Practical Use of Drones for Diverse Infrastructure Projects

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Meet Your Instructor

- Stephen B. Ellingson, Ph.D.
  - Principle at Vatten Associates
  - Mr. Ellingson has Supported ASCE with Drone Training Presentations Since Early 2018
- Educational Background
  - Initially Studied Architecture; Later S.T.E.M.
- Diverse Work History
  - State Regulatory Agency
  - Private Industry
  - Consulting Firms
- Completed Drone Projects
  - Senior Member of Drone Working Group

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Webinar Outcomes

- Overview of Regulatory and Liability Concerns for Drones
- Demonstrations of Drone Capabilities and Infrastructure Opportunities
- Ability to Complete Economic Analysis of Drone Use
- Answers to Your Questions
- Obtain Webinar Certificate

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Regulatory and Liability Overview for Drones

Practical Use of Drones for Diverse Infrastructure Projects

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Potential Regulatory Agencies

OSHA® Occupational Safety and Health Administration

Site Inspections

FEDERAL AVIATION ADMINISTRATION

State/Local Requirements

NATIONAL TRANSPORTATION SAFETY BOARD

Accident Reporting

U.S. Department of Labor MSHA Mine Safety & Health Administration

Quarry Operations

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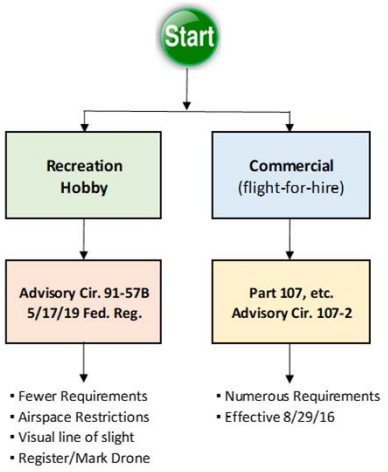
What is a Drone?

(aka Small Unmanned Aircraft System or UAS)



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Three-Part Drone Flight Team

- Drone Pilot
  - Remote Pilot in Command (Remote PIC)
  - Holds Current Certificate with Drone Rating
  - Ability to Immediately Take Control of Drone
  - Has Final Authority and Responsibility for Safe Operation

- Visual Observer
  - Designated by Drone Pilot
  - Assist Drone Pilot and Person Manipulating Controls
  - Help with “See and Avoid”

- Person Manipulating Controls
  - May Operate Drone
  - Must be Directly Supervised by Drone Pilot

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FAA Operating Limitations

Summary of Operating Limitations	
Remote Pilot in Command; Optional Visual Observer and/or Control-Manipulator	Fly < 100 mph (87 knots) Ground Speed
Drone Registration	Stay < 400 ft Above Ground Level, or w/i 400 ft of Structure
Pre-Flight Checklist and Maintenance	Minimum Visibility at Least 3 miles
Suitable Medical Condition, No Impairment, and Carless or Reckless Operations	Stay Away from Clouds (< 500 ft vertically and 2,000 ft horizontally)
Maintain Visual Line of Sight (VLOS)	Prohibited Operation Over People
Class G National Air Space Limitation (no Class B, C, D, or E w/o ATC approval; TFR/NOTAMS, etc.)	Operations from Moving Vehicles in Sparsely-populated Areas Only
Only Daylight Operations	Can Transport Property (no Haz Mats) w/ Limitations
Total Take-off Weight < 55 lbs	Can Deviate from FAA Rules in Emergency
Report Accidents w/i 10 Days	See also: FAA Advisory Circular No. 107-2, 6/21/16

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Selected Operating Limitations

Key Operating Limitations	
Remote Pilot in Command; Optional Visual Observer and/or Control-Manipulator	Fly < 100 mph Ground Speed
Drone Registration	**Stay < 400 ft Above Ground Level, or w/i 400 ft of Structure**
Pre-Flight Checklist and Maintenance	Minimum Visibility at Least 3 miles
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Only Daylight Operations	Can Transport Property (no Haz Mats) w/ Limitations
Total Take-off Weight < 55 lbs	Can Deviate from FAA Rules in Emergency
Report Accidents w/i 10 Days	See also: FAA Advisory Circular No. 107-2, 6/21/16

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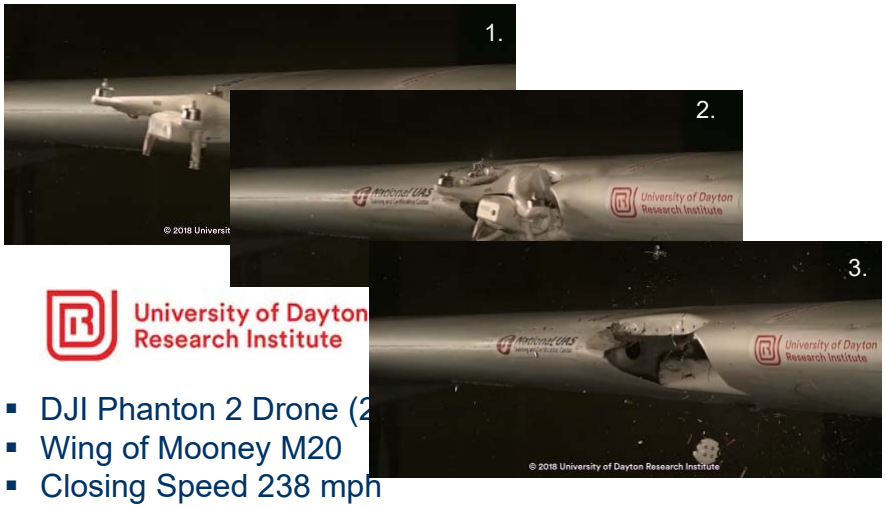
Drone *vs.* Airplane Wing



- DJI Phanton 2 Drone (2
- Wing of Mooney M20
- Closing Speed 238 mph

Source: https://www.udayton.edu/blogs/udri/18-09-13-risk-in-the-sky.php [w/ permission]

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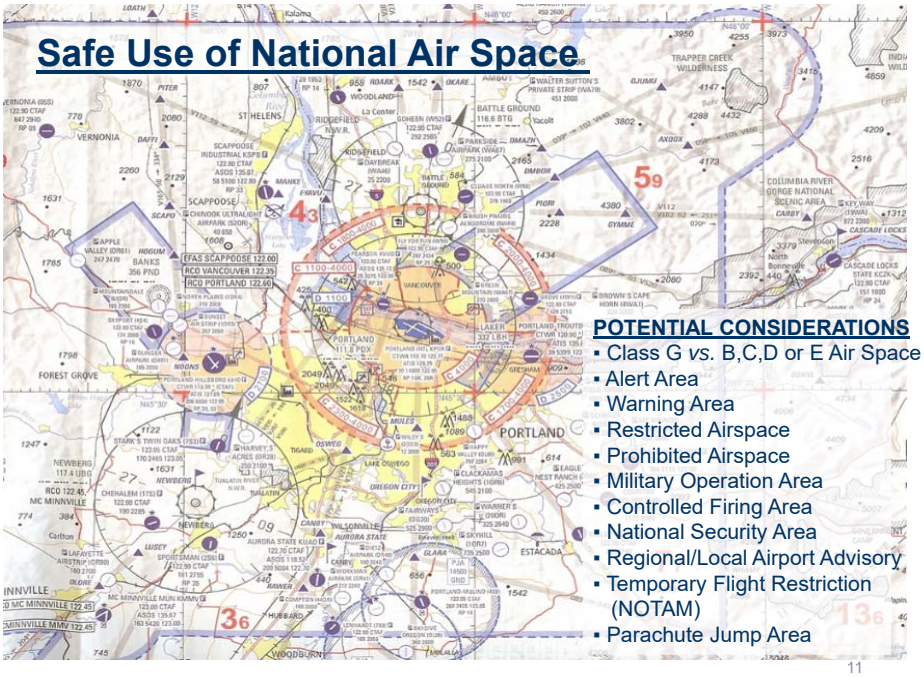
Safe Use of National Air Space



POTENTIAL CONSIDERATIONS

- Class G *vs.* B,C,D or E Air Space
- Alert Area
- Warning Area
- Restricted Airspace
- Prohibited Airspace
- Military Operation Area
- Controlled Firing Area
- National Security Area
- Regional/Local Airport Advisory
- Temporary Flight Restriction (NOTAM)
- Parachute Jump Area

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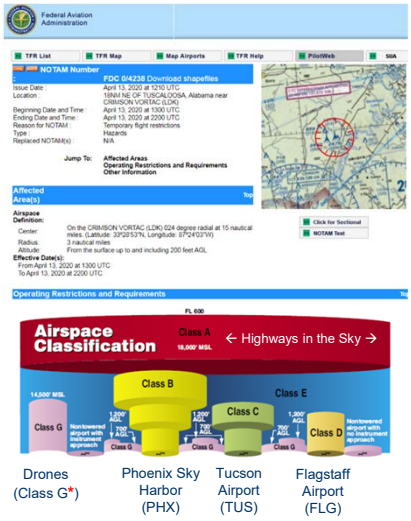
Changes to Airspace Limitations



- Any Temporary Flight Restrictions (TFR)?
  - Check Notice to Airmen (NOTAM) Before Each Flight
- Tuscaloosa, Alabama
  - Special Security Reasons
  - April 13, 2018
  - No Aircraft Within 3 Miles and 200 Feet MSL
- On Pre-Flight Checklist?

NOTAM List: https://pilotweb.nas.faa.gov/PilotWeb

TFR List: http://tfr.faa.gov/tfr2/list.html

B4UFLY Smartphone App

National Airspace Classification

- Controlled Airspace
  - Class A – Highways in the Sky
  - Class B – Larger Airports (Phoenix Sky Harbor)
  - Class C – Medium Airports (Davis Monthan, Tucson)
  - Class D – Smaller Airports (Flagstaff, Prescott)
  - Class E – Not A,B, C or D
- "Uncontrolled" Airspace
  - **Class G** – Drones Can Normally Fly Here
- Special Use Airspace
  - Prohibited, Restricted, Warning, Military Operations, Alert, and Controlled Firing Areas
- Other Airspace
  - **Temporary Flight Restriction (TFR)** listed in Notice to Airman (NOTAM)
  - Local Airport Advisory, Military Training Route, National Security Areas, Parachute Jumps, etc.

NO DRONE ZONE

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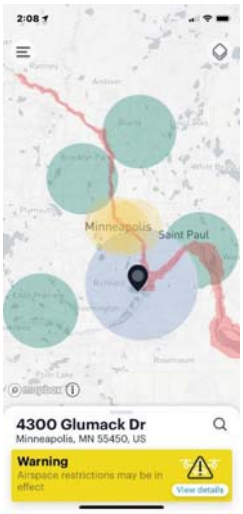
B4UFLY Cell Phone App

←Atlanta, GA
(3/6/20)

Cell Phone App

Minneapolis, MN→
(4/15/20)



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Upcoming Recreational Drone Test

- FAA Reauthorization Act of 2018 Requires
  - Drone Used for Recreational Purpose Only
  - Follow Community-Based Safety Guidelines
  - Stay Within Visual Line of Slight
  - Give Right-of-Way to Other Aircraft
  - Follow Airspace Restrictions
  - Stay Less 400 Feet Above Ground Level
  - **Pass Aeronautical Knowledge Test**
  - Register and Mark Your Drone
- Currently Under Development
  - Aeronautical Knowledge Test
  - Community-Based Safety Guidelines

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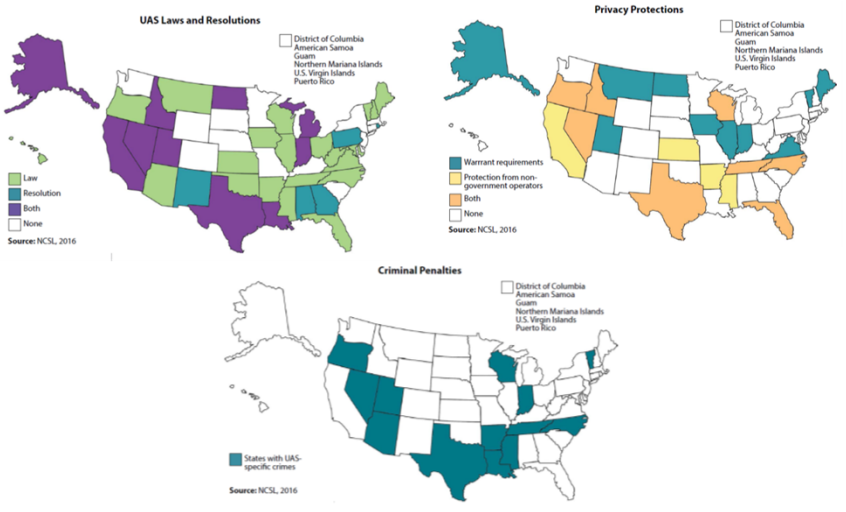
State-Specific Requirements



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North Carolina Drone Permit

- Regulated by North Carolina Division of Aviation
- Requirements to Obtain N.C. Permit
  - Hold Current FAA Drone Certification
  - Must be at Least 16 Years Old
  - Hold a Valid Drivers License
  - Successfully Complete **N.C. Knowledge Test**
  - Fee
- Prohibitions
  - No Surveillance of People, Occupied Dwellings or Property Without Consent
  - No Launching or Recovery of Drones on State or Private Property Without Consent

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Potential Liability Concerns

- "No Person May Operate an Aircraft (Drone) in a Carless or Reckless Manner so as to Endanger the Life or Property of Another"
- Potential Federal, State or Local Regulatory Violations
- Tort Liability for Accident
  - Personal Injury and/or Property Damage
- Invasion of Privacy
  - Operating Above People
- Trespass or Nuisance
- Drone Lost
  - Confidential Electronic Data

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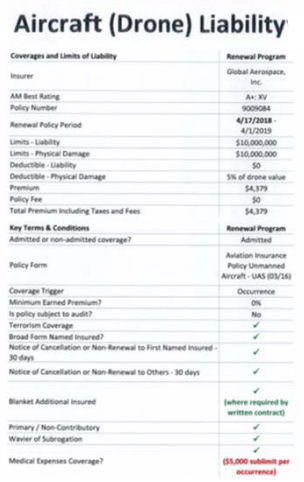
Risk Management and Insurance

- Treat Drones Like Truck Fleet; Not Just Piece of Equipment
  - Procurement, Procedures, Policies, Pilot Oversight and Proficiency, etc.
- Coverage Options
  - Endorsement to Existing Policies
  - Drone-Specific Policy
  - Additional Insured on Subcontractor's Policy
    - Suggest Receiving Copy of Subcontractor's Policy
    - Certificate of Insurance (COI) Does Not Provide Coverage



Aircraft (Drone) Liability

Coverages and Limits of Liability	Renewal Program
Insurer	Global Aerospace, Inc.
AM Best Rating	A+ XV
Policy Number	9009084
Renewal Policy Period	4/17/2018 - 4/1/2019
Limits - Liability	$10,000,000
Limits - Physical Damage	$10,000,000
Deductible - Liability	$0
Deductible - Physical Damage	5% of drone value
Premium	$4,379
Policy Fee	$0
Total Premium Including Taxes and Fees	$4,379
Key Terms & Conditions	**Renewal Program**
Admitted or non-admitted coverage?	Admitted
Policy Form	Aviation Insurance Policy Unmanned Aircraft - UAS (03/16)
Coverage Trigger	Occurrence
Minimum Earned Premium?	0%
Is policy subject to audit?	No
Terrorism Coverage	✓
Broad Form Named Insured?	✓
Notice of Cancellation or Non-Renewal to First Named Insured - 30 days	✓
Notice of Cancellation or Non-Renewal to Others - 30 days	✓
Blanket Additional Insured	✓ (where required by written contract)
Primary / Non-Contributory	✓
Waiver of Subrogation	✓
Medical Expenses Coverage?	✓ ($5,000 sublimit per occurrence)

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Overview of Drone Capabilities and Applications

Practical Use of Drones for Diverse Infrastructure Projects

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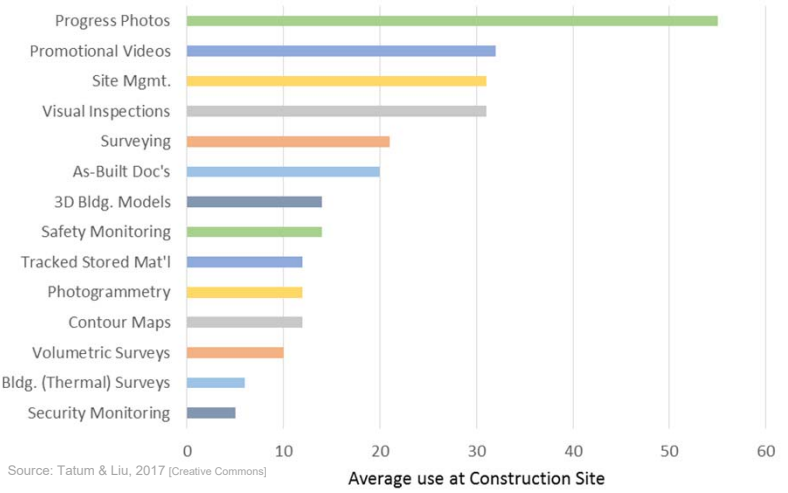
Construction Site Drone Use



Source: Tatum & Liu, 2017 [Creative Commons]

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Data Gathering Capabilities

Sensor Type	Typical Uses
Optical Camera (visible light)	Photography, photogrammetry, mapping 3D-modeling
Thermal Imaging [infrared (IR)]	Building venting, broken solar panels, overheated equipment
Multispectral (visible, IR, & UV)	Soil and vegetative assessments
Laser (LiDAR, LADAR)	Surveying, high-resolution mapping
Other Sensors/Equipment	Emissions, radiation, gas, electromagnetic, vapors
Sampling Equipment	Air (hazardous environments), water, etc.

Notes: LADAR = Laser Detection and Ranging, LiDAR = Light Detection and Ranging, UV = Ultraviolet

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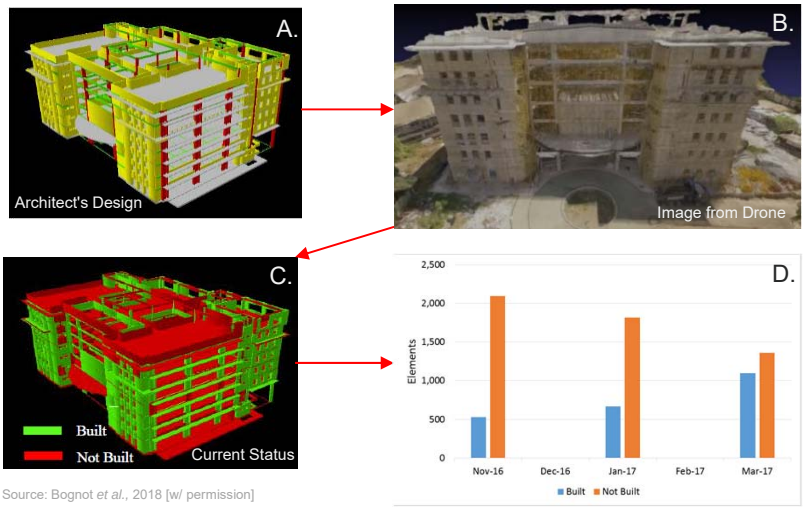
Progress Monitoring



Source: Bognot *et al.*, 2018 [w/ permission]

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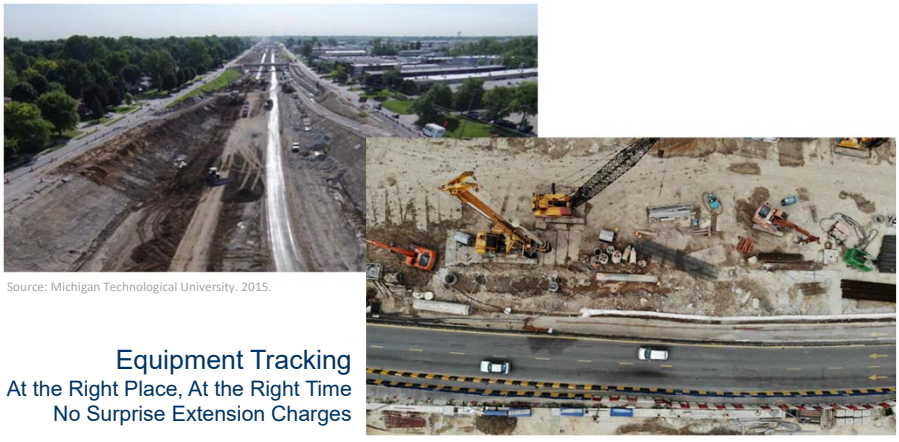
Project and Equipment Monitoring

- Construction Site Monitoring and Imaging



Source: Michigan Technological University. 2015.

Equipment Tracking

At the Right Place, At the Right Time
No Surprise Extension Charges

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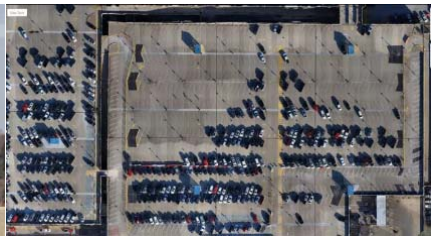
Parking Lot Demo Survey

- Parking Garage Demolition Project
- "Terrestrial" Survey Every 15 feet?
  - Traffic and Parking Disruption
- Restricted Airspace
  - Drone Limited to 200 feet above ground level



Source: https://www.atkinsglobal.com/en-gb/projects/hartsfield-jackson-atlanta-international-airport-drone [w/ permission]

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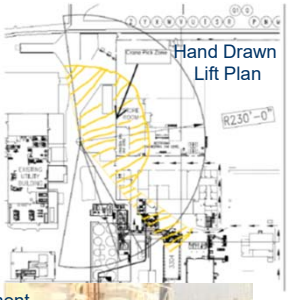
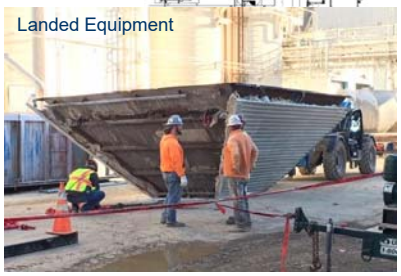
Crane Lifts and Clearance





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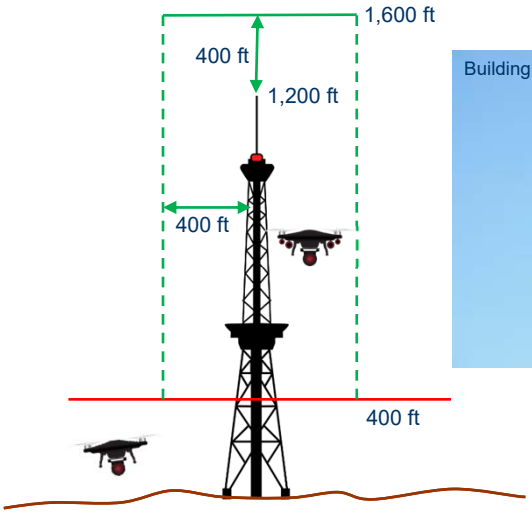
Tower / Building Allowance



Source: 14 CFR 107.51(b)(1) & (2)

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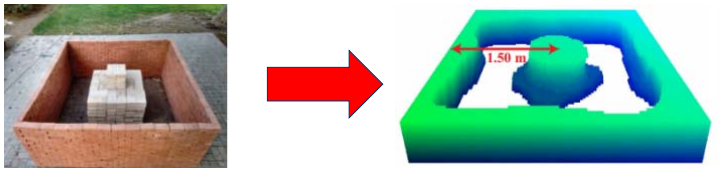
Drones Can See Behind Walls



Processed 3D Image

Source: Karanam & Mostofi, 2017, w/ permission

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Bridge Exterior/Interior Inspections

- State Hwy 55 Bridge Over Lake Street
  - Exterior Inspection Between Beams
  - Interior Inspection of Box Girders
- No Climbing, Ladders or Scaffolding
  - No Employees Inside Girders

Drone in a "Basket"

Source: https://www.flyability.com/casestudies/indoor-drones-in-bridge-inspection-between-beams-and-inside-box-girder [w/ permission]

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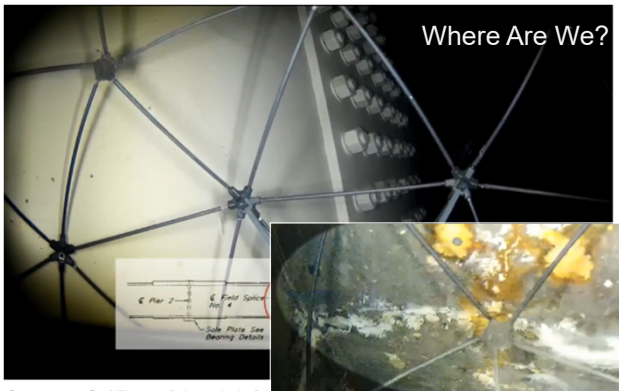
Inspection Inside of Box Girders



Source: www.flyability.com [w/ permission]

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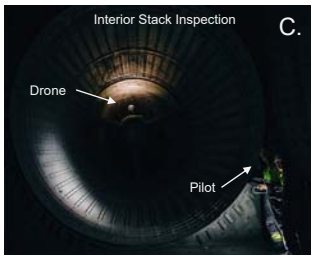
Inside Gas Turbine Stack

- Inaccessible
  - Normally Lowering Workers and Building Scaffolding
- Inspect Brackets, Welds, and Bolts
- Pre-Outage Inspection
  - Ready for Any Repairs at Outage



Source: https://www.flyability.com/casestudies/inside-a-gas-turbine-stack-inspections-without-outages-using-elios [w/ permission]

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Enhance Worker Safety

- Construction Industry Safety Improvements
  - 2003: 5.0 TRIR → 2017: 2.8 TRIR
- Personal Protection Equipment (PPE)
- Dangerous and/or Inaccessible Spaces
- Column Out of Alignment?
- Correct Excavation Shoring
- Falls to Lower Level
  - Cause 39% of Construction Fatalities
- Experience Modification Rate (EMR)
  - Your Ability to Qualify for Jobs
  - Lower Worker Compensation Insurance Premiums

TRIR = OSHA total recordable incident rate

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Drone Safety Applications

Excavation Work
Correct Excavation Shoring?

Dangerous & Inaccessible
Send the Drone Down There!

Source: Michigan Technological University. 2015.

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OSHA Drone Inspections

- May 18, 2018, Memo. Announced New Inspection Policy
  - OSHA Can Use Drones to Conduct Inspections
  - Employer Must Provide Expressed Consent
    - Who is “Employer”
    - Facility Owner, General Contractor, or Subcontractor?
  - At Least Nine Inspections Completed in 2018

OSHA®
Occupational Safety and Health Administration

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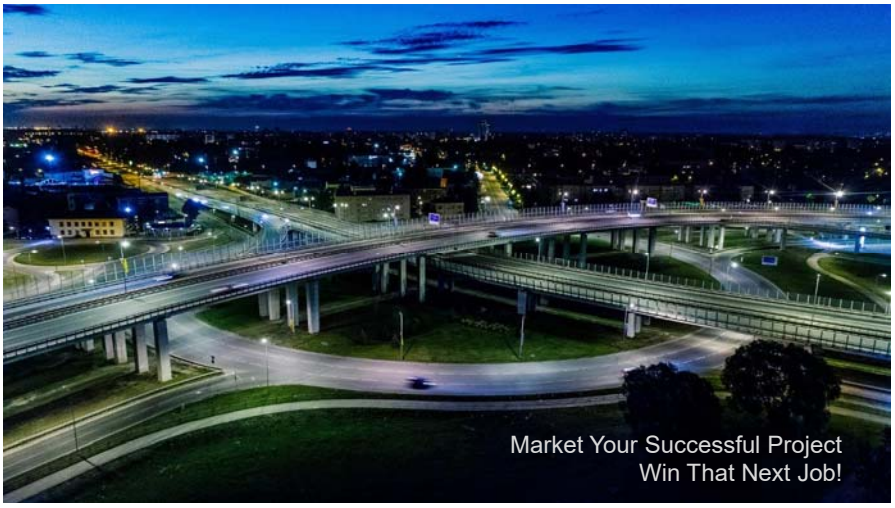
Promotional Videos



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Economic Analysis: Profitability, Return-on-Investment, etc.

Practical Use of Drones for Diverse Infrastructure Projects

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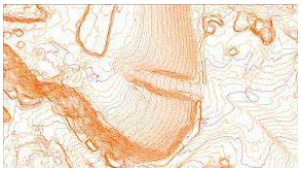
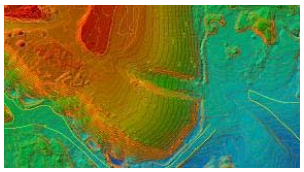
Drone *vs.* Traditional





- Land Clearing and Inert Debris Landfill
- About 60 Acres
- Equipment was 3D Robotics Solo with Sony QX1 Camera
- One Hour Onsite
- 24 Hours Data Processing

Type of Survey	UAS was:
Conventional Ground	10 to 20 % Cheaper
Airplane Photogrammetry	30 to 40 % Cheaper

Stallings, C., **McKim & Creed, Inc.,** 2016. 2016. Exploring UAS Effectiveness for Land Surveys: A Case Study. LiDAR Magazine, 6(4): 18-21. [w/ permission]

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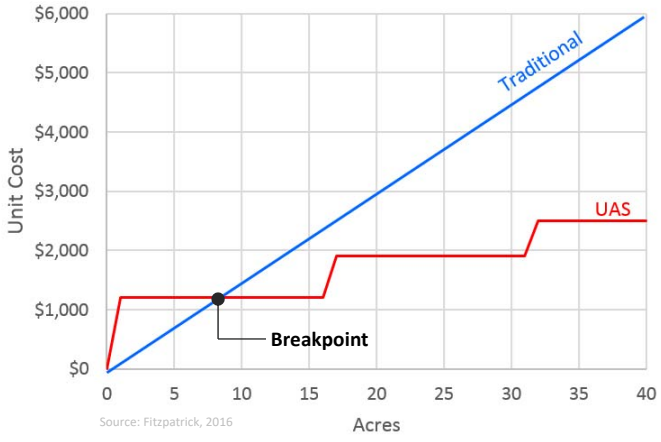
Cost Curve by Area

- Texas Landfill Study Showed
  - Acreage "Breakpoint" for Cost of Traditional Survey *vs.* Drone (aka UAS)



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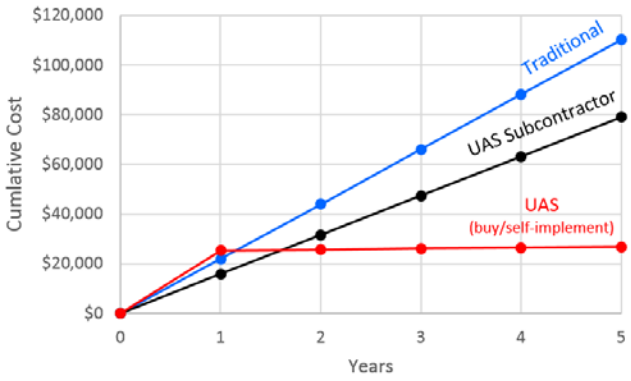
Cost Curve by Years

- Aggregate Company Example
  - Three Quarries and 30 Stockpiles
  - Frequent "Simple" Surveys
  - Comparison Using Subcontractor or Self-Implementation



Source: http://kespry.com/drone-stockpile-cost-savings

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Drone vs. Traditional Surveys

- Four Study Areas
  - About 8 acres
- UAS Equipment was 3D Robotics Iris or 3D Robotics Aero-M
- "Traditional" was Land-Based Surveying Team

Type of Survey	Traditional	UAS	Difference
Volumetric Calculations			
Hours	11	6	▼ 5
Cost	$2,235	$1,317	▼ $918
Topographic Mapping			
Hours	16	8	▼ 8
Cost	$3,200	$1,944	▼ $1,256

Fitzpatrick, B.P. 2016. Unmanned Aerial Systems for Surveying and Mapping: Cost Comparison of UAS versus Traditional Methods of Data Acquisition. MS Thesis, Univ. of California.

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Additional Information

- Federal Aviation Administration (FAA). 2019. Advisory Circular 91-57B - Exception for Limited Recreational Operations of Unmanned Aircraft; dated May 31.
  https://www.faa.gov/documentLibrary/media/Advisory_Circular/Editorial_Update_AC_91-57B.pdf
- Recreational/Hobby Drone Use https://www.faa.gov/uas/recreational_fliers/
- Federal Aviation Administration (FAA). 2016. Advisory Circular 107-2 - Small Unmanned Aircraft Systems (sUAS); dated June 21.
  https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_107-2.pdf
- Temporary Flight Restrictions (TFR) https://tfr.faa.gov/tfr2/list.html
- Notice to Airmen (NOTOMs) https://notams.aim.faa.gov/notamSearch/nsapp.html#/
- B4UFLY Mobile App https://www.faa.gov/uas/recreational_fliers/where_can_i_fly/b4ufly/

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Questions and Answers

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