Eye in the Sky:
Today’s Technology in Agriculture

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What are the Available Sensor Platforms?

What do I need to know about Imagery?
Sensor Platforms
Approach to UAS

“Look-and-See”

Integrated Mapping
Point-and-Shoot Camera

“Look-and-See”
Point-and-Shoot Camera

“Warp-and-See”

- Lens distortion issues
- Oblique viewing issues
- Features can easily be 50-100 feet off
- Should not be used for reliable mapping
What can we Mount on a UAS?

- **Color**: Easy to do.
- **Near-Infrared (CIR)**: Conversion kits available.
- **Multispectral**: Limited camera options, generally low resolution.
- **Hyperspectral**: Some options available. Best suited for research applications.
- **Thermal**: Several options. Low resolution.
Utilize UAS for Field Mapping?

Paid-for-Service
Legally... NOT YET

FAA regulations pending
Due sometime in 2015

Can fly Radio Control (RC) aircraft under “hobbyist” rules
Are UAS Practical for Precision Ag Mapping?

FAA Regulations

Current RC Hobbyist Rules

Maintain Line-of-Sight

* Refer to FAA rules for complete details

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Utilize UAS for Field Mapping?

High-End UAS Systems Exist

Very Expensive

Are UAS always Practical?

Flight Plan

- 400-Feet AGL
- 6.6-cm resolution
- 19 Flight Lines
- 9.5 miles of Flying
- 620 Images

160-acre field

- Flying at 30 mph, ~19 min + turns
- Swap battery packs (2-3 times)
- Flight time to/from landing site
- Setup and teardown time

ONSITE TIME ~1-hour per field

Drive time to each field??
Post-Processing Time??
Overhead Cost of Operation??
Utilize UAS for Field Mapping?

Pros
• Very high image resolution
• Use imagery for near instant visualization

Limitations
• Hundreds of images to stitch together
• What is the final mosaic quality?
Utilize UAS for Field Mapping?

Data Overlay... Measurements... Analysis... Rx Maps...

Image mosaic used to document patterns and field scouting?

Plan to make Rx Maps

Be Careful !!!

A seamless mosaic will require tweaking the imagery to look good.

The Rx Map will be based on tweaked data!
Images line up well, but . . .

Mosaic quality is poor!

Low Quality UAS Mosaic

Uneven lighting and camera effects

Brighter in the middle

Darker around the edges

Quality of Camera & Software
Affect usability of Imagery
Spatial Resolution

Each pixel represents a defined size on the ground

- 6-inch
- 1-meter
- 5-meter
Image Resolution is Important
Eye in the Sky

What are the Options?

UAS / UAV
Localized Operations . . . Good Potential to be Discovered

Manned Aircraft
Regional Flexibility . . . Good Fit

Satellite
Global Coverage . . . Some Viable Options
What is the Science behind . . .

Imagery for Precision Ag?
Precision Agriculture

Precision Agriculture is really about **Problem Solving**

- **Reduce inputs to increase savings**
- **Increase yields to increase ROI**
When Should you Acquire Imagery?

*problem solving*

Depends on Purpose...

**Natural Variability**

*Soil Fertility, landscape position*

**Man-Made Issues**

*Farming Practices*

**Seasonal-Variable Issues**

*Wind & Hail Damage, Insect Pressure, Disease*
Remote Sensing in Agriculture

- Water Stress
- Nutrient Stress
- Tissue Damage (insects, disease, wind, hail)
Vegetation Response

Healthy Vegetation

Stressed Vegetation

bare soil

Reflectance

Radiance

400 500 600 700 nm

3,000 5,000 8,000 14,000 nm

Blue Green Red Near Infrared

Chlorophyll Absorption Chlorophyll Absorption Leaf Structure Biomass Indicator

Thermal

Plant Temperature

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What is Infrared Aerial Photography?

**Color Image**

400 500 600 700 nm 1100

Blue Green Red Near Infrared

**Color Infrared Image**

**Infrared Imagery is RED in color**
What is Thermal-Infrared Imaging?

Detection of thermal infrared energy (heat)

It is a way to look at the heat signature of an object.
What Kind of Imagery Should I Use?

Understand your needs

Be ready to use it
What Kind of Imagery to Use?

- Color Imagery
  - Plant Color
    - Nutrients
  - Biomass / Nutrients / Water Stress
    - Cell Structure
  - Plant Temperature (stresses)

- CIR Imagery
- Thermal Imagery
Corn Water Use

Days After Planting

Days

Emergence
Knee High
Tasseling
Silking
Early Dent
Black Layer

Daily Water Use (inches)

0
0.1
0.2
0.3

V-Stage
VT
R-Stage
Corn Nitrogen Use

- High
- Critical Growth
- N Uptake
- Low
- Crop is too small to detect problems from the air

Temperature and Water Stress

- V-Stage
- VT
- R-Stage

Planting
Silking
Harvest
When to Acquire Imagery

- **Bare Soil**: Thermal, MSI
- **Weeds**: MSI
- **Nitrogen Stress**: MSI, MSI
- **Water Stress**: MSI
- **Summary of Stresses**: MSI

Events:
- **May**: Planting
- **June**: Irrigation Starts
- **July 4th**: VT
- **Aug**: Harvest
- **Sept**: Harvest
- **Oct**: Harvest
Boost the Value of Imagery

Proper Timing of Acquisition

Select the Right Image Type

Enhance Imagery with Ratios
NDVI – Normalized Difference Vegetation Index

\[ \text{NDVI} = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}} \]

Data Range

-1  -0.5  0  0.5  1

Indicates Non-Vegetative Features

Vegetation Vigor
NDVI

Enhance crop vigor differences within a crop
4-Band Imagery

Color
Red, Green, Blue

Near-Infrared (CIR)
NIR, Red, Green

NDVI

Thermal-Infrared

Early Detection of Water Stress
Yield Loss Prevented

Pivot nozzle issue fixed before permanent yield loss occurred

Image taken mid-July

1.5-acres

7.6-acres

Acres: \(1.5 + 7.6 = 9.1\)
Yield Loss per Acre: 25 bu/ac
Total Yield Loss: 227 bushels

Potential Economic Loss @ $6 corn: $1,362
Yield Loss

**Water Stress**

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<table>
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Yield Correlation

Water Stress

Thermal image acquired 3 weeks after irrigation season started

R² = 0.91
Summary

Remote Sensing

The Power to Visualize Patterns

To Increase Profits

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