Drones in Facility Management

PRESENTATION OVERVIEW

- Drone Laws and Regulations
- Applications for Facility Management
- Operations Management
  - Important Considerations
    - Outsourcing Drone Services
    - Internal Operations
Certification and Liability

- **FAA REGULATIONS**
  - New regulations implemented August 31 2016 by FAA
  - Commercial drone operation governed by CFR 14 Part 107
  - Pilots must obtain a SUAS rating and comply with Part 107 regulations
  - SKYPAN fined by FAA $1.9 million for 65 illegal unmanned aerial operations
CFR 14 PART 107

- New rule added to Title 14 Code of Federal Regulations (14 CFR) to allow for routine operation of small Unmanned Aircraft Systems (UAS) in the National Airspace System and provide safety rules for those operations.

- The rule addresses the following:
  - Airspace Restrictions
  - Remote Pilot Certification
  - Visual Observer Requirements
  - Operational Limitations

- Full document here: [CFR 14 Part 107](#)

- AC- Advisory Circular- Document published by FAA providing guidance on how to comply with an FAA regulation

- [AC 107-2](#) Advisory Circular written for CFR 14 Part 107
CFR 14 PART 107 - APPLICABILITY

- Applies to all civil unmanned commercial aircraft operations except the following:
  - Model aircraft operated in accordance with Part 101 Subpart E
  - Operations conducted outside the U.S.
  - Amateur rockets
  - Moored balloons
  - Unmanned free balloons
  - Kites
  - Public aircraft operations (COA)
  - Air carrier operations
CFR 14 PART 107- KEY GENERAL RULES AND REQUIREMENTS

- Falsification, Reproductions, or Alteration
  - FAA relies on information provided when authorizing operations or making compliance determinations. Do not fraudulently or knowingly provide false records or reports

- Accident Reporting
  - Report an accident to FAA within 10 days if
    - Level 3 Injury on AIS skill or loss of consciousness occurs
    - Property damage greater than $500 to repair or replace whichever is lower
  - Refer to AC 107-2 for instructions on accident reporting

- Aircraft Registration
  - Each aircraft should be registered and a unique aircraft registration number should be displayed in a location that does not require access with a tool.
  - Engrave, Permanent Label, or Permanent Marker are acceptable marking methods

- Remote Pilot Certification
  - Person operating controls of sUAS must maintain a current remote pilot certificate or the person operating the controls must be under the direct supervision of a remote pilot certificate holder who can immediately take over control of the aircraft.

- Aircraft Maintenance
  - Aircraft required to be inspected prior to each flight to determine if it is safe for operation
APPLICATIONS

FACILITY MANAGEMENT
Aerial Data Work Flow

Data Collection

Visible, Infrared, LiDAR, GPS, Chemical

Data Visualization

High Resolution Image Processing

Data Analytics

Pattern & Outlier Identification

Data Repository & Database Development

Data Insight

Automated Measurement and CAD Development

Data Storage

Visible, Infrared, LIDAR, GPS, Chemical

Aerial Data Work Flow
Visible (RGB) Sensors

- High resolution sensors commercially available
- GPS & altitude tagging for post processing
- Telephoto lenses for enhanced resolution
- Photogrammetric processing for orthomosaic, topographic, and 3D point cloud development

DJI ZENMUSE Z30 30X optical zoom
HIGH RESOLUTION DOCUMENTATION

✓ Efficient Data Collection
  • 100,000 ft² Commercial building data collection – 30 minutes

✓ Data Processing
  • Hundreds of Images Meshed into 1 single High Resolution Image

✓ High Resolution Data
  • Typical Resolutions Range from 1/16th” to 1/8th” per pixel
  • Individual images geo tagged in mosaic photo for detailed examination
PHOTOGRAMMETRY

- Utilization of photography to measure objects

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Infrared Sensors

- Available in Near Wave 0.78-1.4 μm. Short Wave 1.4-3 μm, Mid Wave 3-8 μm, Long Wave 8-12 μm, Far Wave 13-1000 μm
- Most Common IR Drone sensors record either Near Wave (NIR) or Long Wave frequencies
- Short and Mid Wave sensors requiring cooling, size and weight make Drone implementation expensive
INFRARED INSPECTION

HISTORY

- Infrared Inspection Technology first Introduced to Low Slope Roofs 1980’s
- Preferred NDI Roof Inspection Method
- Manned Aerial IR Inspection
  - Efficient-Easy location of damage
  - Very expensive- Reserved for Roofs > 10,000 square
- Handheld Inspection
  - Cost effective for small roofs
  - Inefficient- Medium to large size roofs impractical
- Drone Inspection
  - Cost effective for all size roofs
  - Efficient- Easy location of damage
Commercial Low Slope Roof Inspection

TECHNOLOGY SOLUTION

- Water Intrusion detection
  - Infrared inspection used to identify wet insulation
  - Infrared preferred method of Non Damage Inspection (NDI)
  - Adherence to ASTM C1153 “Standard Practice for Location of Wet Insulation in Roofing Systems Using Infrared Imaging”

- Inspection Report
  - Documentation of water intrusion and surface area estimate
Infrared Roof Physics

- During the day, the sun radiates energy onto the roof surface and into the roof substrate.
- At night, the roof radiates this heat back into outer space. This is called radiational cooling.
- Areas of the roof that are of a higher mass (wet) retain this heat longer than that of the lower mass (dry) areas.
- Infrared imagers can detect this heat and "see" the warmer, higher mass areas, during the "window" of uneven heat dissipation.
- Thermal windows are often very short. Depending on conditions and roof system, thermal windows can be as short as 30 minutes.
- Inaccurate assessment of roof system and external conditions leads to useless data and false positives.
Low Slope Roof Inspection Candidates

Inspectable Roof Systems
- TPO, PVC, EPDM Membrane
- Modified Bitumen
- Built Up Tar and Gravel
- SPF Roof Systems

Un-Inspectable Roof Systems
- Heavily Ballast Roofs
  - Large river stone
- Metal Roofs
- Asphalt Shingle
Application

TOTALED ROOF SECTION!

Wet Insulation
GOOD ROOF!
Case Study

- Complete roof replacement suggested by roofing contractor
- No interior leakage at locations IR scan identified as undamaged
- Scan extended roof life of 52,000 ft² by 6-8 years. 52,000 ft² of Roof @ $6 ft² and 50% life extension translated to 156 k savings

Roofing Industry

- Manufacturers and contractors incentivized to push full replacements
- A typical roof only has 2-5% wet areas beneath membrane
- Minimal visibility and urgency leads to misguided decisions

Contractor Suggested Replacement of Roof Section with No Leak History. Scan Confirmed Maintenance Professional’s Suspicion That Roof Section Did Not Need Replacement.
Intelligent Roof Maintenance

**REACTIVE**
- Fire fighting
- The Warranty Protects Me
- Annual M&R $0.35 Per ft²
- 5-12 year Roof Life
- Inspect When I Have a Leak
- I Wait Until I Get a Leak Report
- $1400 Occupant Cost per Leak

**PREVENTIVE**
- Fire Proofing
- I Read the Fine Print on The Warranty
- Annual M&R $0.26 Per ft²
- 10-15 Year Roof Life
- Scheduled Visual & Infrared Inspections
- I Catch Leaks Before They Are a Problem

**PREDICTIVE**
- Maintenance is performed before equipment failure using predictive insights
- Roof Data Organized In Database
- I Utilize the Warranty
- Annual M&R $0.21 Per ft²
- 15-20 Years
- Visual, Infrared Data Analyzed
- I Know When to Look for Leaks

**PRESCRIPTIVE**
- Once failure is predicted, solutions are provided to improve outcome
- Roof Database mined for Insights
- I Optimize The Warranty
- Annual M&R $0.19 Per ft²
- 20+ Years
- Annual Visual, Infrared Data Analyzed
- I Know What Material Systems, Contractors Are Best

Maintenance is performed when equipment has failed

Maintenance is performed regularly on equipment to reduce probability of failure

Intelligent Roof Maintenance
Model Based Database Integration

- 2D and 3D models integrated with leak, repair, inspection, and warranty information
- Enhanced Situational Awareness
- Roof Section Prioritization through Analytics
- Eliminate emotional decisions. Let Facts and Data Drive
- Stop Chasing Leaks
- Evaluate contractor repair and replacement performance
- Evaluate Material System Performance
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**Note:**
- Probable areas are marked in red.
- Standing water areas are marked in green.

**Legend:**
- > 20%
- >10%
- >5%
- >0%
- 0%
OPERATIONS MANAGEMENT
Internal Operation or Outsourcing?

- Deciding whether to outsource or set up an internal operation depends on a number of considerations:
  - How often missions are conducted
  - Equipment required
  - Level of experience
  - Turnover
  - Risk tolerance

- For many organizations the answer may be a combinations of both
  - Pilot programs generate “Buy In” from financial decision makers
  - Lessons learned from experienced operators improve internal operations
Internal Operations

Advantages

- Flexibility- New use cases can be developed to improve safety, efficiency, and reduce cost
- Tribal knowledge pertaining to missions leads to more targeted data collection and more accurate data interpretation
- Control over Operations- Safety and operation standards fall in line with standards established by organization

Disadvantages

- Equipment, software, and training costs can quickly erode ROI
- Increased liability
  - Accidents do occur and are costly
  - Regulations are complex
- Drone novelty leads to operations that have negative risk to reward ratios
General Questions to Consider

- What are you looking to get out of a setting up a drone operation?
  - What types of inspections would you like to perform?
    - What type of inspections are currently performed regularly that can be replaced to improve either safety or efficiency?
    - What types of additional inspections can be performed and generate ROI?
  - How many property sights per year?

- How do you plan to demonstrate to the financial management team that a drone program can generate an ROI?

- Do you have any current employees that have aviation experience? Private Pilots, Part 107 certified UAS pilots, UAS operation experience.

- How many resources (time, money, manpower) do you plan to commit to a drone operation?
Drone Operation Considerations

- Certification
  - Part 107 Knowledge Test
  - Aircraft Registration

- Part 107 & COA
  - ATC Governance: 24 Class G, 9 Class E, 27 Class D, 29 Class C
  - Part 107 Airspace Authorizations and Waivers
  - COA Application
    - Training Program Development
    - Air Worthiness Standards
    - Operation Standards
    - Emergency Procedures

- Compliance
  - FAA Regulations
  - State and Local Regulations
  - Privacy Concerns
Insurance

- FAA considers sUAS aircraft
  - FAA v. Raphael Pirker
    - Outcomes
      1. Definition of an “aircraft”: This case determines that UAS are affirmed as an “aircraft” for purposes of § 91.13(a), which prohibits any “person” from “operating” an aircraft in a careless or reckless manner so as to endanger the life or property of another. It has further determined that an aircraft is “any” “device” that is “used for flight.”
      2. The FAA can regulate UAS: Because UAS are considered “aircraft,” the FAA has the authority to regulate aircraft flying within the National Airspace System

- Insurance carriers follow suit with this designation
  - What are the risks?
Insurance- Risks

- Current policies will not likely cover sUAS incidents.
- 2015 Munich RE RIMS Survey- Survey of Risk Managers

What is the greatest risk of using drones?

1. Invasion of privacy- 69%
2. Inadequate insurance- 12%
3. Bodily injury- 11%
4. Property damage- 8%

- Evolving Rules and Regulations
Insurance - Fines & Penalties - Not Covered By Insurance

Your insurance policy will never cover:

▪ The cost of fines or penalties that are imposed as a result of your failure to comply with local and federal laws or negligence/reckless operation.

▪ Any legal fees and costs associated with defending or settling any fines or penalties

▪ Illegal activity performed by the insured (including any executive officers, partners, or managing agents), at the insured’s direction, or with the insured’s knowledge unless otherwise noted in the policy.

Cost of Fines & Penalties

The cost of unlawful or reckless operation of unmanned aircraft can be very expensive. Fines have ranged from several hundred dollars to a record $1.9M penalty that was recently brought against a commercial operator.
Organization Policy

- A Organization policy should be written for the use of sUAS on organization property or for organizational purposes.
- At a minimum policy should include considerations for the following:
  - Statement of Intended Use
  - Federal, State, Local Compliance
  - Operator Training
  - Flight Operations
  - Insurance
  - Data Security and Privacy
  - sUAS Maintenance
Training

- A training program is essential for all operators to complete prior to conducting operations for the organization.
- Training program should consist of both ground and flight training

Internal Training Course

**Advantages**
- Flexible course offerings
- Training tailored to specific operations

**Disadvantages**
- Course development and teaching is time consuming and expensive
- Courses must continue to evolve with new laws and regulations

Outsourced Training Course

**Advantages**
- No training development cost
- Third party training maintains currency with laws and regulations
- Reduced compliance risk

**Disadvantages**
- Canned courses contain content that may not be tailored to specific operations
- Lead time for scheduling may not suit current needs
Operations Procedures

- It is essential that standard procedures for operation are developed

Types of Operation Procedures

- Standard operations procedures
  - Defined by a standard operations manual

- Application Procedures
  - Tailored to specific types of inspections or data collection
  - Updated periodically based on lessons learned and best industry practices
Maintenance

- There are two types of maintenance
- **Scheduled Maintenance** - Maintenance performed in accordance with manufacturers instruction or accepted industry practices.
  - If there is no maintenance schedule provided by manufacturer, the operator should establish a scheduled maintenance protocol.
  - Document repair, modification, overhaul, or replacement of a system
- **Unscheduled Maintenance** - Maintenance may required out of sequence with maintenance schedule due to findings during pre-flight inspection
- **Performing Maintenance** - Certain maintenance tasks may be required to be performed by the manufacturer, an authorized person of facility.
  - Maintenance tasks performed outside the manufacturers requirements should be performed according to guidance provided by maintenance personnel familiar with the sUAS and its components.
  - If determined that the sUAS can not be brought back to its safe operational specification it should be replaced.
Social Responsibility- General Rules

- The introduction of any new technology welcomes both proponents and adversaries. It is important that employees and contractors remain sensitive to everyone’s rights.

- Adversaries to drone use are particularly concerned with privacy. It is important that privacy concerns of stakeholders affected by operations are reasonably respected.

- Images of private property explicitly identified by a bystander should never be recorded.

- If private property was inadvertently recorded prior to the complaint or by accident the data should be deleted immediately.

- Notifying bystanders of operation is essential to maintaining positive relationship with the community.
Drone Operation Challenges

- **Airspace Authorization**
  - Controlled airspace authorization lead times can take more than 3 months. Not practical for trigger event inspections
  - FAA Implementing new authorization systems to streamline process
    - Low Altitude Authorization and Notification Capability (LAANC)
  - Facility Charts

- **Privacy and Data Security**
  - Many state and local government laws enacted addressing privacy and drones
  - Use of drones for surveillance Illegal in many states - Florida, California, Texas, Virginia
  - Data management essential - security breaches exposing sensitive data can be costly

"Orlando Area Facility Map – May 2018", FAA
Drone Operation Pitfalls

- Inadequate Planning
  - Operation manual development
  - Inspection Standard development
  - Data processing, storage, and recall

- Inadequate Training
  - Familiarity with all local, state, and federal laws and regulations
  - Operation limitations
  - Risk management and Aeronautical Decision Making

- Accelerated implementation
  - Implementation should be gradual
  - Document lessons learned and ROI
  - Focus on high ROI missions. Infrared moisture inspections, commercial property
PLATFORM SELECTION
Platform Selection

- DJI is the largest and most reputable drone manufacturer
- Started as a hobbyist drone manufacturer
- Recently expanded into commercial market with drones tailored to agricultural, industrial inspection, and mapping and surveying applications
- Best industry solutions for educational and for inspection applications
- All drones are rotorcraft
DJI Phantom 4 Advanced & PRO

- Only difference between Advanced and Pro is Obstacle Avoidance
- Best wind resistance of all DJI drones
- Best Non-RTK photogrammetric mapping solution
- Small to medium in size
- Good educational drone
- Medium Cost
- Inspection capability is average
  - 20 Megapixel sensor
  - No Optical Zoom
  - No dual operator option
  - No top mount option
DJI Mavic Pro, Mavic Air, Mavic 2 Pro, Mavic 2 Zoom

- Good all purpose drone
- Average Mapping and Modeling Capability
- Average Inspection Capability
- Good Educational Drone
- Low Cost
- Good Flight Times
  - Mavic Air – 21 Minutes
  - Mavic Pro – 27 Minutes
  - Mavic 2 Pro/Zoom- 31 Minutes
DJI Inspire 1 & 2

- Inspire 2 offers longer flight times with dual battery (27 min. vs 18 min.)
- Inspire 2 tailored for video production - Better camera options
- Inspire 1 is only drone in enterprise/educational class that is compatible with Infrared Sensor (Zenmuse XT). Inspire 2 is not compatible.
- Interchangeable sensors
- Average wind resistance
- Average mapping capability
- Inspire 1 Poor Flight time
- Medium – High Cost
Matrice 200 Series

- Industrial Inspection & Precision Mapping Solution
- ADS-B Sensor Equipped (senses approaching aircraft)
- M210 has capability to mount sensor above drone
- M210 RTK tailored for precision mapping (superior GPS recording)
- Excellent Mapping Capability
- Excellent Inspection Capability
- High Cost
Post Processing Software

- **2D & 3D Mapping and Modeling Solutions**
  - **Drone Deploy**
    - **Advantages**
      - Easy to learn
      - Open Source Customized applications – Roof Reports
      - Cost - $3000 Annual Subscription + Additional Add on Applications and Reports
    - **Disadvantages**
      - Data Security - Data uploaded to external server

- **Pix4D**
  - **Advantages**
    - Data Security - Desktop & Online Application
  - **Disadvantages**
    - Requires high end computing solution
    - Steep Learning Curve
    - Cost - $8000

- **FLIR Tools + Infrared Data Processing Software**
  - **Advantages**
    - Used to process and evaluate thermal images
    - Cost - $295