In-field and Remote Sensing for Precision Agriculture

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UAS in Precision Agriculture

- In-field Sensors
- Selecting UAS Equipment
- NDSU UAS Activities
- Current UAS Applications
- Future UAS Applications and Needs
Precision Agriculture & Data Management
## Selecting sUAS Equipment for Agricultural Applications

<table>
<thead>
<tr>
<th></th>
<th>Multi-Rotor</th>
<th>Fixed-wing</th>
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</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td></td>
<td></td>
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<tr>
<td>Any Camera</td>
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<tr>
<td>Ease of use</td>
<td></td>
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<tr>
<td>Ability to hover</td>
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<tr>
<td>Vertical takeoff and landing</td>
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<tr>
<td>Less expensive</td>
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<tr>
<td><strong>Disadvantages</strong></td>
<td></td>
<td></td>
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<tr>
<td>Short flight time</td>
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<tr>
<td>Small area</td>
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<tr>
<td>Slower Speed</td>
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<tr>
<td>More complex</td>
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<tr>
<td>Smaller Payload</td>
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<tr>
<td><strong>Advantages</strong></td>
<td></td>
<td></td>
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<tr>
<td>Cover larger area</td>
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<tr>
<td>Longer flight time</td>
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<tr>
<td>Simpler structure</td>
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<tr>
<td>More stable flight</td>
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<tr>
<td>Greater payload</td>
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</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Takeoff space</td>
<td></td>
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<tr>
<td>Assistance for takeoff</td>
<td></td>
<td></td>
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<tr>
<td>Larger in size</td>
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<td></td>
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<tr>
<td>More expensive</td>
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</tbody>
</table>

[https://www.ag.ndsu.edu/agmachinery](https://www.ag.ndsu.edu/agmachinery)
UAS Platforms

Small UAS Rules

https://www.ag.ndsu.edu/agmachinery
Small UAS Rules

- Less than 55 lbs.
- Remote Pilot Airman Certificate
- Line of Sight
- Daylight Hours
- 400’ or Below

https://www.ag.ndsu.edu/agmachinery
Remote Sensing for Agricultural Applications

- Color – RGB
- Multi-spectral
- Hyper-spectral

Vegetative Index
NDVI

https://www.ag.ndsu.edu/agmachinery
UAS Sensors

Cameras
- GoPro Camer
- ICI 9640 S Thermal camera
- Large area scanning EO/IR/NIR camera
- Sony NEX-5R camera with NIR
- Tetracam ADC
- Sentera dual sensor (4 band)
- Sentera Quad sensor (6 band)
- MicaSense Rededge
- Ximera Hyperspectral sensor
- Rikola Hyperspectral sensor
NDSU UAS Activities
Small and Large UAV

Phantom 3

Trimble UX5
Large-scale UAS Project

Imagery in May, June, July and August

- Color, Infrared Sensor
- 4,000, 6,000 and 8,000 ft

Small UAS, Satellite, Ground and Yield Data

All Imagery Securely Stored on NDSU Computers

Objectives

Uses for Crop Management
Economic Value to Producers
Hermes 450 UAS
Hermes 450 UAS – Control Center
Hermes 450 UAS – Control Center
Flight Coordination and Preparation
First Large UAS Civilian Flight in North Dakota
Landing the Hermes 450
View from CAP Chase Plane
## Data Management

Large UAS – Entire Corridor Each Date

<table>
<thead>
<tr>
<th>Date</th>
<th>May 23-27</th>
<th>June 20-24</th>
<th>July 18-22</th>
<th>August 15-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude</td>
<td>4,000’</td>
<td>6,000’</td>
<td>6,000’</td>
<td>4,000’</td>
</tr>
<tr>
<td></td>
<td>6,000’</td>
<td>8,000’</td>
<td>8,000’</td>
<td>8,000’</td>
</tr>
<tr>
<td>Image Quantity</td>
<td>2.0 TB</td>
<td>1.5 TB</td>
<td>1.5 TB</td>
<td>2.0 TB</td>
</tr>
<tr>
<td>Total Size</td>
<td>0.5 TB</td>
<td>0.5 TB</td>
<td>0.5 TB</td>
<td>0.5 TB</td>
</tr>
<tr>
<td></td>
<td>4.0 TB</td>
<td>2.0 TB</td>
<td>2.0 TB</td>
<td>2.5 TB</td>
</tr>
</tbody>
</table>

Total Quantity of Imagery Collected during the Project: **10.5 TB**
Plus Small UAS Imagery
Plus Image Analyses
NDSU Extension Role

- Facilitate
- Collaborate
- Educate
May Imagery: 4,000’ – 6,000’ – 8,000’

4,000’

6,000’

8,000’

Detailed Imagery - 50,000 Acres/Hour
Analyses from Imagery: Cattle from 8,000’
Cattle in May Imagery: 4,000'}
Corn Imagery: May – June – July - August
Analyses from Imagery: Zone Map

Elbit UAS
Cleaveland
New folder
6cm_Lovas31_RGBVI

- 18.1206 8.4 Acres
- 22.9889 16.1 Acres
- 26.1078 36.8 Acres
- 28.0278 77.4 Acres
- 29.6001 115.0 Acres

Average: 27.8 Area: 253.19 Acres
Std Dev: 2.64855 Total: 7047

NDSU NORTH DAKOTA STATE UNIVERSITY
NDSU EXTENSION SERVICE
~ 40 Acres
Imagery 4,000’
RGB Image
4 cm Pixel Size
~ 200’x200’ Imagery 4,000’
RGB Image
4 cm Pixel Size
Imagery Issues: Time Between Images
Imagery Issues: Time Between Images

Color Image
Imagery Issues: Time Between Images

NDVI Image

- NDVI Mean = 0.6514
- NDVI Mean = 0.4975
Sensors

Ag Leader
OptRx
Available Crop Sensors

- OptRx – Ag Leader
- CropSpec – Topcon
- GreenSeeker – Trimble
- Crop Circle – Holland Scientific
FIELDSCOUT®

GreenIndex+ App

iPad – iPhone app

Android coming soon!

$100

$50

NDSU NORTHERN DAKOTA STATE UNIVERSITY

NDSU EXTENSION SERVICE
Collecting NDVI with Ground Sensors

Collecting In-field OptRx Sensor Data
NDSU Soybean Plots
Variety 1: 1b N and Aug NDVI
NDSU Steele County Plots

\[ y = 0.0001x + 0.5411 \]

\[ R^2 = 0.9643 \]
August NDVI and Yield for 0, 25, 50 lb N
NDSU Steele County Plots

$$y = 268.03x - 83.261$$
$$R^2 = 0.74$$

0 lb N /acre

25 lb N /acre

50 lb N /acre
Hail Damage: Corn from 4,000’

17 Acres out of 67 acres
Digital Elevation Model Using Large UAV
Corn Field – May 23, 2016
Flight Altitude: 50ft
NDVI Mosaic
Corn plants detection and counting – ground truth

- Equation: $y = 1.0308x + 0.4078$
- $R^2 = 0.9991$
Web Application for Stand Count Analyses from UAS Imagery

Statistics for the selected area:

- The area of the selected rectangle (Acre): 0.188
- Total number of stands for selected area: 4811
- Average number of stands per acre (based on selected area): 25625
- Minimum distance of stands in the selected area: 6.1 cm, 2.4 inch
- Maximum distance of stands in the selected area: 67.4 cm, 26.5 inch
- Average distance of stands in the selected area: 20.5 cm, 8.1 inch
- Standard deviation of the distances in the selected area: 8.9 cm, 3.5 inch
Identifying Herbicide-resistant Weeds
Sugarbeet Disease Detection with UAS

Rhizoctonia solani infestation

Cercospora infestation

Cercospora Nursery - Foxhome, MN

NDSU North Dakota State University
What Has Gone Well

- Collaboration: NDSU – NP UAS Test Site – Elbit - CAP
- FAA and FCC
- NDSU County Extension Service
- Hillsboro Airport Authority
- Image Quality

Objectives:
- Imagery from 4,000’ – 6,000’ – 8,000’
- Transfer and Storage of Imagery at NDSU
- Analyses
  - Nitrogen Management
  - Stand Count
  - Disease Identification
  - Hail Damage
  - Elevation Model
Future of UAS in Agriculture

Small UAS
- Plant Stand Count
- Monitoring and Scouting
- In-season Fertility

Large and Small UAS
- Digital Elevation Model
- In-season Fertility
- Yield Predictions
- Insect and Disease Movements
- Identification of Management Issues

One More Layer for Big Data Precision Agriculture

Yamaha RMAX
8 liters x 2 tanks

AeroDrone
Book for Technology Early Adopters

“Innovation and It’s Enemies. Why People Resist New Technologies”

Calestous Juma

- Moral Values
- Human Health
- Environmental Safety
- Socioeconomic

Coffee
Printing Press
Margarine
Farm Mechanization
Electricity
Refrigeration
Recorded Music
Transgenic Cops
Transgenic Animals
Questions - Comments

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