ new jobs (at least 34,000 jobs over \$40K/year)
 - \$13.6 billion in first 3 years
 - \$1.56 billion in Missouri with 1,970+ jobs over 10 years
- **Every year that integration is delayed, the U.S. loses over \$10 billion in potential economic benefit**
= \$27 million loss per day

Source: Association for Unmanned Vehicle Systems International (AUVSI)

UAS best suited for the Four D's

- Dirty
- Dangerous
- Difficult
- Dull



Aerial Precision Ag, also known as APA, is a division of Cirrus Rotors - <http://aparotors.com/about-us/>



Photo credit: CBS News

Possible Jobs for UAS



- **Agricultural monitoring (crops & animals)**
- **Weather monitoring**
- **Disaster assessment & management** (tornadoes, floods, wildfires, earthquakes)
- Tower, bridge, rail and power line surveys
- Hazardous site evaluation (fire, chemical, nuclear, etc.)
- Law enforcement (locate lost people, threats, document site for evidence)
- **Environmental monitoring & research**
- **Aerial imaging/mapping** (real estate)
- Oil and gas exploration
- Telecommunications (news coverage, sporting events, moviemaking)
- Freight transport/package delivery
- **Agri-tourism**
- **Entertainment** (unique photography, remote dog walking 😊)

UAS, UAV, drone

Next High-Tech Tool for Agriculture and Beyond



Photo credit: <http://modernfarmer.com/2014/01/precision-hawk/>



Photo credit: <http://hoosieragribusiness.wordpress.com/2014/09/22/are-drones-the-next-big-thing-in-ag/>



Photo credit: <http://nimbus.unl.edu/projects/crop-surveying-using-aerial-robots/>

Most Common Uses by Farmers

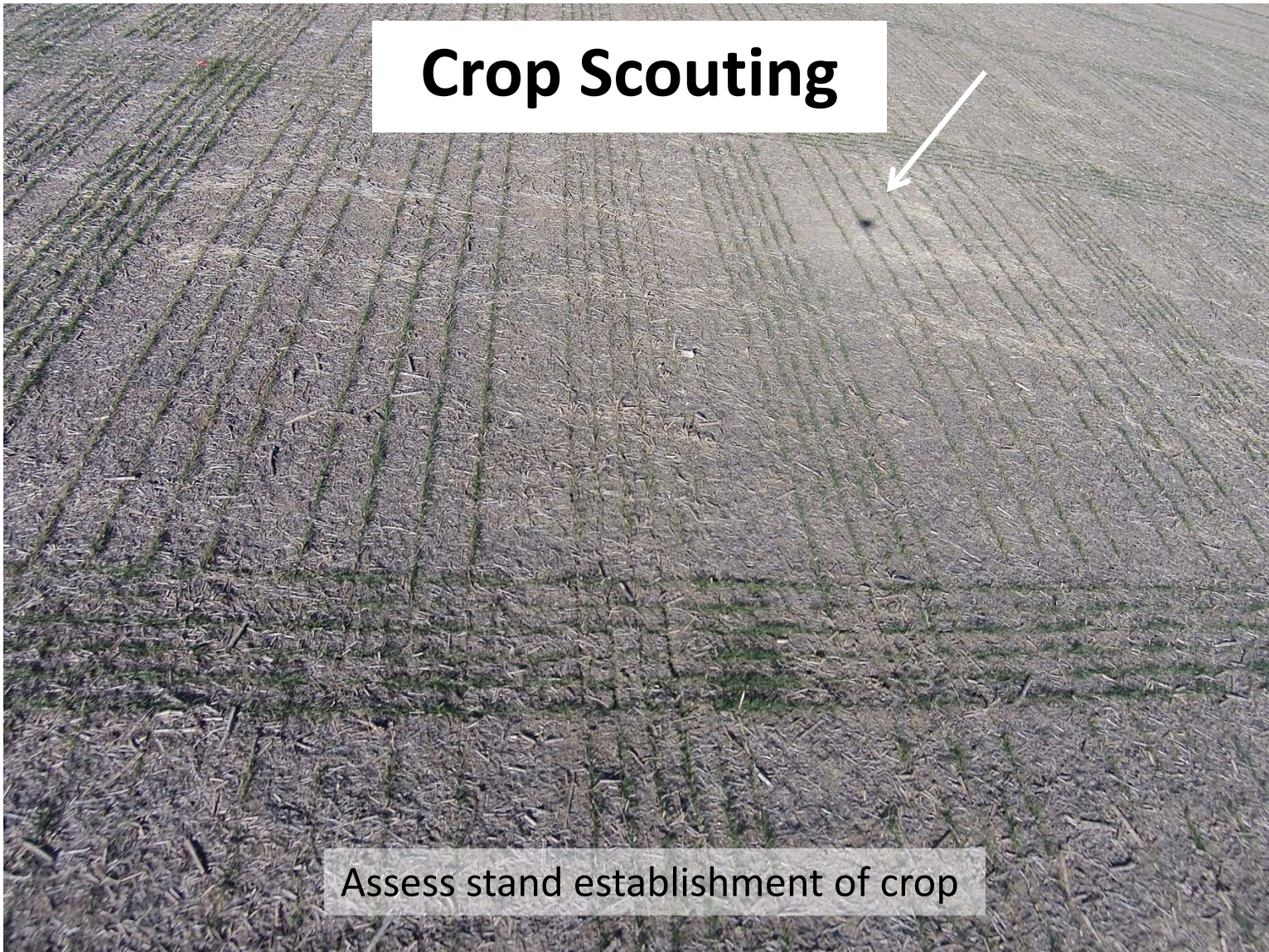
- “Directed scouting” of animals and crops, which involves “ground-truthing” what you observe from air
 - Crop condition (growth, insects, diseases)
 - Cattle counts, rustler monitoring



Crop Scouting



Assess stand establishment of crop



Crop Scouting



SPARC Plots at South Farm on August 2, 2013

Crop Scouting

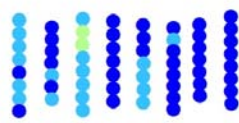
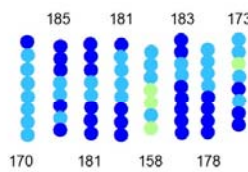
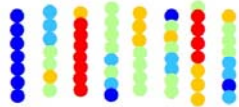


SPARC Plots at South Farm on August 28, 2014

Crop Scouting – Nitrogen Stress



Nitrogen Rate Study at Graves-Chapple Farm on August 27, 2013



Corn Yield in bu/acre
 willot_yld_northplots_buff25ft_cln
 YLD_VOL_DR

- 56.8 - 96.8
- 96.9 - 130.8
- 130.9 - 156.7
- 156.8 - 177.7
- 177.8 - 207.7

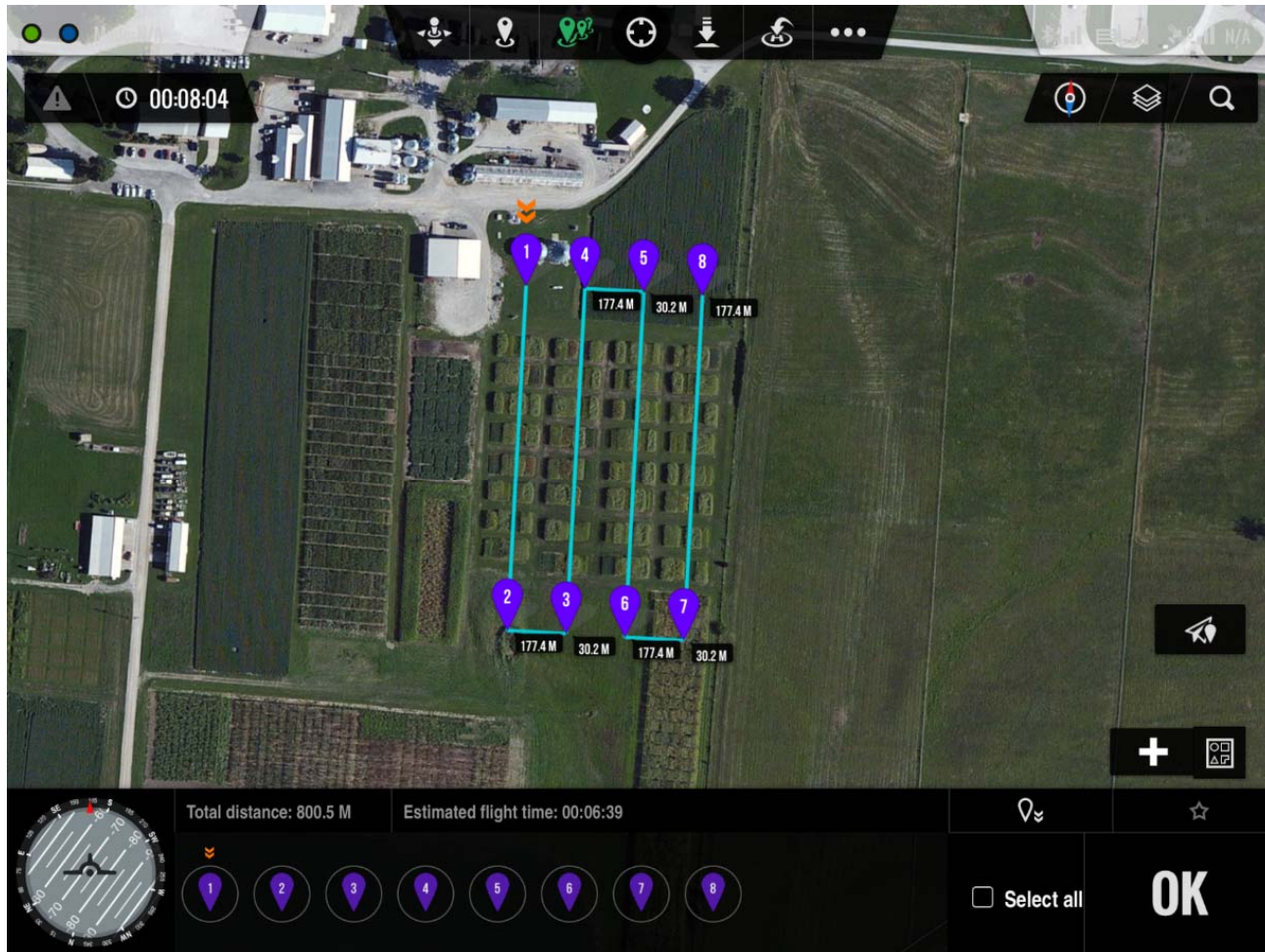


Crop Scouting – Corn Hybrid Differences



Hundley-Whaley Farm on August 28, 2013

Crop Scouting – Autonomous Flight

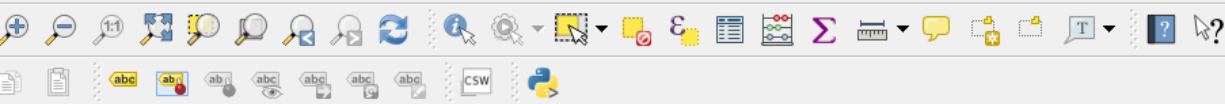


Capture Images via Autonomous Flight

DJI Phantom Vision +



Mosaic of 77 images taken on August 14, 2015 – flying at 50 meters



Doing Stand Counts



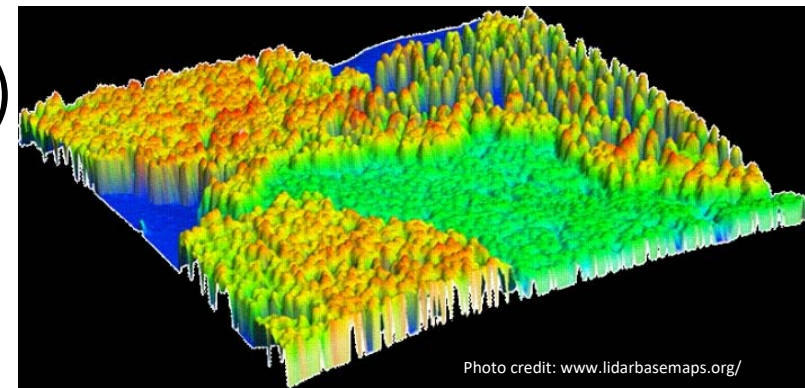


Doing Stand Counts



Possibilities with Other Sensors

- **Thermal (infrared)**
 - Livestock detection, sick animals
 - Fires, farm safety
 - Water temperature, source identification
- **Multispectral**
 - Crop growth, plant identification
- **LiDAR (Light Detection And Ranging)**
 - Measuring plant height, 3-D terrain mapping



Utilizing a Thermal Camera



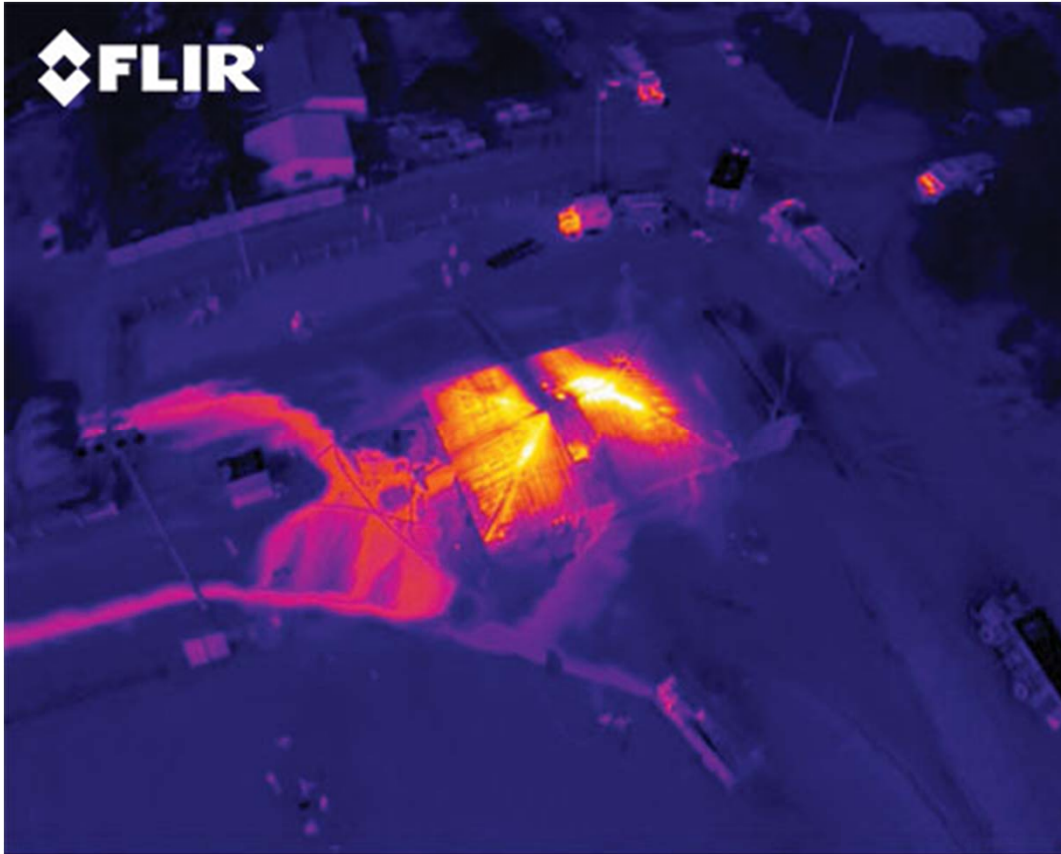
\$10,229.00

Utilizing a Thermal Camera



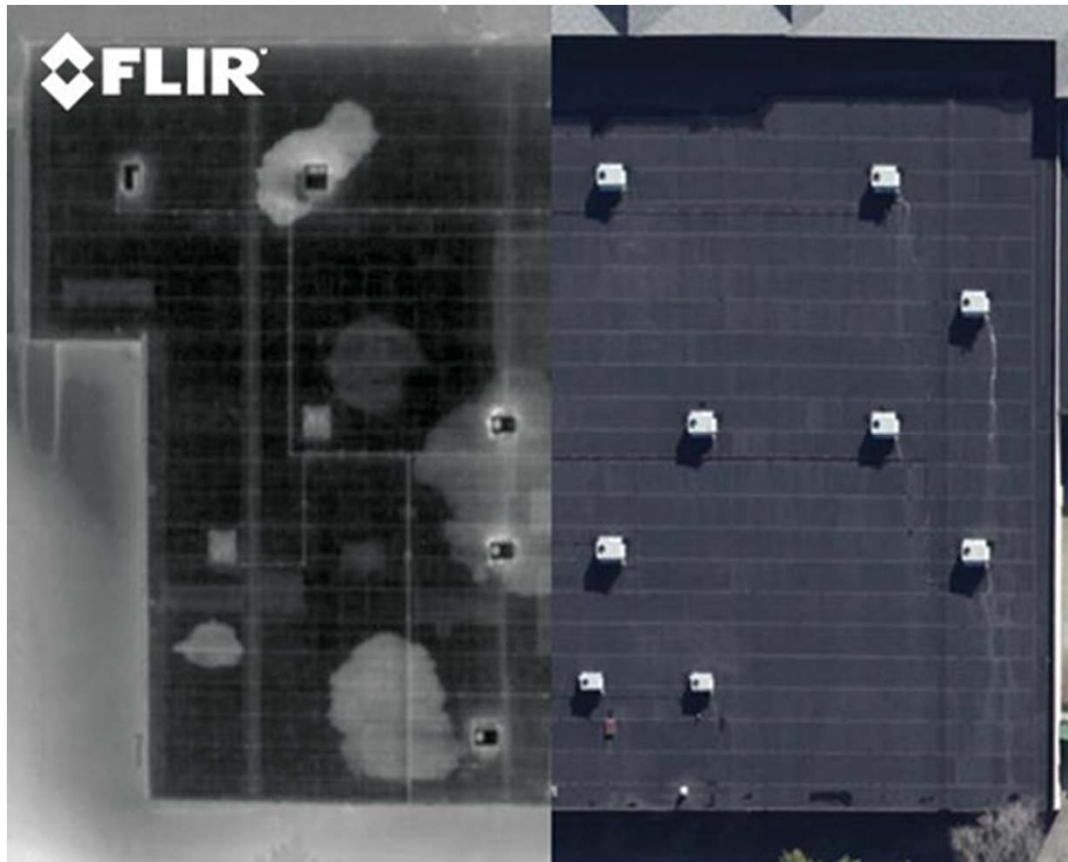
Find lost people or
accident victims
night and day

Utilizing a Thermal Camera



See through smoke and guide water application for efficient attacks

Utilizing a Thermal Camera



Find invisible water damage in seconds

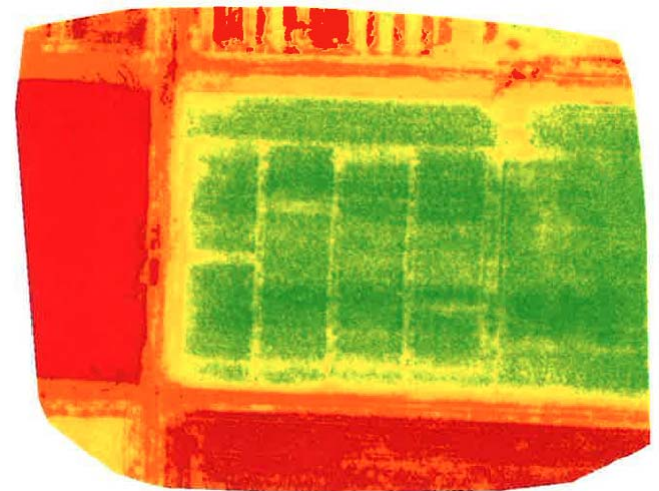
Crop Growth / Sensor Technology



RGB image mosaic



NIR image mosaic

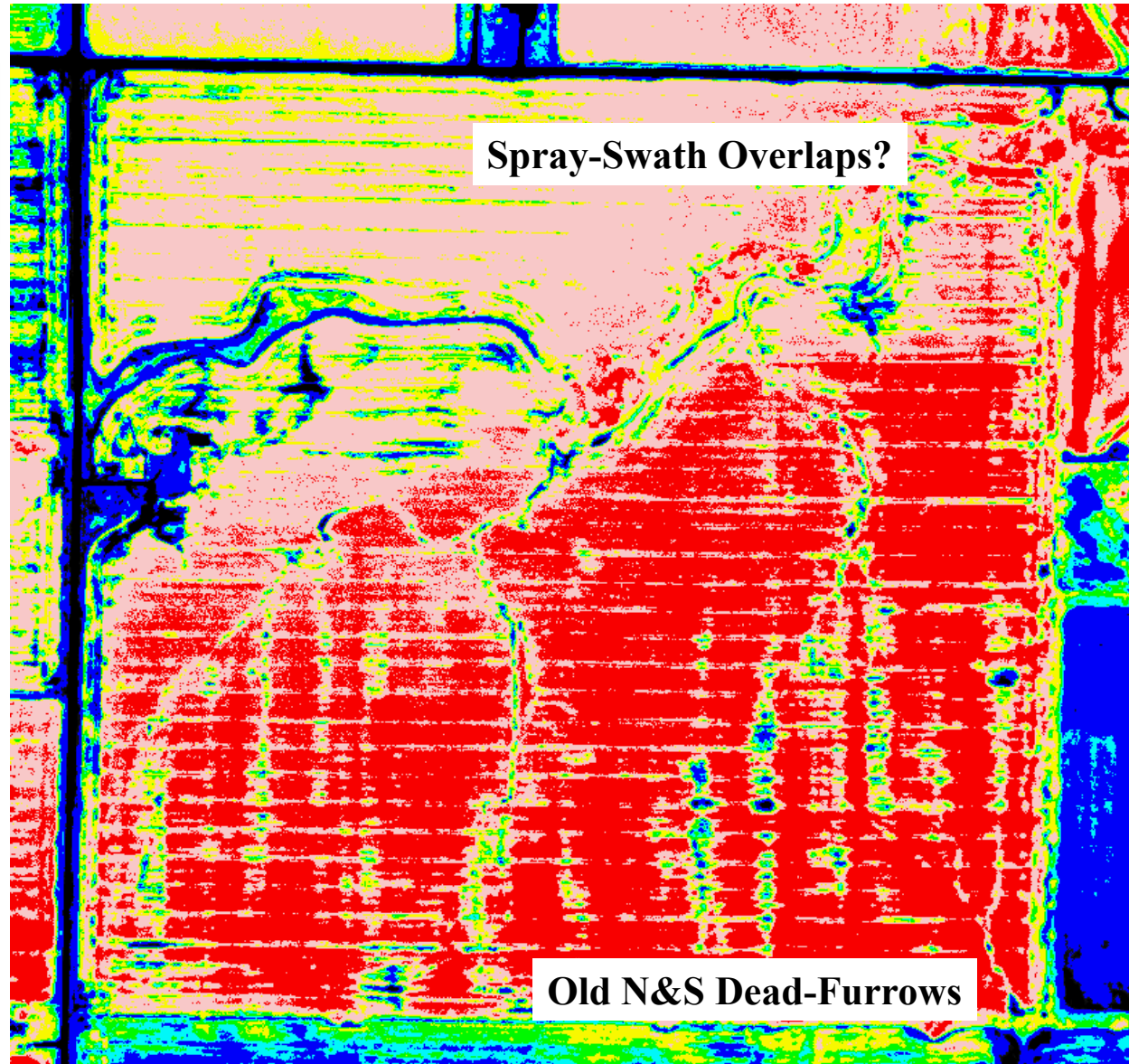


Software-enhanced NIR mosaic

from DJI Phantom 3 with Standard RGB Camera and Sentera Single NIR Sensor

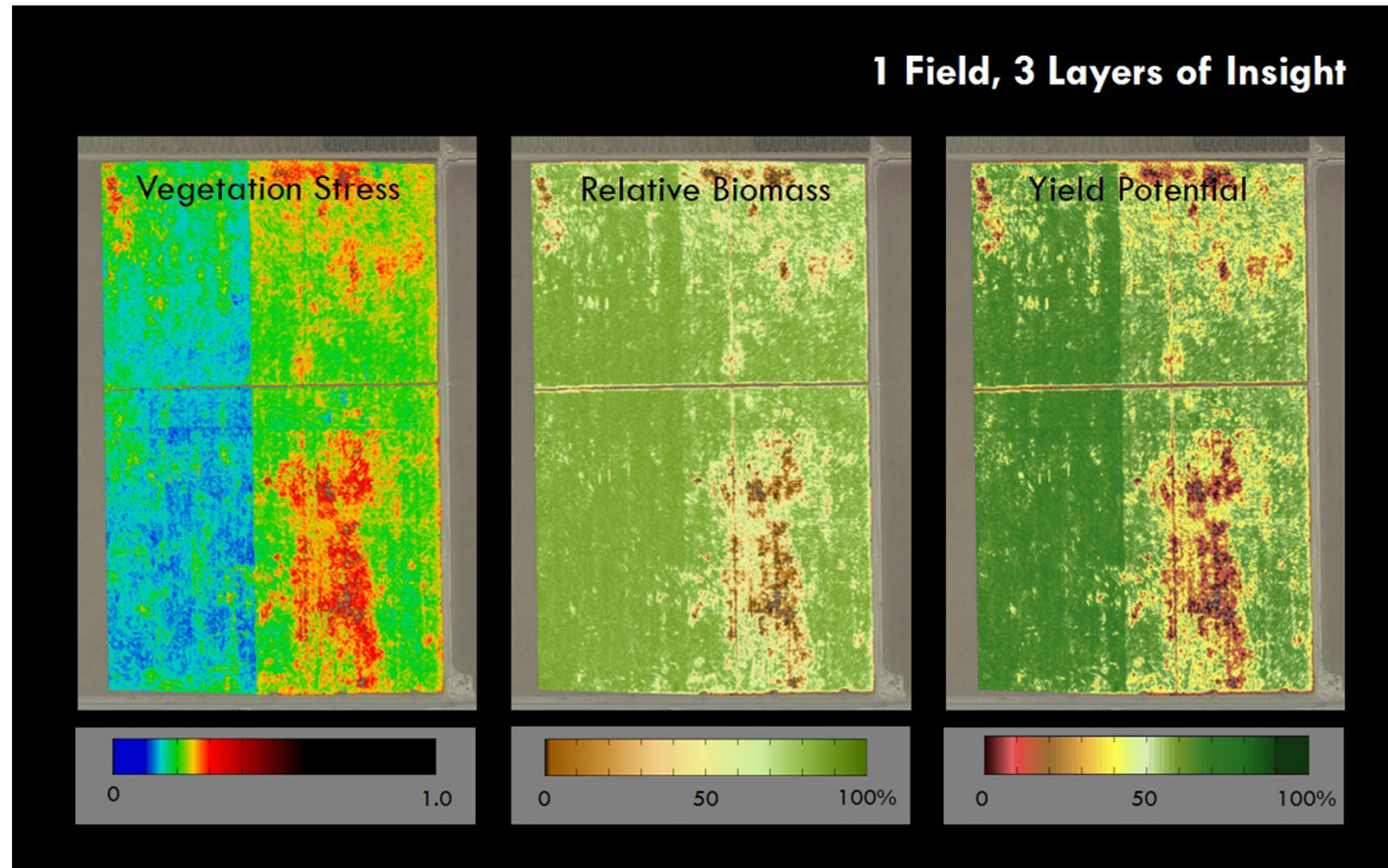


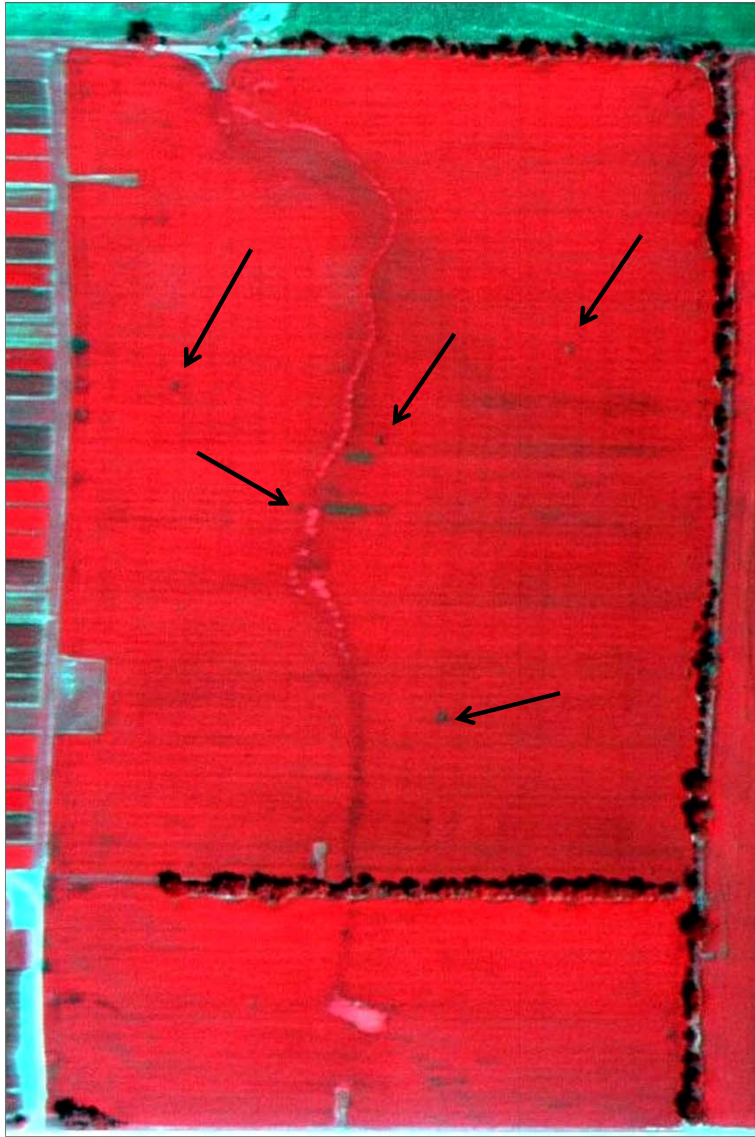
**Use of
Multispectral
Cameras**



Slantrange – Multispectral Camera

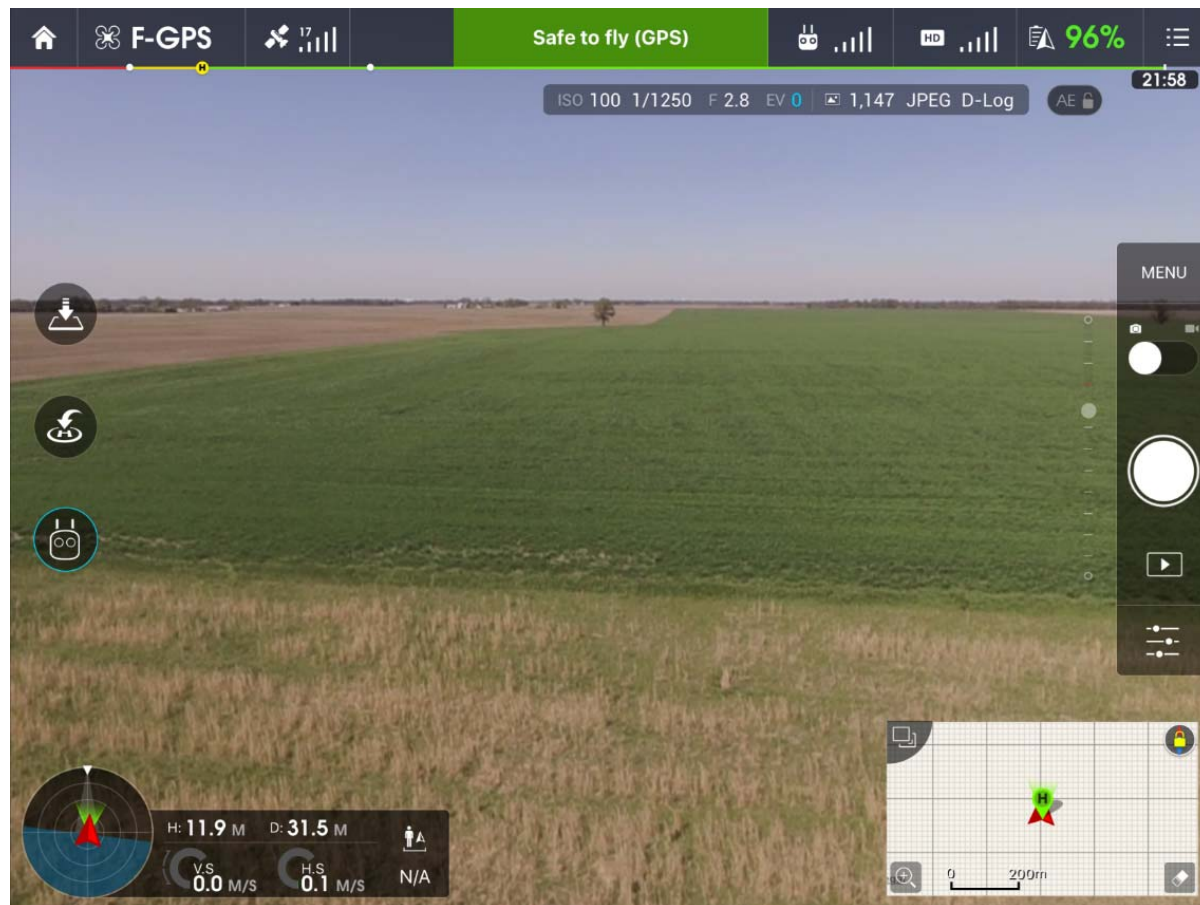
1 Field, 3 Layers of Insight



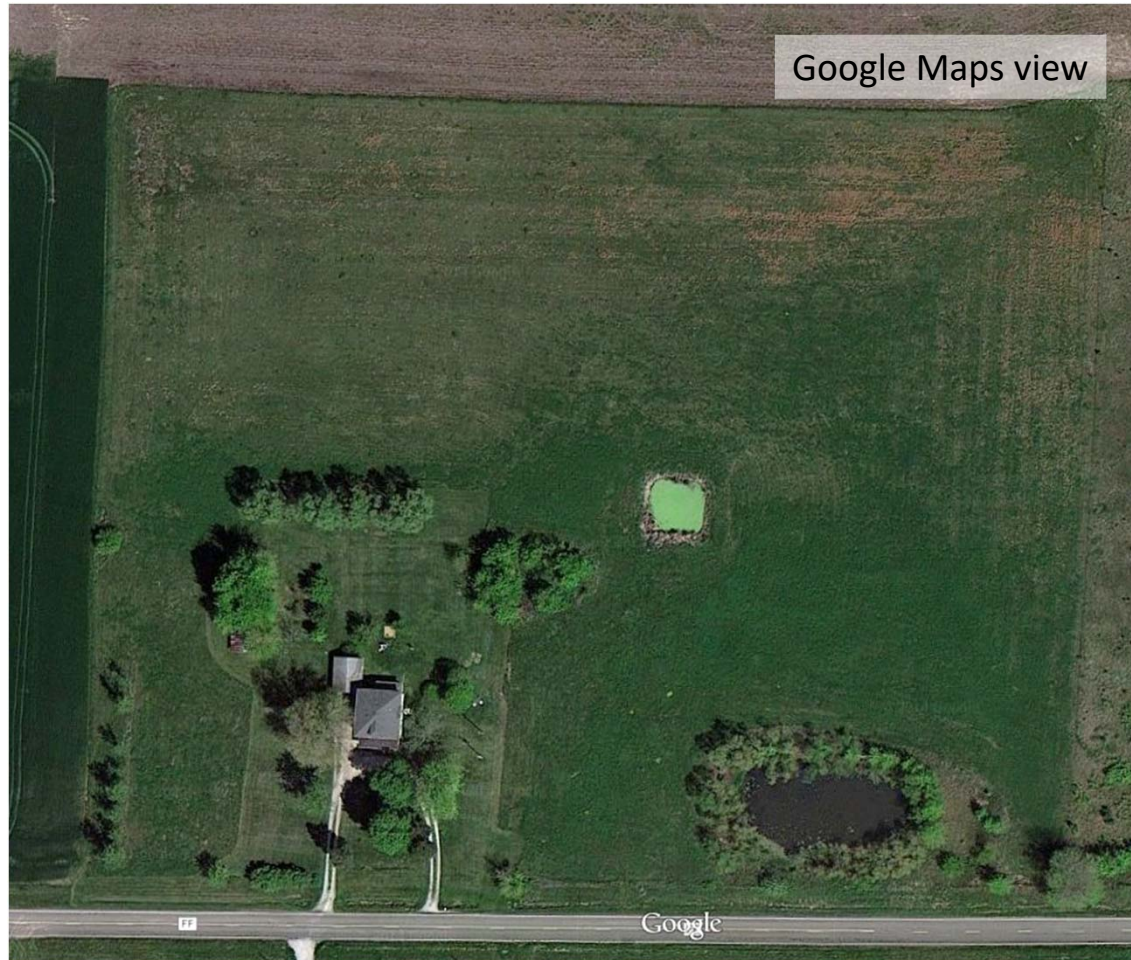


Lightning strikes

Using DJI Go App



Rural Property Evaluation

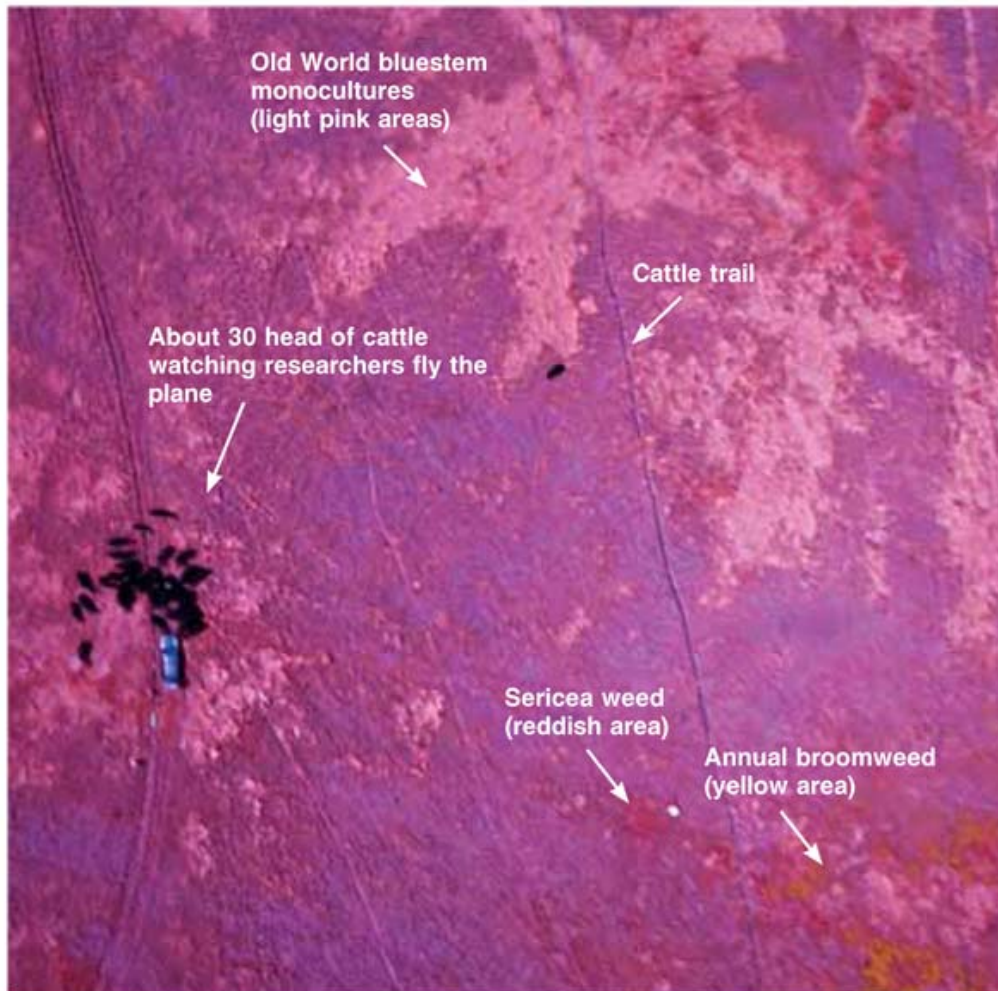


Rural Property Evaluation

Drone photo - March 24, 2014



Monitoring of Beef Cattle and Pastures



Color infrared photos can help ranchers manage invasive species. This picture of an Old World bluestem pasture was taken in the fall, after the grass browned down, but the image still showed the bluestem (light pink), annual broomweed (yellow) and invasive sericea (reddish areas). Photo courtesy of Kevin Price

Work being conducted through Kansas State University

Unmanned Sprayer



The Yamaha RMAX crop sprayer (246cc gasoline twin) with an AUV of 207 lb. has an endurance of 60-90 minutes with a payload capacity of 66 lb. (equivalent to about 10 gallons of gasoline, which could be used for extending endurance)



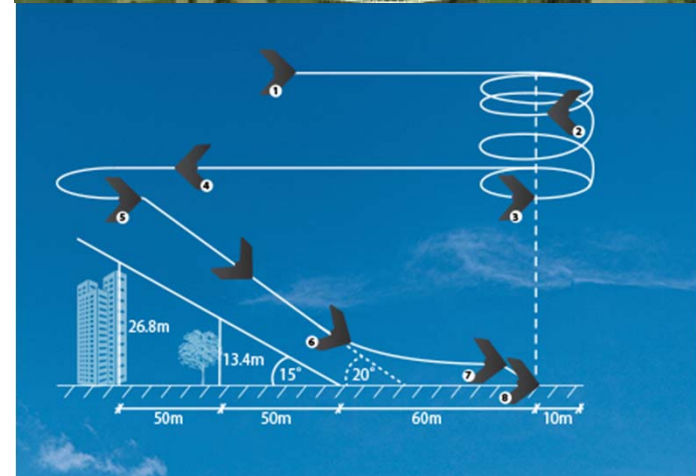
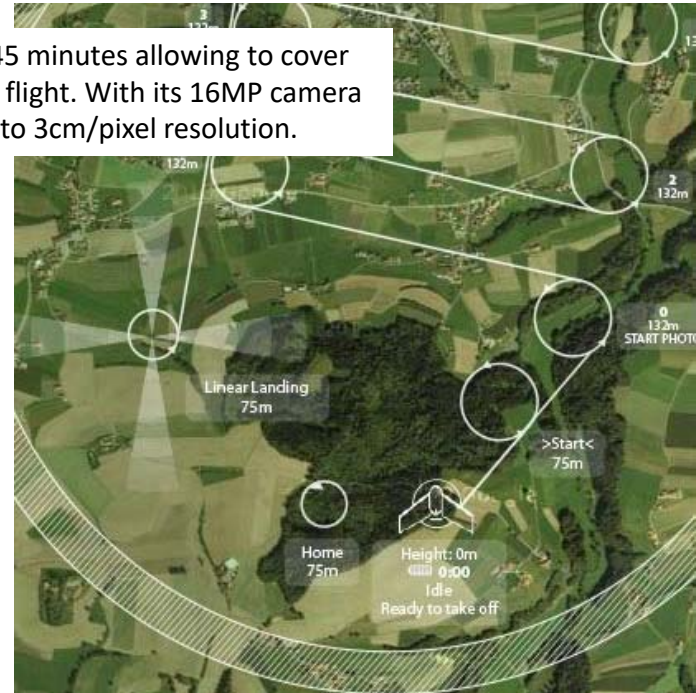
23 cc two-cycle engine from a Yamaha weed whacker.
A tank of mixed gas keeps the chopper flying for an
hour.

G15 AutoCopter - \$50,000 to \$75,000

The G15 weighs 15 pounds and is capable of carrying
15 lb. The carbon fiber rotors have a 71 inch span.



The eBee has a flight time of up to 45 minutes allowing to cover areas of up to 2400 acres in a single flight. With its 16MP camera it can shoot aerial imagery at down to 3cm/pixel resolution.



SenseFly – eBee - \$12,000

Can I Fly a Drone Today?

- What are you using the drone for?
 - Recreation / Hobby
 - Business



Further Interpretations – June 25, 2014

Allowed

Not Allowed

Hobby or Recreation	Not Hobby or Recreation
Flying a model aircraft at the local model aircraft club.	Receiving money for demonstrating aerobatics with a model aircraft.
Taking photographs with a model aircraft for personal use.	A realtor using a model aircraft to photograph a property that he is trying to sell and using the photos in the property's real estate listing. A person photographing a property or event and selling the photos to someone else.
Using a model aircraft to move a box from point to point without any kind of compensation.	Delivering packages to people for a fee. ⁶
Viewing a field to determine whether crops need water when they are grown for personal enjoyment.	Determining whether crops need to be watered that are grown as part of commercial farming operation.

DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
14 CFR Part 91
[Docket No. FAA-2014-0396]
Interpretation of the Special Rule for Model Aircraft

Can I Fly a Drone?

- The aircraft is flown strictly for hobby or recreational use
- Fly below 400 feet and remain clear of surrounding obstacles
- Keep the aircraft within visual line of sight at all times
- Remain well clear of and do not interfere with manned aircraft operations

**SEC. 336. SPECIAL RULE FOR MODEL AIRCRAFT –
FAA Modernization and Reform Act of 2012**

AC 91-57A - Model Aircraft Operating Standards - Including Change 1

Can I Fly a Drone?

- Don't fly within 5 miles of an airport unless you contact the airport and control tower before flying
- Don't fly near people or stadiums
- Don't fly an aircraft that weighs more than 55 lbs.
- Don't be careless or reckless with your unmanned aircraft – you could be fined for endangering people or other aircraft

**SEC. 336. SPECIAL RULE FOR MODEL AIRCRAFT –
FAA Modernization and Reform Act of 2012**

AC 91-57A - Model Aircraft Operating Standards - Including Change 1

SUMMARY OF SMALL UNMANNED AIRCRAFT RULE (PART 107)

June 21, 2016

went into effect August 29, 2016

Operational Limitations

- Unmanned aircraft must weigh less than 55 lbs.
- Visual line-of-sight (VLOS) only;
 - The unmanned aircraft must remain within VLOS of the remote pilot in command and the person manipulating the flight controls of the small UAS
 - Alternatively, the unmanned aircraft must remain within VLOS of the visual observer

Operational Limitations (cont.)

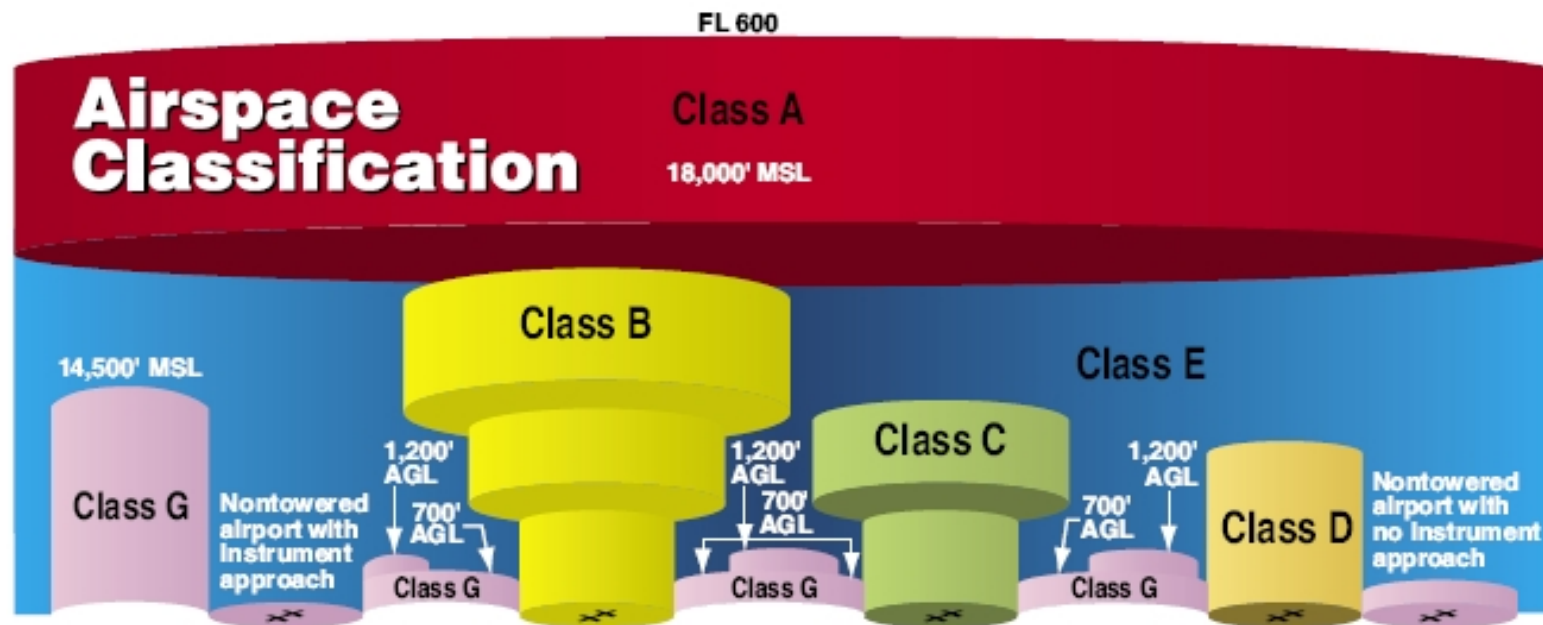
- Small unmanned aircraft may not operate over any persons not directly participating in the operation, not under a covered structure, and not inside a covered stationary vehicle
- Daylight-only operations, or civil twilight (30 minutes before official sunrise to 30 minutes after official sunset, local time) with appropriate anti-collision lighting (need FAA waiver for night operations)
- Must yield right of way to other aircraft
- May use visual observer (VO) but not required

Operational Limitations (cont.)

- First-person view camera cannot satisfy “see-and-avoid” requirement but can be used as long as requirement is satisfied in other ways
- Maximum ground speed of 100 MPH
- Maximum altitude of 400 feet above ground level (AGL) or, if higher than 400 feet AGL, remain within 400 feet of a structure
- Minimum weather visibility of 3 miles from control station

Operational Limitations (cont.)

- Operations in Class B, C, D and E airspace are allowed with the required ATC permission.
- Operations in Class G airspace are allowed without ATC permission



Operational Limitations (cont.)

- No person may act as a remote pilot in command or VO for more than one unmanned aircraft operation at one time
- No operations from a moving aircraft
- No operations from a moving vehicle unless the operation is over a sparsely populated area (need FAA waiver)
- No careless or reckless operations
- No carriage of hazardous materials

Operational Limitations (cont.)

- Requires preflight inspection by the remote pilot in command
- A person may not operate a small unmanned aircraft if he or she knows or has reason to know of any physical or mental condition that would interfere with the safe operation of a small UAS
- External load operations are allowed if the object being carried by the unmanned aircraft is securely attached and does not adversely affect the flight characteristics or controllability of the aircraft

Remote Pilot in Command Certification and Responsibilities

- Establishes a remote pilot in command position
- A person operating a small UAS must either hold a remote pilot airman certificate with a small UAS rating or be under the direct supervision of a person who does hold a remote pilot certificate (remote pilot in command)

Remote Pilot in Command Certification and Responsibilities

- To qualify for a remote pilot certificate, a person must:
 - Demonstrate aeronautical knowledge by either:
 - Passing an initial aeronautical knowledge test at an FAA-approved knowledge testing center; or
 - Hold a Part 61 pilot certificate other than student pilot, complete a flight review within the previous 24 months, and complete a small UAS online training course provided by the FAA
 - Be vetted by the Transportation Security Administration
 - Be at least 16 years old

Remote Pilot Knowledge Test – What to Expect

METAR KINK 121845Z 11012G18KT 15SM SKC 25/17 A3000
METAR KBOI 121854Z 13004KT 30SM SCT150 17/6 A3015
METAR KLAX 121852Z 25004KT 6SM BR SCT007 SCT250 16/15 A2991
SPECI KMDW 121856Z 32005KT 1 1/2SM RA OVC007 17/16 A2980 RMK RAB35
SPECI KJFK 121853Z 18004KT 1/2SM FG R04/2200 OVC005 20/18 A3006

FIGURE 12.—Aviation Routine Weather Reports (METAR).

The wind direction and velocity at KJFK is from:

1. 180° magnetic at 4 knots
2. 180° true at 4 knots
3. 040° true at 18 knots

Remote Pilot Knowledge Test – What to Expect

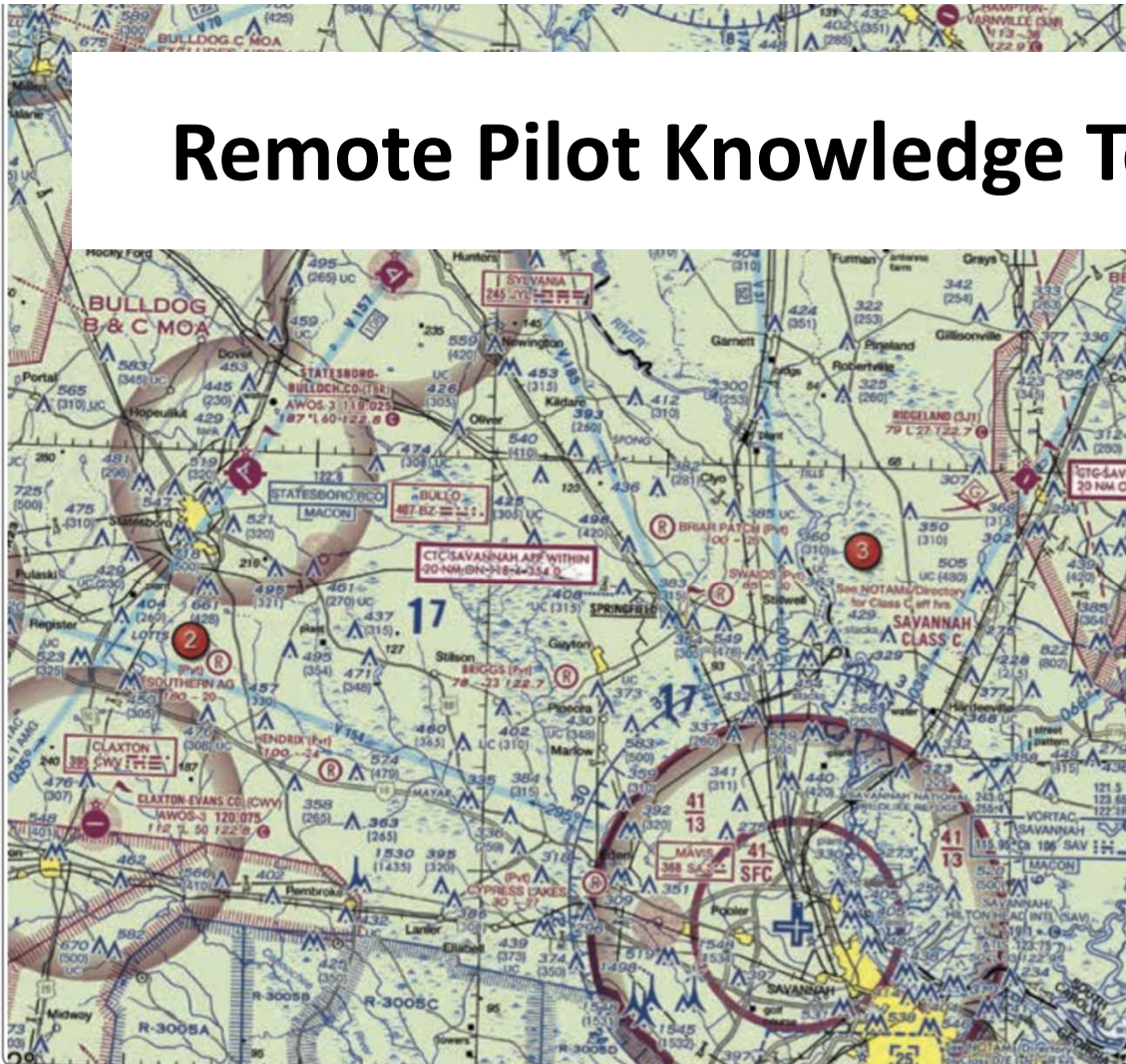
METAR KINK 121845Z 11012G18KT 15SM SKC 25/17 A3000
METAR KBOI 121854Z 13004KT 30SM SCT150 17/6 A3015
METAR KLAX 121852Z 25004KT 6SM BR SCT007 SCT250 16/15 A2991
SPECI KMDW 121856Z 32005KT 1 1/2SM RA OVC007 17/16 A2980 RMK RAB35
SPECI KJFK 121853Z 18004KT 1/2SM FG R04/2200 OVC005 20/18 A3006

FIGURE 12.—Aviation Routine Weather Reports (METAR).

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Remote Pilot Knowledge Test – What to Expect



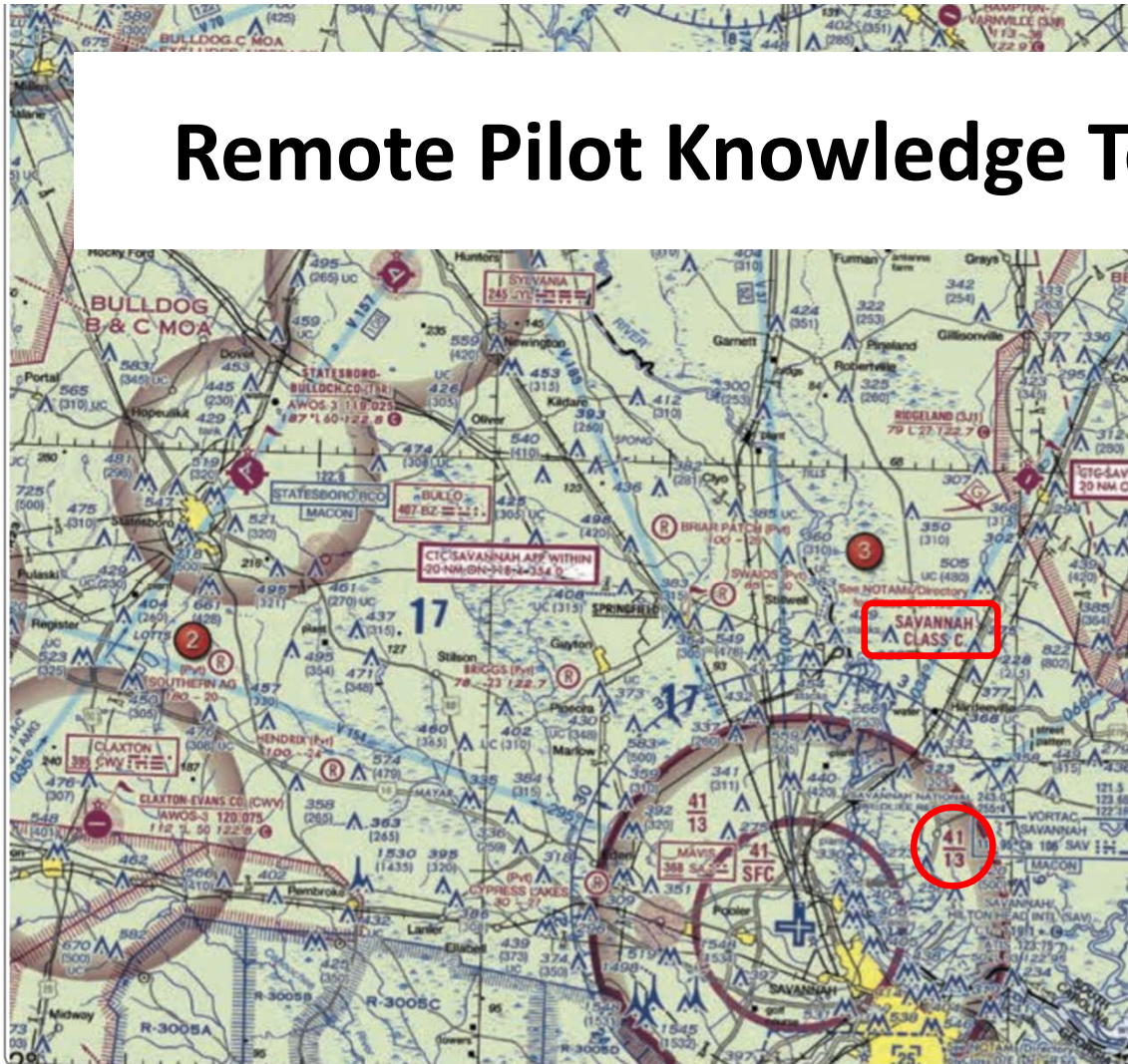
What is the floor of the Savannah Class C airspace at the shelf area (outer circle)?

1. 1,300 feet AGL
2. 1,300 feet MSL
3. 1,700 feet MSL

FIGURE 23.—Sectional Chart Excerpt.

NOTE: Chart is not to scale and should not be used for navigation. Use associated scale.

Remote Pilot Knowledge Test – What to Expect



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FIGURE 23.—Sectional Chart Excerpt.

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KNOW **FLY** BEFORE YOU

knowbeforeyoufly.org

DID YOU KNOW?



Unmanned aircraft must follow temporary flight restrictions around stadiums and racetracks.

[Click here to learn more.](#)

DID YOU KNOW?

Universities need permission from the FAA in order to use unmanned aircraft for research.

[Click here to learn more.](#)



DID YOU KNOW?

The FAA Modernization Reform Act of 2012 required the FAA to create rules for the use of unmanned aircraft in the U.S.



[Click here to learn more.](#)

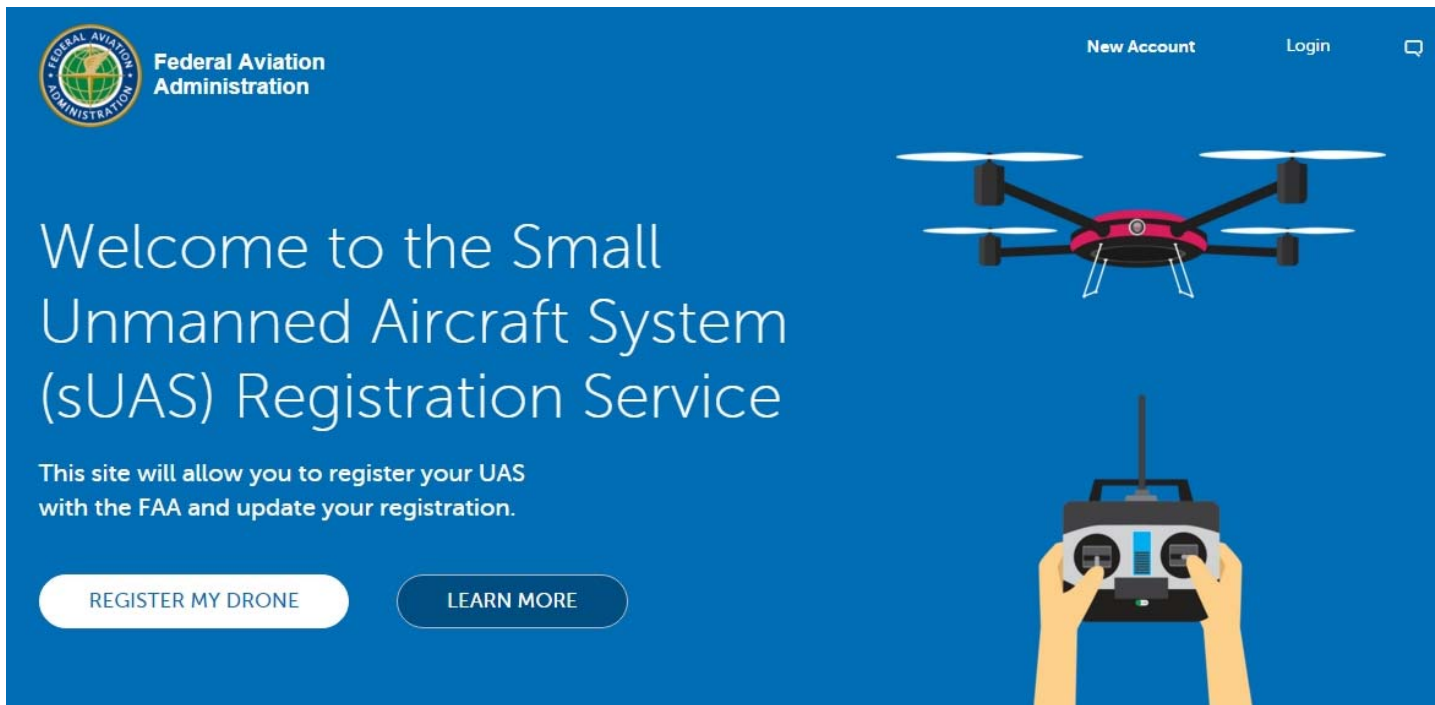
DID YOU KNOW?

Operators must keep unmanned aircraft in their sight.



[Click here to learn more.](#)

As of December 21, 2015, FAA requires drone registration
<https://registermyuas.faa.gov/>

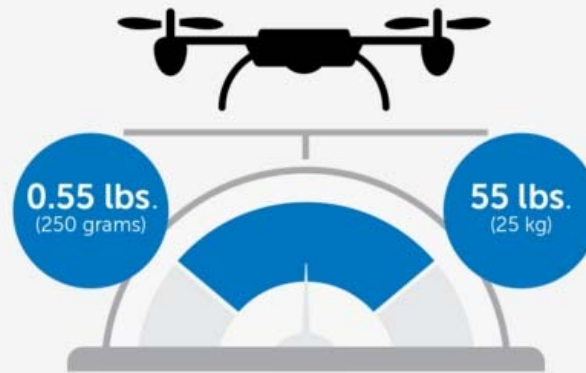


The image shows a screenshot of the FAA's Small Unmanned Aircraft System (sUAS) Registration Service website. The page has a blue background. In the top left corner is the Federal Aviation Administration logo, which includes a globe and the text "FEDERAL AVIATION ADMINISTRATION" and "Federal Aviation Administration". In the top right corner, there are links for "New Account" and "Login", along with a small speech bubble icon. The main heading reads "Welcome to the Small Unmanned Aircraft System (sUAS) Registration Service". Below this, a sub-heading states: "This site will allow you to register your UAS with the FAA and update your registration." At the bottom of the main content area, there are two buttons: "REGISTER MY DRONE" and "LEARN MORE". On the right side of the page, there is an illustration of a red and black quadcopter drone flying above a pair of hands holding a remote control.

Federal law requires owners to pay \$5 to register their aircraft.

Do you need to register your drone?

You need to register your aircraft if it weighs between
0.55 lbs. (250 grams) and up to 55 lbs. (25 kg)



You will be subject to civil and criminal penalties if you meet the criteria to register a drone and do not register.

If you purchase your UAS after Dec. 21, 2015,
you must register before you operate it outdoors

Exception: Special Rule for Model Aircraft ([P.L. 112-95, Section 336](#))

Certificate of Registration – Business Use

Small UAS Certificate of Registration

Name: University of Missouri Extension

Manufacturer: DJI

Model: Phantom 3 Professional

Serial Number: P77DCL18B26813

Certificate Number: FA34KPCRY9

Issued: 10/13/2016 Expires: 10/13/2019



For U.S. citizens, permanent residents, and foreign citizens, this document constitutes a Certificate of Registration. This document represents a recognition of the FAA's authority.

For all holders, for all operations under Part 107 of Pub. L. 112-95, additional safety requirements from DOT may be required.

This Small UAS Certificate of Registration is valid for flight operations with an unmanned aircraft system in accordance with the applicable FAA regulations. The holder is responsible for knowing and understanding the rules. For more information on flying for non-recreational purposes, visit www.faa.gov/uas



Final Thoughts

- There is information in your pastures and fields that remote sensing can help you extract and use
- Other forms of remote sensing (airplane, satellite) are expensive and frustrating
- UAS puts the control in your hands either directly or through your adviser
- Are you prepared to make use of all the additional data?



– Serving Missouri



A 10:1 return on investment of taxpayer funds



Questions??

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Web: extension.missouri.edu/webster



Program Complaint Information

To file a program complaint you may contact any of the following:

University of Missouri

- MU Extension AA/EEO Office
109 F. Whitten Hall, Columbia, MO 65211
- MU Human Resources Office
130 Heinkel Bldg, Columbia, MO 65211

USDA

- Office of Civil Rights, Director
Room 326-W, Whitten Building
14th and Independence Ave., SW
Washington, DC 20250-9410

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