Unmanned Aerial Systems: A Look Into UAS at ODOT

Tim Burkholder, PS
Mapping Manager
Division of Engineering
Office of CADD and Mapping Services

Kyle Ince, EI
Transportation Engineer
Division of Engineering
Office of CADD and Mapping Services

July 2016

ODOT’s Current Position

_flight Operation Testing_

- Accuracy Assessment
- ODOT Business Policy
- Processing Workflow
- Deliverables
  - Several active COAs
  - LAW-52 and Deer Creek State Park
  - Section 333 Exemption
  - Flying under Part 107
ODOT’s Current Platform: SenseFly eBee RTK

- Weight = 1.61 lb including camera
- Wingspan = 38 in.
- Material = EPP foam, carbon structure & composite parts
- Propulsion = Electric pusher propeller, 160 W brushless DC motor
- Battery = 11.1 V, 2150 mAh

---

SenseFly eBee RTK

**Hardware**

- Connects directly into the CORS RTK network for survey grade accuracy and real time corrections. (L1/L2, GPS and GLONASS)
  - 3 cm horizontal and 5 cm vertical accuracy without ground control pts.*
- Canon WX (18.2 MP) auto-triggering camera
- 40 min. max flight time
  - During the duration of this presentation the eBee RTK can map a 4.5 square mile area (lowest resolution at the highest altitude)
  - More typical flight 50 acres (2.5 cm per pixel) in less than 10 minutes*
  - *Perpendicular flight lines
SenseFly eBee RTK

**Software**
- eMotion
  - Flight Planning and Control Software
- Postflight Terra 3D → Pix4D
  - Professional Photogrammetry Software

---

A Look Into UAS at ODOT

**eMotion**

*Flight Planning and Control Software*

- **Planning**
  - Allows user to use 3D mission planning to plan the perfect flight.
- **Simulation**
  - Puts the perfect flight plan to the test in 3D with the UAS safely on the ground.
- **Monitoring and Control**
  - Using the same interface the operator can control and monitor the UAS in flight
Postflight Terra 3D

- **Check in the Field**
  - Provides a quick quality report in the field to insure proper coverage and accuracy

- **Generate Orthos, 3D models & Point Clouds**
  - Creates deliverables directly into the remote sensing workflow. (.las and georeferenced tiff images)

Remote Sensing Deliverables

- Orthomosaic Raster
- 3D Point Cloud in .las format
- DSM in a geoTIFF
- 3D Textured Mesh
- Contours
- Imagery in .tif format
ODOT Best Practices and Workflow

Planning → Simulation → Site Preparation → Flight Operations → Processing and Deliverables

A Look Into UAS at ODOT

Planning

- Site Reconnaissance
  - Obstacles
    - Trees
    - Utilities
    - Airports
  - Safe Zones
  - Primary and Alternate Landing Sites
  - Access Control
Simulation

Site Preparation

- Ground Truth
- Day of Flight Conditions
  - Obstacles
  - Weather
  - Site Access
- Internet Connection
- Line of Sight
Flight Operations

- **Pre-flight checks**
  - **Airframe Condition**
    - Wings, Propeller, Pitot Tube, Ground Proximity Sensor, Batteries, Camera, etc.
  - **Crew Briefing on Operations**
  - **Flight Plan Upload**
    - Check parameters, set landing point, etc.
  - **Document Operations and variables**

Flight

A Look Into UAS at ODOT
Post Flight

- PAPERWORK!!!!!
- Flight, Resolution
- Altitude, Battery Voltage
- Flight Time, Wind

Data check
- Overlap
- Sidelap
- Photo Quality

Data Downloading and Processing

Download
- Flight Data Logs
- Command module (computer)
- UAS on-board log
- Images

Meta Data Infusing
- Geo-tagging Images
- Writing header information
Structure from Motion

Structure from Motion is a photogrammetric technique used to estimate 3D structures with 2D photos.

Similar to how stereo vision works

3D LiDAR and Imagery

- Camera Captures Overlapping Images while in Motion
- Software Identifies and Matches Thousands of Keypoints
- Photogrammetry Extracts Geometry to Calculate Pixel Positioning
Final Processing

- **Software Packages**
  - PostFlight Terra 3D, Pix4D, Agisoft, and Context Capture

- **Inputs**
  - Control (Ground Truth)
  - Geotagged Images

Ground Control
Deliverable Creation

- **Point cloud**
  - Exported in multiple formats
  - Example .las

- **Orthophoto**
  - Exported in google tiles and geotiff

- **Textured Mesh**
  - Meshed surface with the orthophoto referenced

Deliverable Creation Continued
A Look Into UAS at ODOT

Orthophoto

Outlined area was tested against our manned aircraft & topographic surveying using a total station.

Deer Creek Test

A Look Into UAS at ODOT
Deer Creek Test

Flight @ 235.4 AGL 60% Lateral & 75% Longitudinal Overlap

Flight @ 353.5 AGL 60% Lateral & 75% Longitudinal Overlap

A Look Into UAS at ODOT

Deer Creek Test

Flight @ 353.5 AGL 60% Lateral & 75% Longitudinal Overlap

Combined Flights @ 353.5 and 235.4

A Look Into UAS at ODOT
Pros vs. Cons

Pros

- Affordability
  - Compared to conventional data collection
- Accessibility (except over live traffic)
- Safety
  - Removes human interaction from dangerous situations
- Field to finish capabilities

Cons

- Accuracy
  - Determining viability
- Inability to traverse live traffic
- Specialized training
- Liability Issues
- Black-Box type Software
- Enormous amounts of data
Limitations with Photography

- **Inability to triangulate key points across water**
  - Photogrammetric problem
- **Structure from Motion without the motion**
  - Objects can’t move within photos
  - Example vegetation

Camera Variables

- **When choosing a camera:**
  - Megapixels are not the most important part
  - Fixed Focal Length***
  - Stable photography
    - Fast exposure times with less image blur
    - Metric lens
A Look Into UAS at ODOT

ODOT Moving Forward

- Reviewing FAA guidelines to evaluate ODOT safety and policy needs that will need to be required above FAA regulations (i.e. may require additional observers, liability insurance, develop additional privacy policies, public notifications, etc.)
- Once all specifications and policies are in place, will develop prequalification process for contractors and consultants
- Will evaluate program expansion to DOT District Survey Offices
  - As well as expansion to other business areas within ODOT
Hurdles with the Start of a UAS Program

- Waviers and Regulations
- Rogue Operators
  - Over 583 UAS sightings reported by pilots in the last 6 months
  - Halted firefighting operations in California wildfires
- Preparing the Proper Workflow and Safety Plan
- Deciding and Evaluating a Platform
  - Sensors and Airframe

Ohio Contacts/ Information for UAS

Indiana/Ohio UAS Center and Test Complex:

http://www.dot.state.oh.us/Divisions/uas/Pages/default.aspx

Ohio Department of Transportation:

Questions?

Tim Burkholder, P.S.
Mapping Manager
Timothy.Burkholder@dot.ohio.gov

Kyle Ince, EI
Transportation Engineer
Kyle.Ince@dot.ohio.gov

A Look Into UAS at ODOT