Unmanned Aircraft in GIS: GIS Workshop

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NY
AF
85 500
NOT a GIS UAS

Fixed Wing Example

Falcon Unmanned

Longmont Flood Stitched Map – Falcon UAV

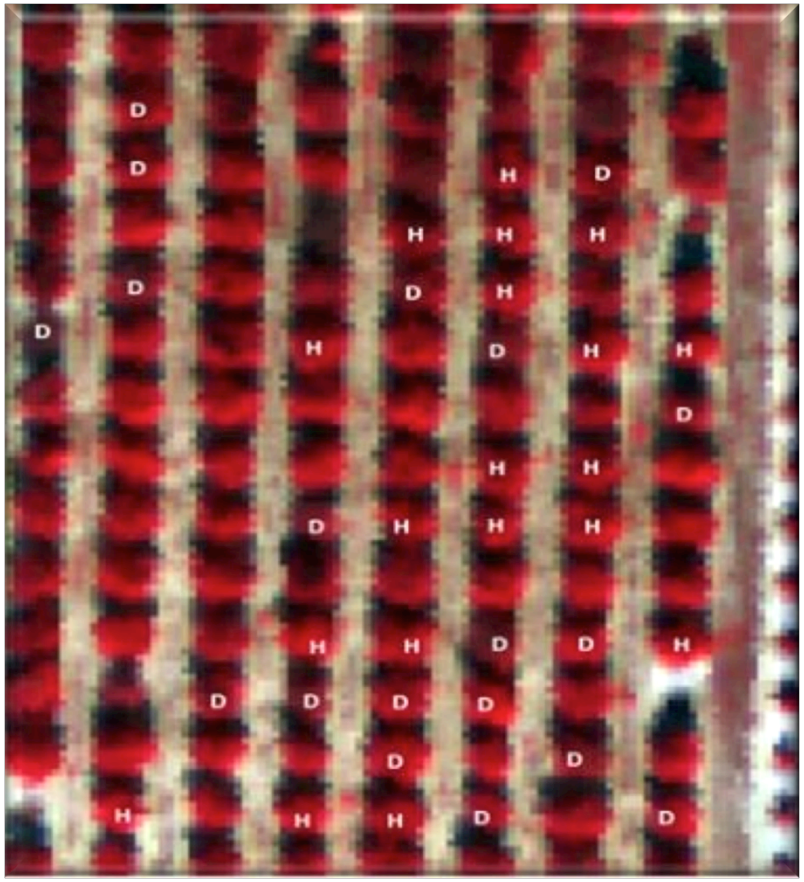
Remote Sensing

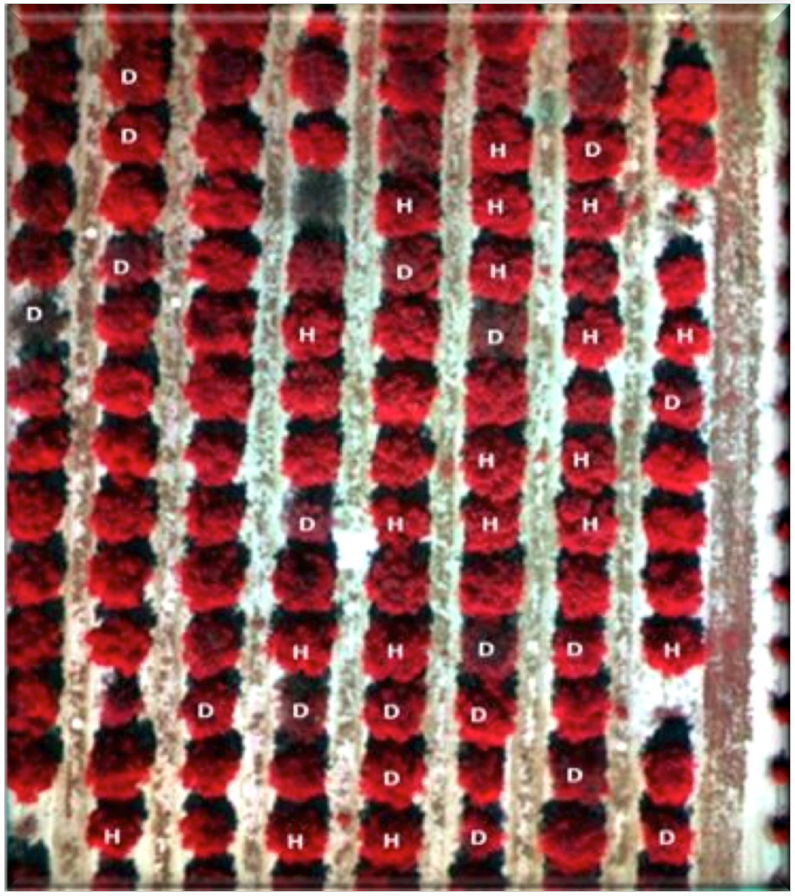
- Primary use of UAVs is in remote sensing
- Typically, remote sensing can divide into four stages or levels based on the altitude of the sensor.
  - *Ground Observation: 0 - 50 ft.*
  - *Small Unmanned Aircraft: 50 – 1,000 ft* ⟸ SUAS Sweet Spot
  - *Low Altitude Aircraft: 1,000 - 10,000 ft*
  - *High Altitude Aircraft: > 10,000 ft*
  - *Satellites > 150 miles*

UAS Advantages - Imaging

~ 50 cm/pixel
(20 inch/pixel)

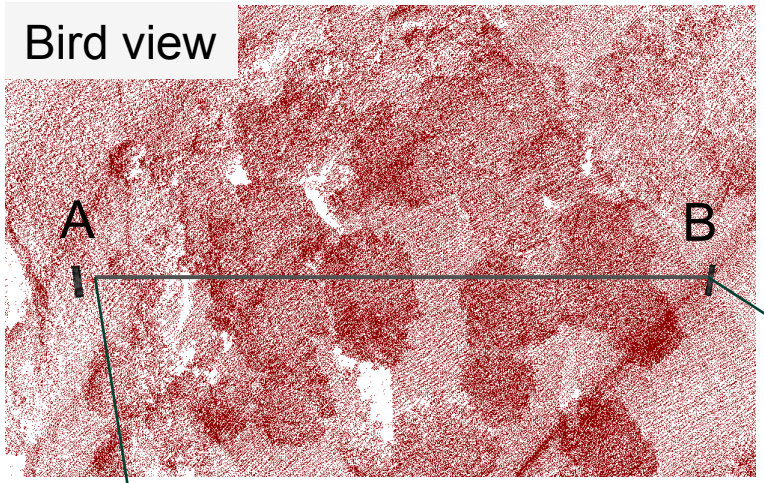
~ 1 cm/pixel
(<1/2 inch/pixel)

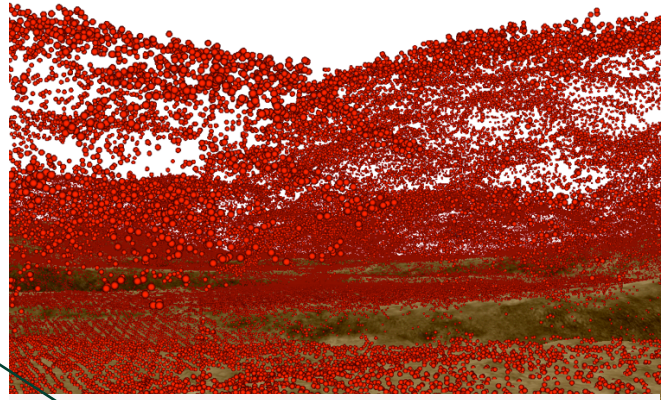




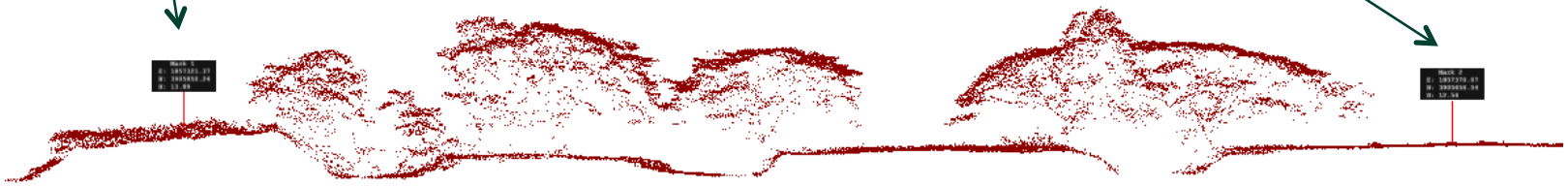
UAS Advantages – Point Clouds and Surface Maps

- Can acquire data from multiple perspectives



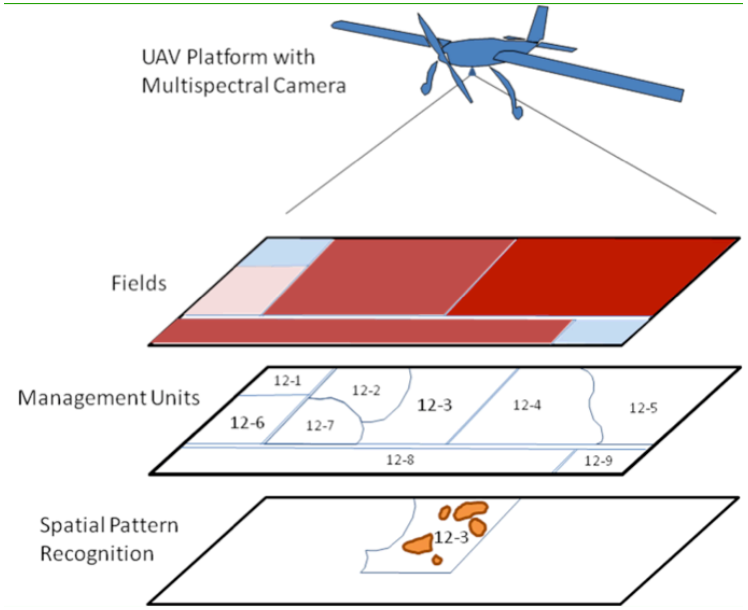


Looking from Pt. B towards A

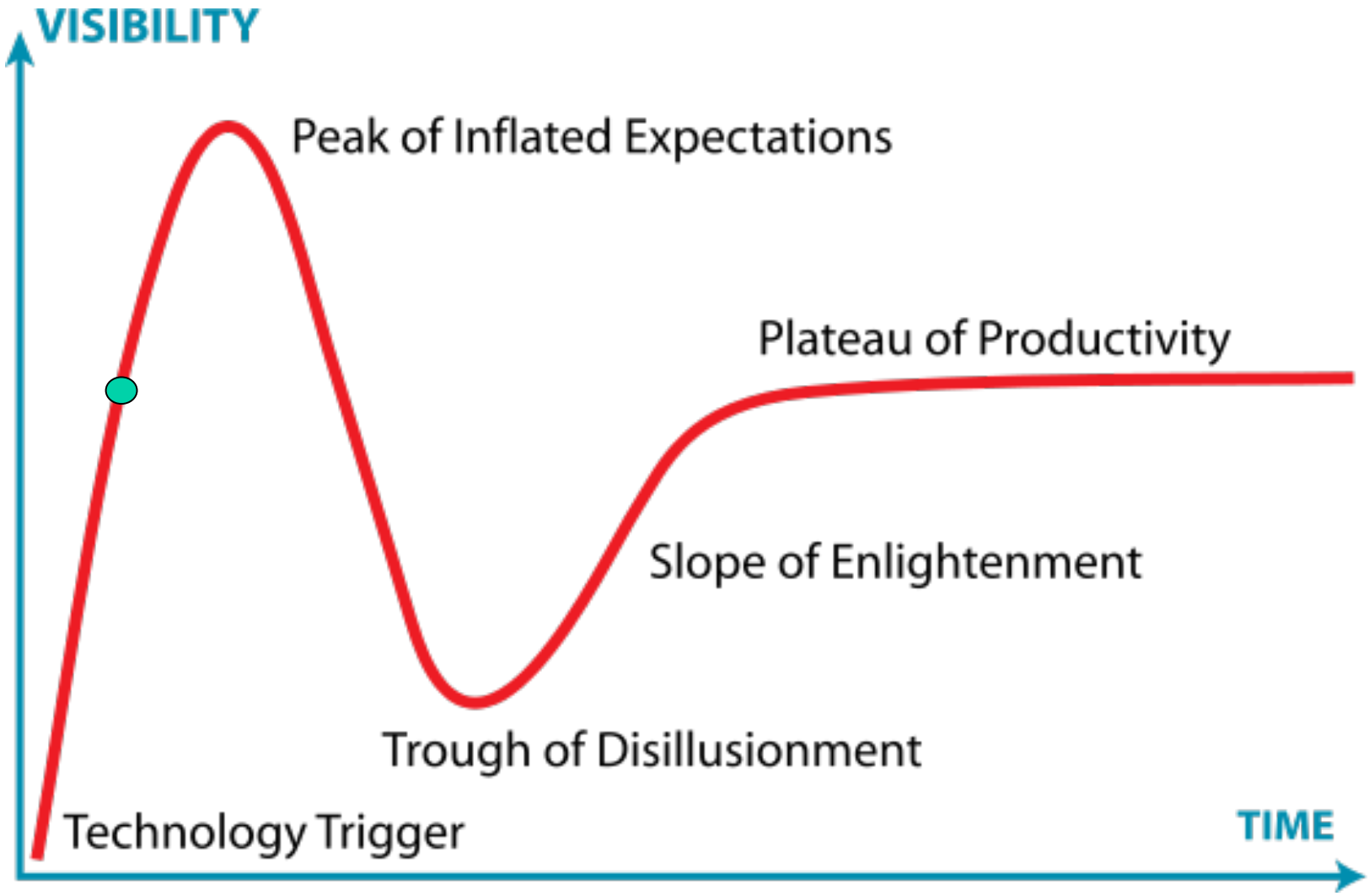


Cross section between mark A and mark B (depth 5m)

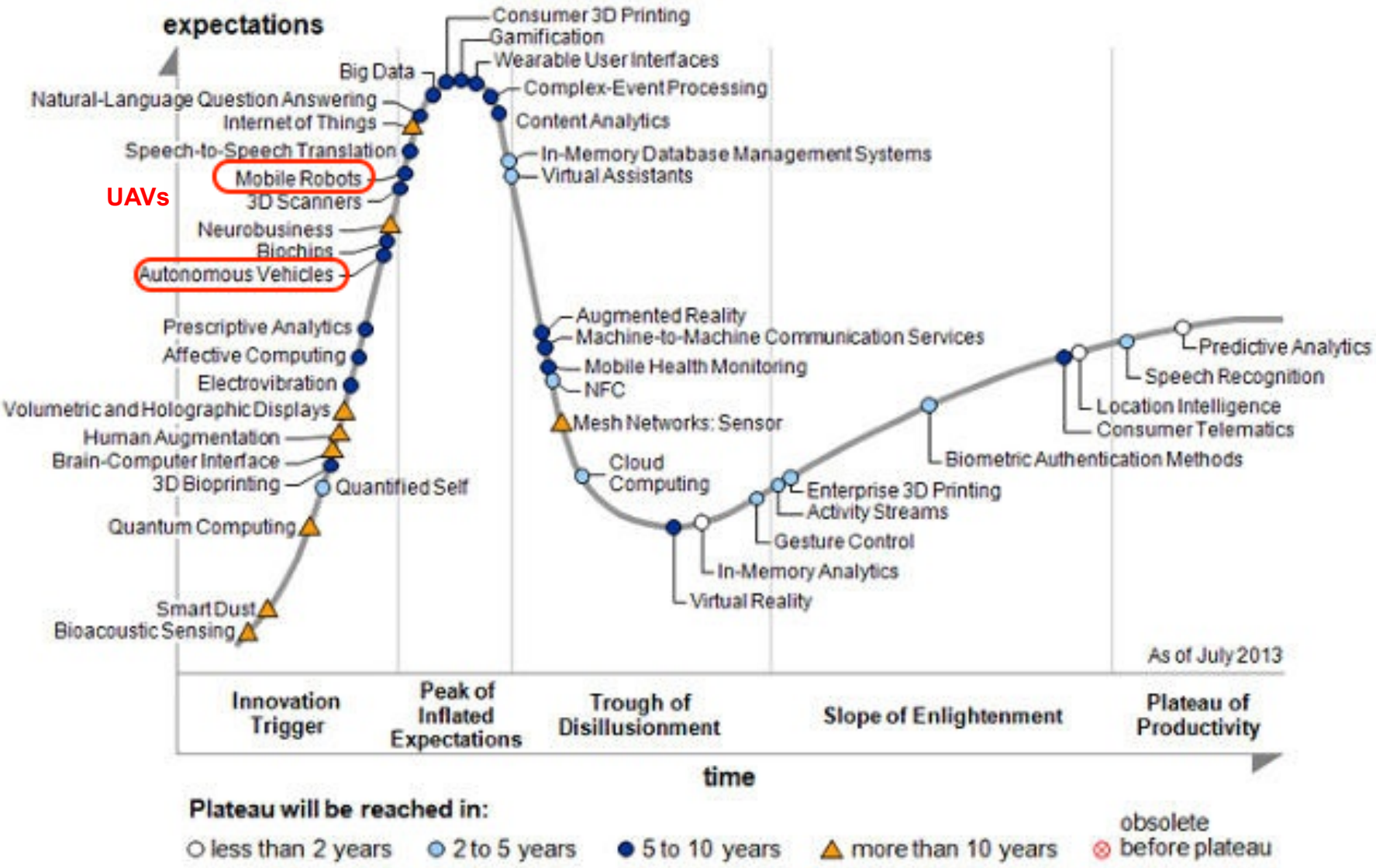
UAS Advantages – Approval & Cost



The Hype Cycle



UAVs Still Have a Long Way to Go…



Forbes

Sample Onboard Video

UA TYPES, ROLES & PAYLOADS – SUAS FOCUS

UAV Selection

- UAV types
  - *Fixed wing*
  - *Rotary wing (Single or Multi)*
- Payload selection
  - *EO/IR (Electro-optical/Infrared sensor); HD; NDVI*
- Things to consider – mission success factors
  - *Operational needs (mission, endurance)*
  - *Costs*
  - *Setup time*
  - *Failure rate*
  - *Human to robot ratio*

General Platform Comparison

- FW (Fixed Wing)
  - *Long(er) range*
  - *Long(er) endurance*
  - *Large(r) payload*
  - *Fast(er) flight*
  - *May require catapult and recovery system for platforms > 10 lbs*

Sensefly eBee

- Helicopter
  - *Hover and stare capability*
  - *VTOL (Vertical TO and Landing)*
  - *May be well suited for small crop spraying*
  - *Short endurance*
  - *More difficult to control*

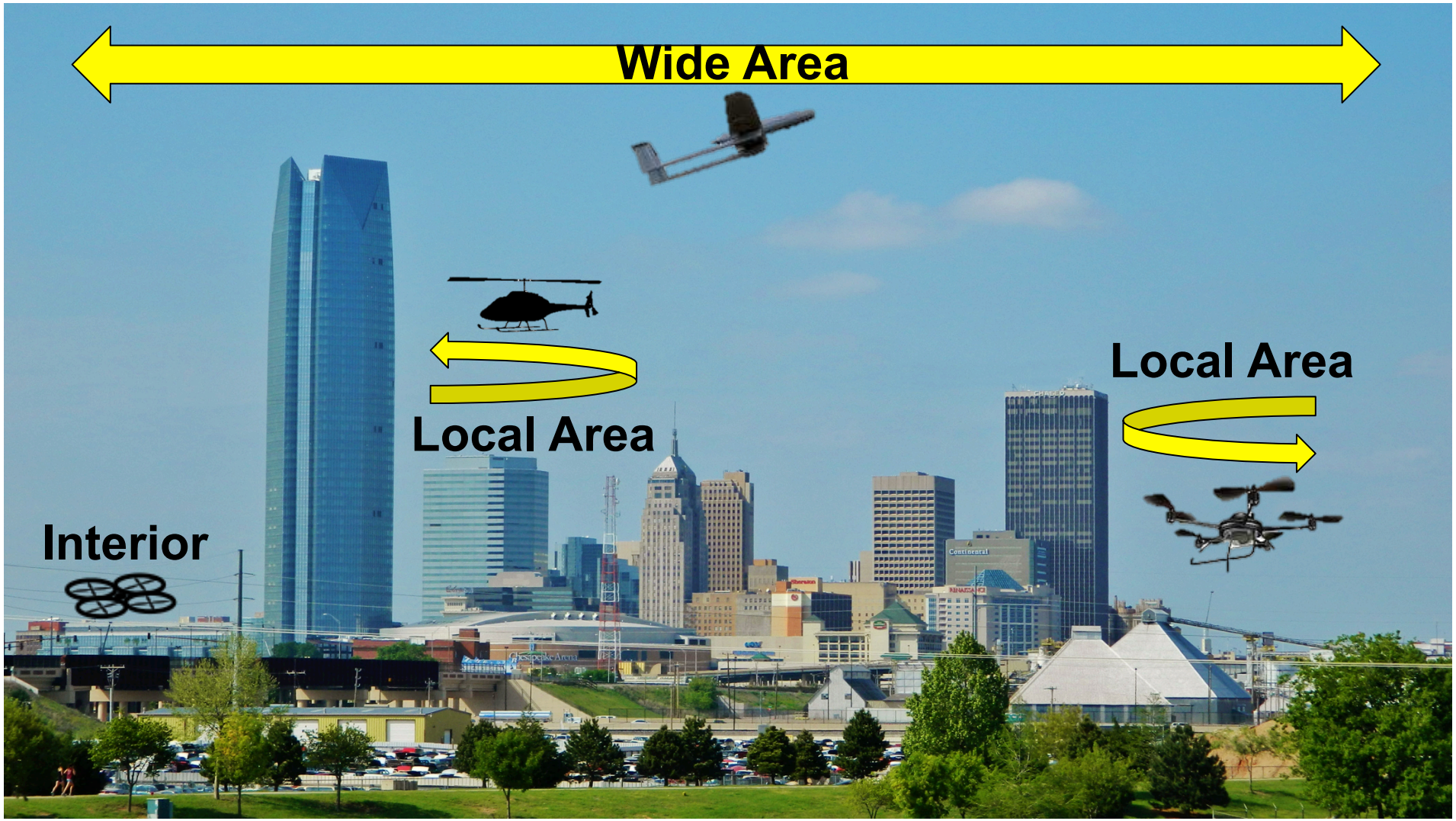
OSU AgCopter

- Multirotor
  - *Hover and stare capability*
  - *VTOL (Vertical TO and Landing)*
  - *Stable*
  - *Short endurance*
  - *Electric only*
  - *More failure points*

DJI Phantom

Roles

- Different missions (roles) require different assets



Robotic Aircraft for Public Safety Evaluation

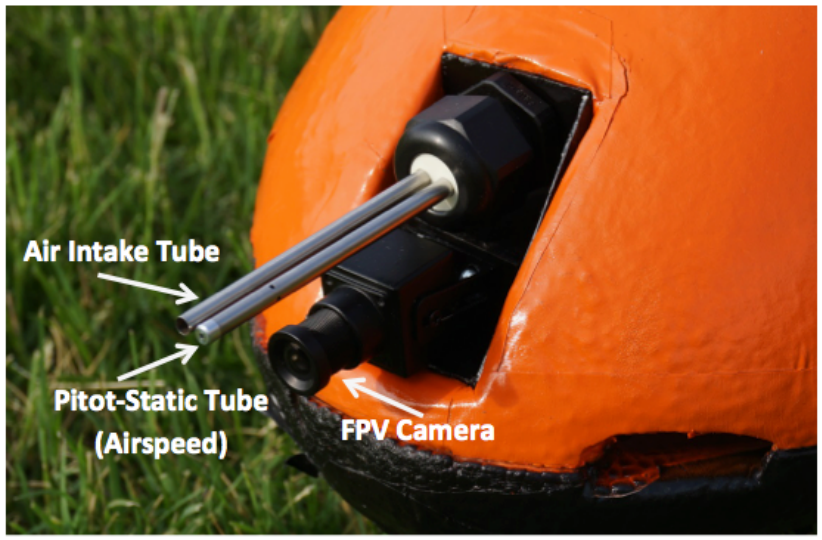
- **No one platform performs well in *all* scenarios**

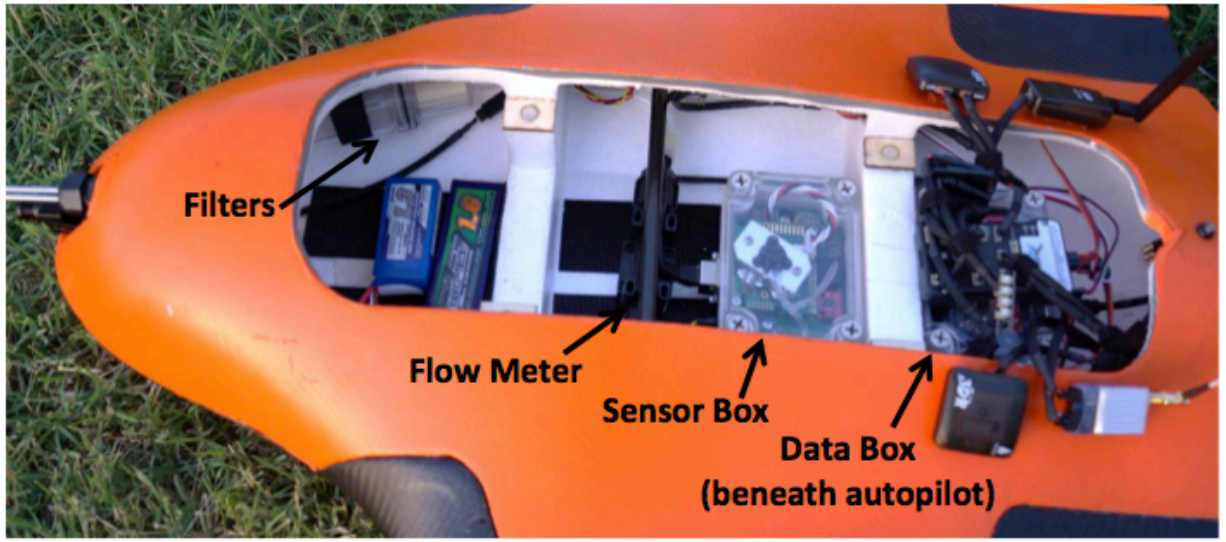
- **Fixed-wing aircraft:**
  - Very good in search and rescue (SAR), fire monitoring
  - Some fixed wing SUAS need operating areas > 200 ft radius
    - Launch and recovery zones
    - Deep stall landings affected by winds

- **Rotary-winged aircraft:**
  - Perform well in crime, accident, and arson scene investigation, and in SWAT
  - Hover ability is very beneficial
  - Some systems are relatively quiet, providing stealth, and can "perch"
  - Up to 50-min endurance was tested/verified – winds are not a limiting factor (flying in winds up to 30 mph)
  - In winds, maintain commanded flight profiles better than fixed wing aircraft

Appleby, DHS

Fixed Wing Example





OSU X8

Helicopter Example

Multi-Rotor Example

Hybrid VTOL/FW

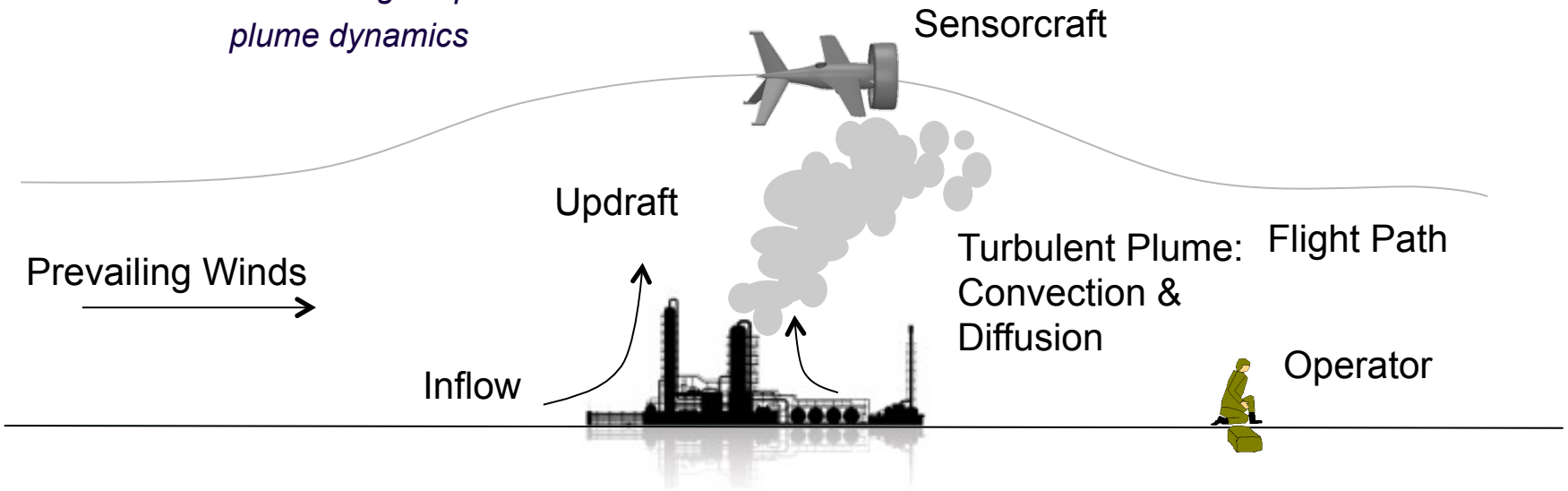
No Free Lunch:
Endurance reduced
from 12 to 6 hours

Arcturus T-15 Jump

Environmental Surveillance and Data Gathering

- Surveillance to provide situational awareness
  - *Georeferenced cameras to track boundaries and terrain*
  - *IR cameras to detect temperature variations and crew*
  - *Fuel source and load maps*
  - *Gas sensors for chemistry*
- Data gathering for models
  - *Meteorological parameters and plume dynamics*

Applications to other systems; e.g. oil & gas

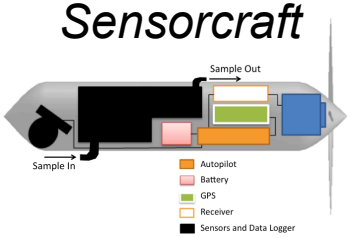


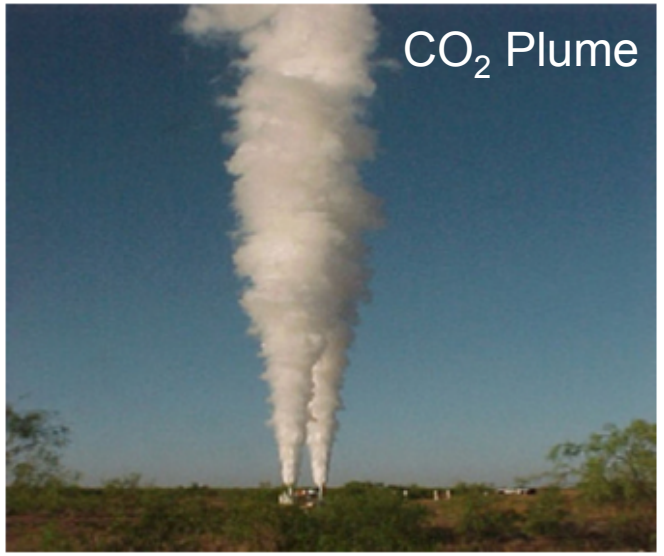
Applications

- Tracking of plume advection based on scalar concentration measurements and tracing back to source

$$\frac{\partial c}{\partial t} = -\underbrace{\nabla\cdot(c\vec{u})}_{\text{advection}} + \underbrace{\nabla\cdot(K\cdot\nabla c)}_{\text{turbulent diffusion}} + \underbrace{S_c}_{\text{source}}$$

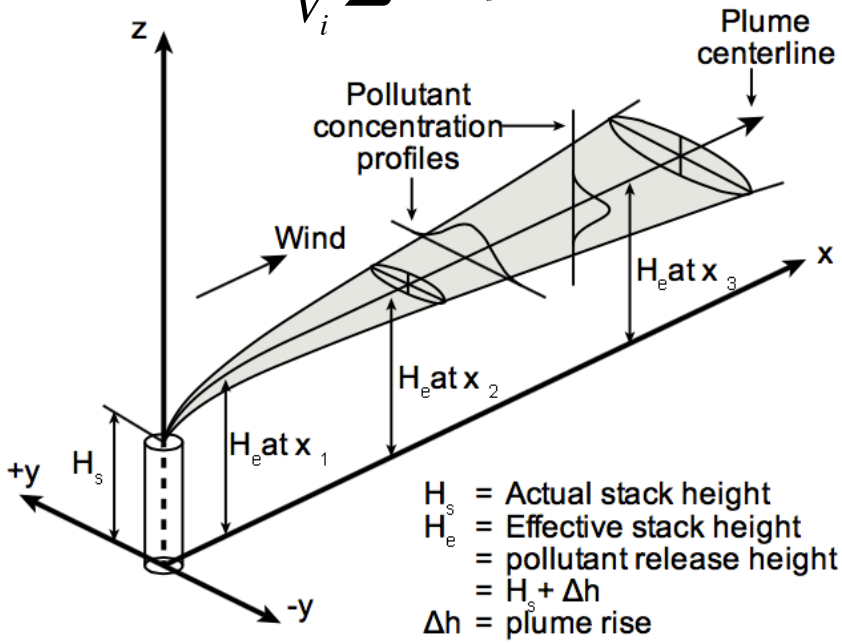
Sensorcraft

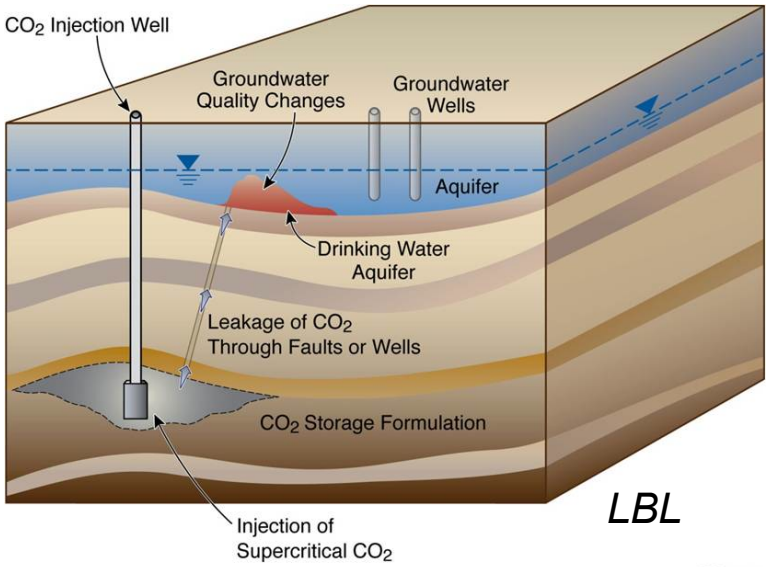




Kuijper

$$c_{i,t} = \frac{1}{V_i}\sum m_{i,t_o} p_{i,t} f_i$$

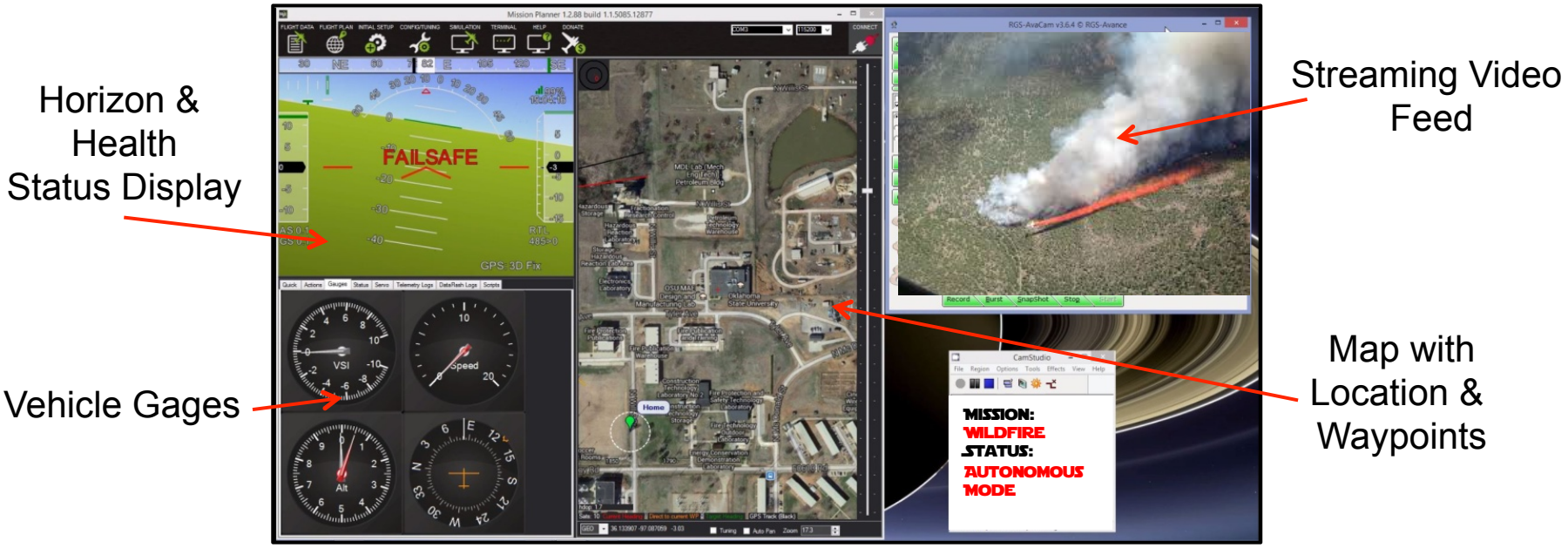




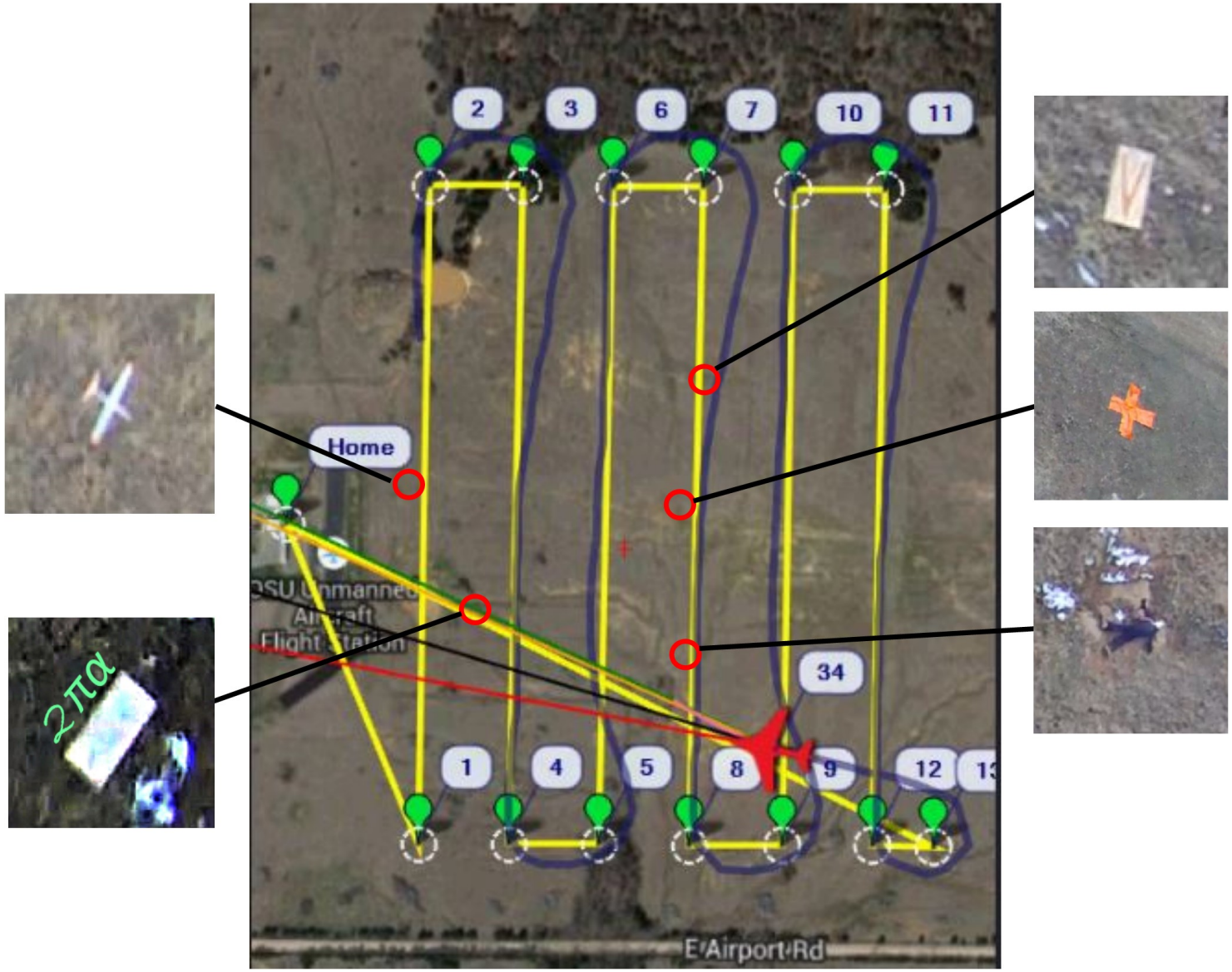
LBL

Typical Low Cost GCS

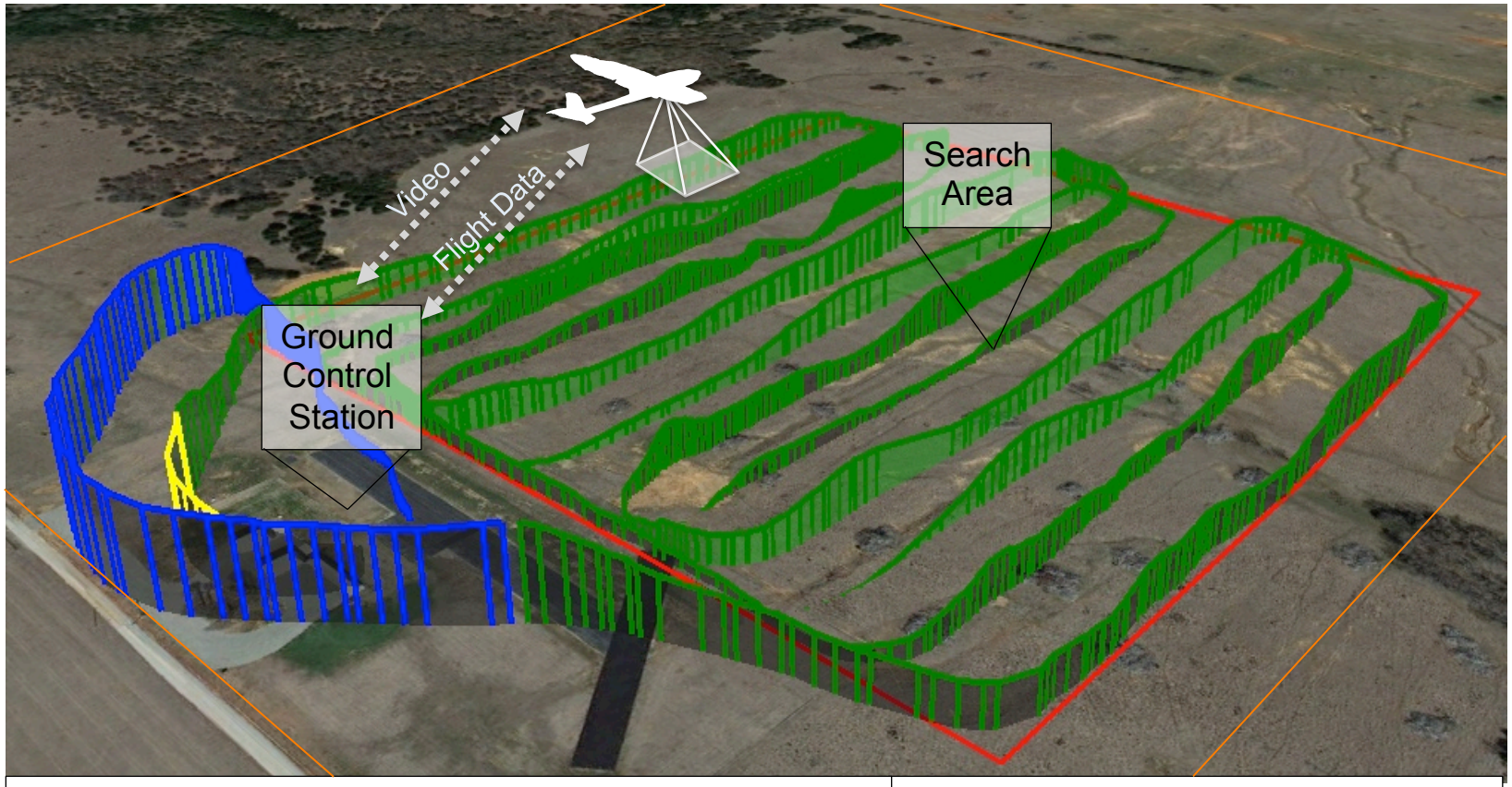
- The ground station can consist of a single laptop viewing flight information and video from the aircraft using multiple antennae for flight and video
- Platform transmits both:
  - *Video from an on-board camera to the ground station*
  - *Flight information and GPS from the autopilot.*



Sample Mission



Sample Flight Sequence



1. Launch in manual mode.
2. Enter autonomous search mode.
3. Refine flight plan on-the-fly as necessary.
4. Recover in manual mode.
5. Analyze video/images prior to next flight.

Manual Launch
Autonomous Search Pattern
Maual Recovery
Search Area
Geofence

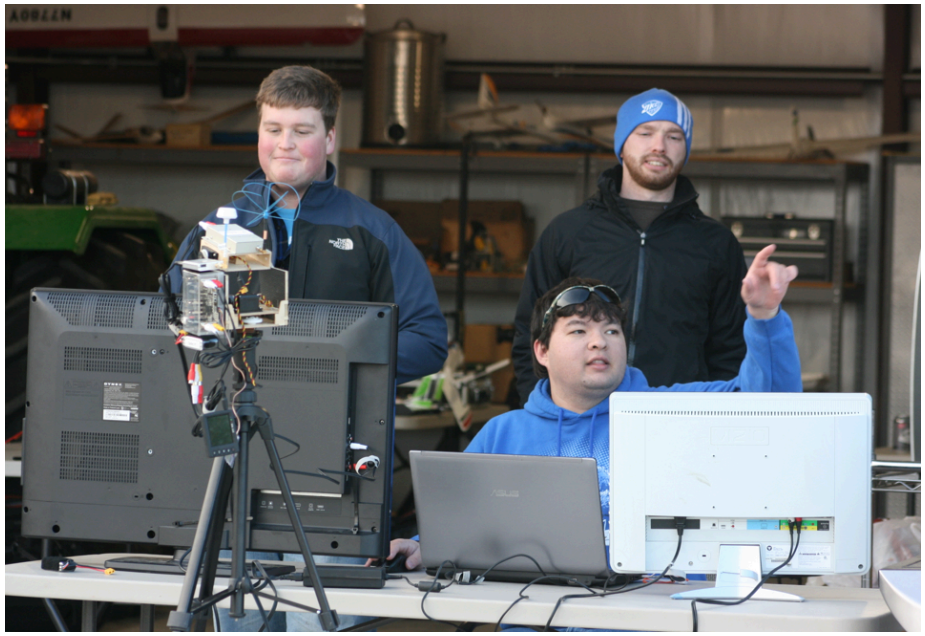
Sample Mission

Pilot (PIC) tracks vehicle status and health, varying waypoints as needed, while a separate payload operator views live video.

R/C vs. UAS Flight

Crew Roles and Tasks

Role	Operational Tasks	Non-operational Tasks
Flight Director	Observer, flight safety, data management, logbook	Team liaison, time planning, logistics
Vehicle Operator (PIC)	Aircraft control, flight planning	Vehicle maintenance
Payload Operator	Camera control and data collection, system checks	Maintenance, safety and security



The Importance of Communication

Failure Modes

- Human Error
  - *CFIT: Controlled Flight Into Terrain*
  - *Situational awareness (disorientation, system knowledge)*
  - *GIGO: Garbage In, Garbage Out*
- Navigation
- System failure
  - *Engine*
  - *GPS*
  - *Electrical*
  - *Communication (TX/RX, Video)*
  - *Other*
- Spoofing or jamming

Most Common Source of Accidents? Human Error.

2007

Schiebel S-100 Crash

- 330 lb unmanned helicopter crashed into control vehicle during training exercise in South Korea, killing one operator and injuring two more
- **Loss of the aircraft's GPS signal was an initiating event in the accident**

Mikrokopter

AIRSPACE & LEGAL STATUS

Current Legal Status

SUAS Operations

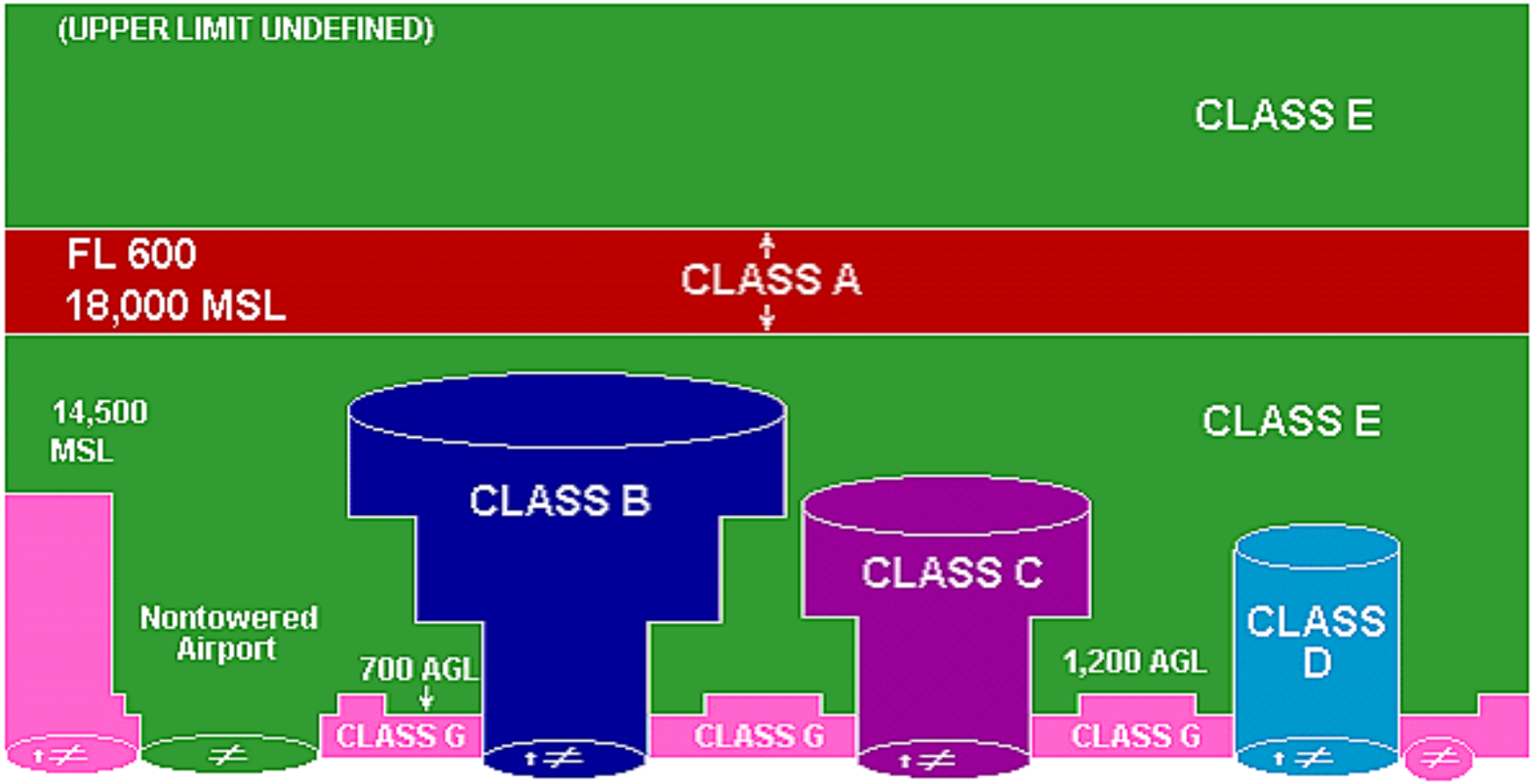
- Commercial operations are not allowed except in restricted cases under section 333 (these exemptions will grow)
- FAA is expected to release long delayed SUAS rules by end of year, but wait take effect until 2016

Ways to Legally Fly UAS in the NAS

- Private recreational use (**RC hobbyist aircraft**)
  - *Advisory Circular 91-57 (will soon be replaced by new rules)*
- Special Airworthiness Certificate (**Civil Aircraft**)
  - *Experimental Category*
    - *No Commercial operations*
    - *Can fly for development, market survey, or training*
  - *Restricted Category*
    - *Commercial operations*
    - *2 so far (Arctic operations for ScanEagle and Puma AE)*
    - *Very recently authorized over land operations by BP in Alaska (but under a COA…)*
  - *Section 333*
    - *New process – one approval to date*
- COA - Certificate of Authorization (**Public Aircraft**)
  - *Public aircraft or civil commercial operation*
  - *Specific location and aircraft under defined conditions*
  - *If public aircraft , agency determines airworthiness (that's YOU!)*

Virginia Bull Run

Civilian Airspace Classification



FAA

Airspace Classes	Communications	Entry Requirements	Separation	Special VFR in Surface Area
A	Required	ATC clearance	All	N/A
B	Required	ATC clearance	All	Yes
C	Required	Two-way communications prior to entry	VFR/IFR	Yes
D	Required	Two-way communication prior to entry	Runway operations	Yes
E	Not required for VFR	None for VFR	None for VFR	Yes
G	Not required	None	None	N/A

Examples:

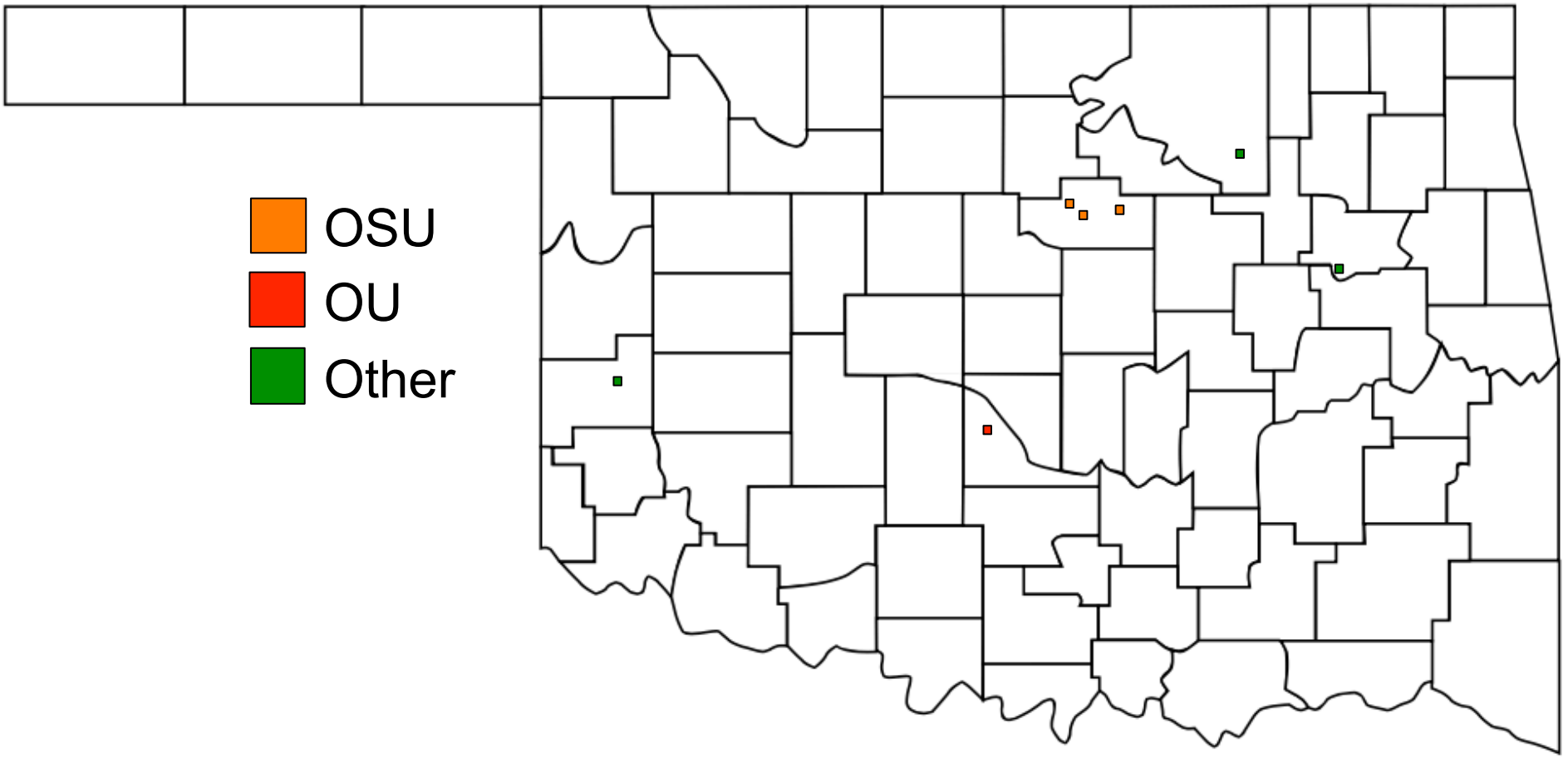
DFW – Class B

OKC – Class C

Stillwater, Max Westheimer – Class D

OSU/OU UAS Fields – Class E/G

Current OK COA Sites



Some Basic Rules of Operation

- VFR conditions (daytime, aircraft visible)
- PIC must be trained in UAS operation (operator defines what this training entails); may also need to be licensed pilot (this is recommended)
- Observers required to monitor airspace/UAV
- Class II medical required for PIC and observers
- Must be at least 5 miles from airport
- Class G or E airspace
- Aircraft must be registered with FAA and require an “N” number
- Operations must be for “aerospace research”
- See https://www.faa.gov/uas/regulations_policies/

SUAS Rules

- What will the SUAS look like?
- Refer to 2012 FAA Reauthorization Act for guidance
- The 2012 reauthorization bill directed the FAA to "allow a government public safety agency to operate unmanned aircraft weighing 4.4 pounds or less" under certain restrictions. The bill specified these UAS must be flown within the line of sight of the operator, less than 400 feet above the ground, during daylight conditions, inside Class G (uncontrolled) airspace and more than five miles from any airport or other location with aviation activities.

The Future?

Questions:
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