A Down to Earth
Look at UAVs in Agriculture

Brian Arnall
Precision Nutrient Management
Oklahoma State University
Technology Trigger | Peak of Inflated Expectations | Trough of Disillusionment | Slope of Enlightenment | Plateau of Productivity

- **R&D**
- **On the Rise**
  - Supplier proliferation
  - Mass media hype begins
  - Early adopters investigate
  - First-generation products, high price, lots of customization needed
  - Startup companies first round of venture capital funding

- **At the Peak**
  - Activity beyond early adopters
  - Second/third rounds of venture capital funding
  - Less than 5 percent of the potential audience has adopted fully

- **Sliding into the Trough**
  - Negative press begins
  - Supplier consolidation and failures

- **Climbing the Slope**
  - Methodologies and best practices developing

- **Entering the Plateau**
  - High-growth adoption phase starts: 20% to 30% of the potential audience has adopted the innovation
  - Third-generation products, out of the box, product suites
UAS/UAV/The D Word in Ag
DJI soon to have NO FLY ZONE Capability
Hints on Platform

• They will crash. Period.
• Easier to get a replace pieces the better.
Styles

• Copters, Hover and stable
  • More motors ???
• Planes / Fixed Wing, Covers ground
Communication

#CowArt
Consulting

https://www.youtube.com/watch?v=Rh7KKO12Mj8
Moving Beyond the GoPro

- We can collect data, and potentially a lot of it.
- To Get Quality

### AREA COVERAGE TABLE

<table>
<thead>
<tr>
<th>Height</th>
<th>GSD</th>
<th>Coverage/flight [km²] (1)</th>
<th>Coverage/day [km²] (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>70%</td>
<td>80%</td>
</tr>
<tr>
<td>75 m</td>
<td>2.4 cm</td>
<td>1.1 km²</td>
<td>0.8 km²</td>
</tr>
<tr>
<td>(246 ft)</td>
<td>(0.94 in)</td>
<td>(0.31 m²)</td>
<td>(0.15 m²)</td>
</tr>
<tr>
<td>100 m</td>
<td>3.2 cm</td>
<td>1.8 km²</td>
<td>1.2 km²</td>
</tr>
<tr>
<td>(328 ft)</td>
<td>(1.26 in)</td>
<td>(0.7 m²)</td>
<td>(0.64 m²)</td>
</tr>
<tr>
<td>150 m</td>
<td>4.8 cm</td>
<td>3.1 km²</td>
<td>2.1 km²</td>
</tr>
<tr>
<td>(492 ft)</td>
<td>(1.89 in)</td>
<td>(1.2 m²)</td>
<td>(0.81 m²)</td>
</tr>
<tr>
<td>200 m</td>
<td>6.4 cm</td>
<td>4.4 km²</td>
<td>3.0 km²</td>
</tr>
<tr>
<td>(656 ft)</td>
<td>(2.52 in)</td>
<td>(1.7 m²)</td>
<td>(1.16 m²)</td>
</tr>
<tr>
<td>250 m</td>
<td>8 cm</td>
<td>5.8 km²</td>
<td>3.8 km²</td>
</tr>
<tr>
<td>(820 ft)</td>
<td>(3.15 in)</td>
<td>(2.24 m²)</td>
<td>(1.47 m²)</td>
</tr>
<tr>
<td>300 m</td>
<td>9.6 cm</td>
<td>7.1 km²</td>
<td>4.7 km²</td>
</tr>
<tr>
<td>(984 ft)</td>
<td>(3.81 in)</td>
<td>(2.86 m²)</td>
<td>(1.92 m²)</td>
</tr>
</tbody>
</table>

- Notes:
  1. For a 2:1 aspect ratio, which is a flight block with length equal to 2 times the width. This is a good approximation of the average flight block.
  2. Assuming on average 5 minutes pre-flight and 5 minutes post-flight setup and recovery time and operation between 10 am and 4 pm.
Imagery Stitching

• OrthoRectification
  • [http://www.satimagingcorp.com/services/orthorectification/](http://www.satimagingcorp.com/services/orthorectification/)
  • open sources available
Challenges

- Small footprint
- Image distortion
- Locating ground control points
- Relatively large errors in exterior orientation parameters (X, Y, Z, roll, pitch, heading)

- Wind comes sweeping down the plains........ 20 mph or less.
A lot of Salesmen

- Obtain flight data when you need it
- Create NDVI based zones for accurate chemical applications
- Pre-scout your fields and find stresses before you get there
- Ground truth flight data with incredible efficiency
Wavelengths & Indices

- NDVI and Simple Ratio
  - **Biomass**: Red and NIR (650, 780)
  - Green or Amber instead of Red (550, 590)
  - Growth Stage for Amber v Red
  - Red Edge 680
- Chlorophyll
  - SPAD (650 – 940)
- Protein
  - 710, 810
    (Kelly et al 04)
Reflectance Data

• Historically satellite and aerial imagery widely used.

• Ok State in the mid 90’s started investigating VRT N work.
  • Evaluated Aerial and Satellite.
Precision Ag Research at OSU
NDVI of OSU Experiment Station
1m Resolution
False Color (green, red, NIR) Image
< 1 m Resolution - Raw Radiometric Data
(Courtesy F. Schiebe, SST Software)
Passive vs Active

• Active Sensor emits light, typically via LED.
• Passive Sensor records reflectance of natural light.
  • Sun Angle, impacted by time of day and time of year.
  • Clouds
  • Atmospheric interference.
Use of relative values

*From Auto Copter

- Map segmented into NDVI values
  - Fertilizer into 150lb, 130lb, 110lb, 90lb, and 70lb
    - 150lb for the lowest NDVI value
    - 130lb for the middle-lowest NDVI value
    - 110lb for the middle NDVI value
    - 90lb for the middle-highest NDVI value
    - 70lb for the highest NDVI value
Aerial Imagery values w/o Cal

- Yield Monitor

Rendel 2010 Harvest
To Calibrate

- With Spectrometer, use white plate.
- NUE Wheat project with 330+ plots.
  - 10 to 2
  - White plate
  - Incoming and reflectance
  - Reverse order
Beyond reflectance

- Stand Count
  - Quite easy
- Canopy Temp
- Soil Moisture
- Soil OM
- DOCUMENTATION

http://agloop.com/how-to-produce-more-with-less-the-emergence-of-uav-technology/
Resolution
Satellites

**June 10-2014** Google Tuesday agreed to buy satellite startup Skybox Imaging Inc. for $500 million in cash, the latest in a number of moves by the world's largest Internet search provider to collect and provide data from the sky. **Skybox has designed small, relatively cheap satellites that can collect daily photos and video of the Earth.** Skybox satellites weigh roughly 260 pounds, making them much cheaper to build and launch than traditional satellites that can weigh tons. Skybox planned to launch 24 such satellites that could shoot pictures of the Earth more often.

**Feb 3 2015** Wilbur-Ellis Co. has reached an agreement with Planet Labs to bring satellite imagery to the AgVerdict software platform, Wilbur-Ellis’ technology in agricultural data usage. This enhancement will significantly improve the delivery of satellite imagery to a grower, making the data available in a matter of minutes rather than days. This new feature will benefit **Wilbur-Ellis** customers by providing imagery using “**ultra-compact**” satellites that will soon scan the planet every twenty-four hours.
Today

• Consultants can be more efficient and make more money.
  • With low end UAV’s
• Platforms available for high end imagery.
• Companies scrambling to find
  • Increase easy of data processing
  • Create decision aid tools.
Nothing

• I mean NOTHING takes the place of Scouting and good Agronomy.
• NOTHING..
• Get dirty walk the field, take samples.
• But there is always a degree of WRONG We are dealing with a living system. More so we are dealing with a Weather Dependent system.

• Have a Plan, Have a goal
Thank you!!!

Brian Arnall
373 Ag Hall
405-744-1722
b.arnall@okstate.edu
Presentation available @
www.npk.okstate.edu
Twitter: @OSU_NPK
www.Facebook/OSUNPK
YouTube Channel: OSUNPK
Blog: OSUNPK.com
www.Aglandlease.info