The Evolution of UAS:
Applications in Research and the Private Sector

MSU, RS&GIS
http://www.rsgis.msu.edu

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Statewide GIS Users Group Meeting
2/4/2016
RS&GIS @ Michigan State University

• Geospatial Research and Outreach services group at MSU
  ▪ Department of Geography, College of Social Sciences

• Established in 1972 as the Remote Sensing Project

• Serving
  ▪ Research community,
  ▪ Local/State/Federal government
  ▪ Municipalities, Not-for-Profits and the private sector
RS&GIS @ Michigan State University

- Geographic Information Systems (GIS)
- Remote Sensing
- GPS/GNSS
- Application Development
- Cartography and Graphic Design
- Geospatial Training
Unmanned Aerial Systems (UAS)

- UAS are aerial systems that navigate autonomously using GPS or other techniques
- Extra-small → Small → Large → Extra Large
- Size is determined by application
- Smaller UAS are easier to deploy...duh.
Drones Now....

• Flood of new manufacturers over the past 5 years
  ▪ Nearly 100 in the U.S. Alone
  ▪ Hobby, Commercial, Military/Homeland Security

• DIY vs. Ready-to-Fly
  ▪ Build my own or pay someone else?

• Turnkey solution vs. User-assembled solution (hardware, software)
  ▪ $$$$$$ vs. $$

• Safety and reliability concerns
Drones Tomorrow....(my view)

• Modular
  ▪ Plug and Play just like desktop PCs
  ▪ Little to no experience will be needed to assemble

• Open Source Applications will rule

• Much more affordable
  ▪ More competition = lower prices

• Just another tool in the toolbox
  ▪ Why not have a drone?

• Improved safety
  ▪ See and Avoid Technology
  ▪ Protective measures
  ▪ New regulations
What About Regulations? Current UAS FAA Requirements

• No Commercial Use*
• Must apply for a Certificate of Authorization (3-6 month process) – Public Universities and Law Enforcement agencies only (with some exceptions)
• Must register your UAS with the FAA
• Pilots must pass private pilot knowledge exam
• Flights to occur at or below 400 feet above ground level only
• No flights over buildings or high-trafficked roads
• No flights over urban areas or gatherings of people
• Daylight operations only
• Visual contact of UAS at all times
• Two observers required in addition to Pilot-In-Command

• Radio/Cellular contact at all times between PIC and Observers
• Required to have the following in place
  ▪ Emergency procedures
  ▪ Lost radio link procedures
  ▪ Communications procedures
  ▪ Launch and Recovery procedures
  ▪ Observation procedures
  ▪ Procedures for special circumstances

*Commercial use allowed under Section 333 waiver
• Requires operator to have pilot license
• Altitude limited to 200’ above ground
Expected UAS FAA Requirements - 2016

• **Commercial Use Allowed**
• Must apply for a Certificate of Authorization (3-6 month process)—Public Universities and Law Enforcement agencies only (with some exceptions)
• Must register your UAS with the FAA
• Pilots must pass UAS Operator knowledge exam
• Flights to occur at or below 500 feet above ground level only
• No flights over buildings or high-trafficked roads
• No flights over urban areas or gatherings of people
• Daylight operations only
• Visual contact of UAS at all times
• Two observers required in addition to Pilot-In-Command

• Radio/Cellular contact at all times between PIC and Observers
• **Must receive permission from any airport or heliport within 5 nautical miles of flight area**
• **Certain airspace restrictions**
• Required to have the following in place
  * Emergency procedures
  * Lost radio link procedures
  * Communications procedures
  * Launch and Recovery procedures
  * Observation procedures
  * Procedures for special circumstances
Research involving UAS

• What awesome sensor can I strap to this thing?
• How long can I get this thing to fly?
• How can I program this thing to do what I want?
• What information can I extract from data collected by this thing?
• How accurately can I navigate with this thing?
• Can I get these things to talk to one another?
RS&GIS UAS Platforms

• Aeromapper
  ▪ 50 minutes of flight time
  ▪ Parachute recovery
  ▪ Large-area acquisition
  ▪ 100 acres+ per battery

• 3D Robotics X8 and X8+
  ▪ 10 - 15 minutes of flight time
  ▪ Agile and flexible payload
  ▪ Close proximity, smaller-area collection
  ▪ 20 acres per battery

• DJI Phantom 2
  ▪ 10 - 15 minutes of flight time
  ▪ Agile and flexible payload
  ▪ Close proximity, smaller-area collection
  ▪ 20 acres per battery
RS&GIS UAS Platforms – COMING in 2016!

• Custom Quad-Copters (2)
  ▪ Large props and low rpm motors
  ▪ 25+ minutes of flight time
  ▪ 2 kg + payload
  ▪ First-Person View (FPV)
  ▪ Realtime-Kinematic GNSS
RS&GIS UAS Activities and Personnel

- RS&GIS provides UAS services in the context of platform research
  - FAA-certified pilots-in-command (PIC) and Observers
  - FAA certificate of authorization (COA) application process
  - Sensor integration and project flight planning
  - Ground reference data collection (GPS)
  - Imagery acquisition
  - Image processing
Where can RS&GIS fly?

- RS&GIS has 5 current Certificates of Authorization covering...
  - MSU South Campus
  - MSU Experiment Stations
  - Several private properties
- RS&GIS has applied for additional COAs throughout the State of Michigan
Typical UAS Project Workflow

1. Identify UAS Solution (Platform & Sensor)
2. Set Ground Control Points (mapping reference)
3. Plan Collection Route (Overlap, shutter speed, flying height, etc.)
4. Collect Data (Adherence to FAA regulations)
5. Process Data (Spatial Accuracy, software, etc.)
6. Extract Secondary Data (Terrain, Health)
RS&GIS Project Examples

UAS Team @ RS&GIS:
Robert Goodwin, UAS Manager and PIC
Dave Lusch - Ph.D., Remote Sensing Specialist
Joe Welsh, Geospatial Analyst and PIC
Nick Weil, Geospatial Analyst
Turf Imaging

- Canon S100
  - Natural Color Image Mosaics
  - 3D Terrain Models

- Tetracam ADC Lite
  - False-Color Image Mosaics
  - Normalized Difference Vegetation Index (NDVI) analysis

- FLIR Tau-2 324p
  - Thermal Image Mosaics
  - Site-specific thermal images
  - Identification of Hot Spots
  - Analysis of temperature differences
Don’t Forget the Video!
Data Processing – Point Cloud

- Densification of Point Cloud (Pix4D)
Data Processing – Generating Outputs

- Referenced images, mosaics, 3D surface (Pix4D)
Turf Research – UAS + Thermal IR

- Studying the relationship between moisture content and turf temperature

- FLIR Tau-2 324p
  - Mid-market Thermal camera
  - Video and Still Frames
  - Hot spot detection
  - High sensitivity to temperature changes
Turf Research – UAS + Thermal IR

Elevation differences of a few inches show differences in temperature.
3D Modeling of Drains

- Drain Inspection and 3D Mapping
Real-Time Drain Assessment

• Extremely detailed, precise point cloud – PhoDAR not LiDAR!
UAS Investigations of Soybeans

Use various sensors to collect data for the purpose of examining health and developing classification algorithms.
Corn Hybrid UAS Research

- Corn Hybrid Imaging
  - Plant counts
  - Health and Damage Assessment
  - 3D Surface generation to map topography and estimate biomass
Crop Damage Assessment

- Identification and quantification of damaged areas due to ponding, disease, etc.
Plant Counts

- Image field when plants are visible and have not merged with one another
- **Key:** Use high-resolution camera at low altitude
- Weeds complicate the process
- Use image processing techniques to extract plants
  - ISO Classification
  - Class Combination
  - Raster → Vector
  - Subset on Rows
  - Count
3D Modeling of Sand Dunes

• Generating Mosaics and Point Cloud Data for Dune Systems from Overlapping Photographs (PhoDAR)
UAS Investigations for AgBioResearch

- Biomass – Switchgrass
- Soybean disease patterns
- Chestnut estimation
- Forest Species Identification
What’s Next for RS&GIS?

• Improve expertise in the area of PhoDAR (3D models)
• Expand platform capabilities to address needs requiring larger payloads and longer flight times
• Improve sensor packages, particularly multi-spectral
• Provide instruction to entities on and off campus
• Adapt to new Regulations from the FAA
• Fine-tune processing workflows and expand classification routines
• Pursue research opportunities on campus
• Move beyond research to business applications (as regulations allow)
Questions?

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