

Delaware Wing HQ, Civil Air Patrol



sUAS in CAP

Development of small Unmanned Aerial Systems



Advent of the sUAS

- Small Unmanned Aerial Systems have become very common recently
 - Sophisticated microprocessors
 - Solid state gyros and accelerometers
 - Strong public interest
- Most sUAS are quadcopters, hexacopters or octocopters
 - Generically known as Multicopters
- sUAS are so popular that the FAA has instituted special rules governing their (commercial) operation
 - All commercial operation – including CAP operation – are governed by CFR 14 part 107
 - Hobbyists are governed by non-governmental organizations such as AMA



Why sUAS for CAP?

- One of our missions is post-disaster photography using light aircraft
- Following the tornados in Moore, Oklahoma of May 2013 CAP could not fly much for several days because of low clouds and visibility
- Ground imagery was collected in Moore, but in some cases was very limited due to legal restrictions for how we collect under AFAM status
- The concept of using sUAS to supplement the light aircraft was developed with FEMA & DHS
- Multiple images from low-flying sUAS can be stitched together into a single mosaic image



Exploratory steps

- DHS Science and Technology funded an R&D project with Innovative Imaging and Research (I2R) to develop an sUAS package to fill the gaps
- I2R fielded a hexacopter unit that could be used for collection of imagery over small areas like neighborhoods after a tornado
- CAP/DO contracted with I2R to then deliver and train personnel from 8 wings as our beta units
- The systems were deployed to these wings in the summer of 2016
- DE wing gained a lot of experience flying the hexacopter, but concluded that there are other options that need to be considered for the varied missions that CAP supports with imagery collection, especially large area collections



Integrity-Volunteer Service-Excellence-Respect





Match performance to our mission

One of the primary Civil Air Patrol sUAS mission profiles is to provide post-disaster imagery to relief organizations from which they may direct aid and support over large areas.

Criteria

- Maximum area of coverage
- Automatic generation and execution of grid structure flight plan
- Stable and secure photo platform
- Easy field deployment and setup, unimproved terrain operation
- Rapid and painless post-processing to generate suitable data files (pictures)
- Easy training, good supply and support

Is a multirotor the best choice for this mission profile, or should we consider a fixed-wing sUAS?



Fixed-wing sUAS vs Multirotor for Large Area Collection Missions

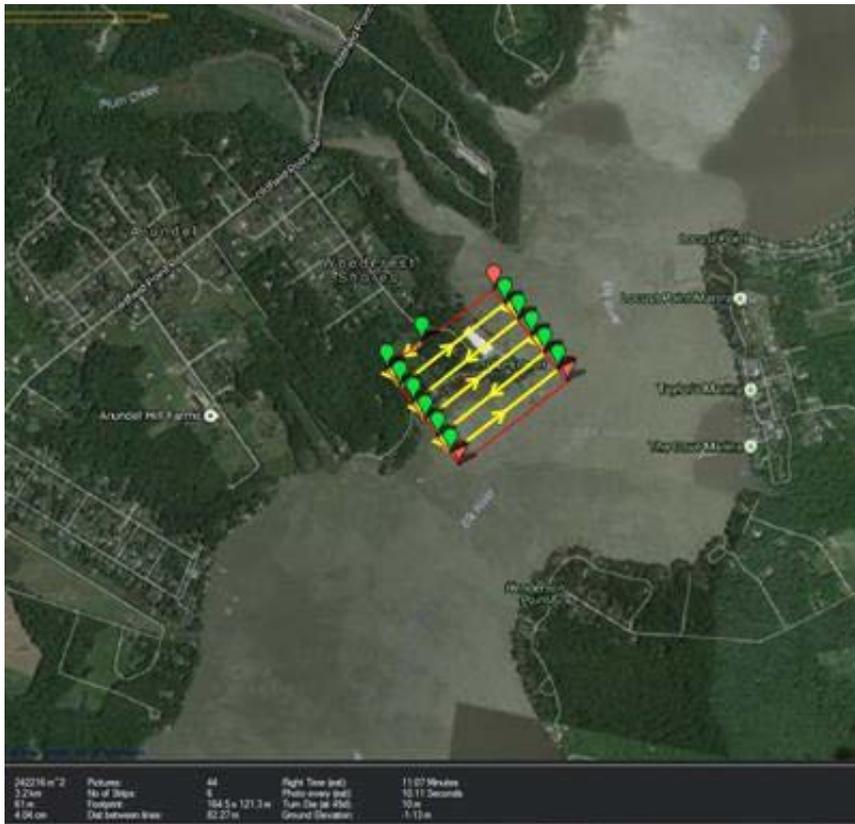
Criterion	MultiCopter	Fixed Wing
Maximum area of coverage	Underperforms - Limited by low speed and high energy consumption	Meets Criteria – Flies faster and uses less energy than a multicopter
Automatic generation and execution of grid structure flight path	Meets Criteria. Mission Planner and Pixhawk are industry standards. Systems using proprietary software may be less attractive to CAP	Meets Criteria. Mission Planner and Pixhawk are industry standards
Stable and secure photo platform	Underperforms. Poor wind performance, exposed camera, but gimballed cameras on some vehicles allow higher speeds. Does allow for continuous imagery collection from a fixed point though.	Meets Criteria. Able to penetrate winds up to 20 knots. Camera internal and protected. Most units can only circle targets though, review of items of interest can be limited
Easy field deployment and setup, unimproved terrain operation	Meets Criteria. Can be deployed and recovered from small sites. However, limited area coverage requires frequent relocations	Meets Criteria. Requires larger fields for deployment and recovery, but can cover 5x to 10x the area of a multicopter so relocation is less problematic
Rapid and painless post-processing to generate suitable data files (pictures)	Underperforms as evaluated, but more solutions are coming available all the time	Same as multicopter
Easy training path, Supply and Support	Underperforms. A multicopter is inherently fragile and hard to repair in the field without experienced technicians.	Meets Criteria. A fixed wing UAV is robust and easily repaired in the field.

This does not mean that there isn't a place for hexacopters in the CAP mission set. CAP will still be deploying hexacopters, but also expects to field lower end COTS products like DJI quadcopters for first person view support as well as higher end fixed wing assets for large area collections

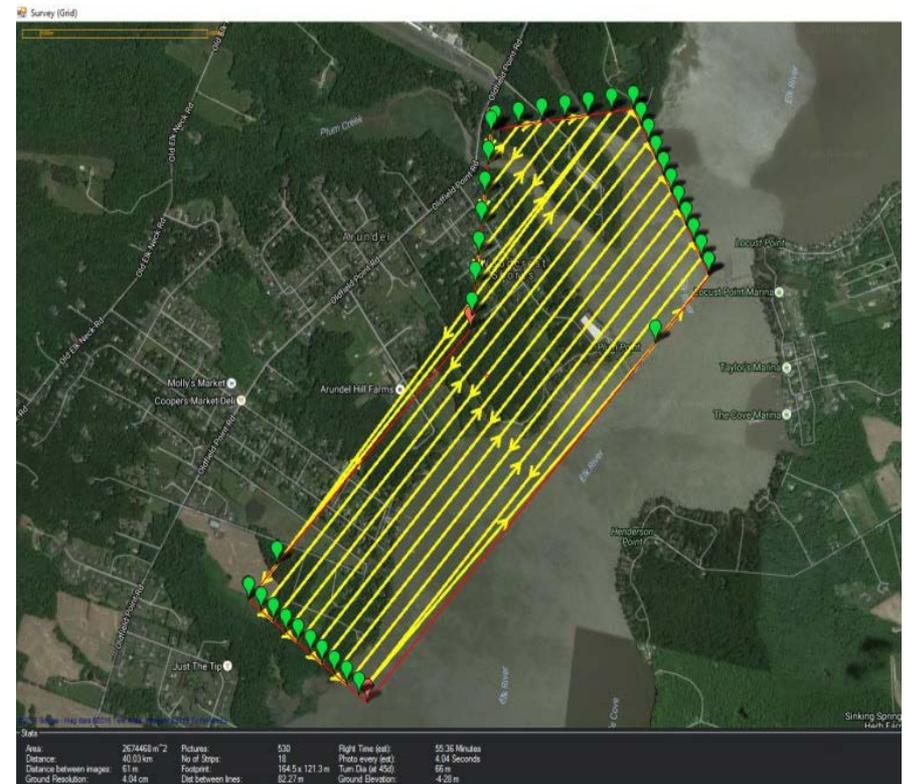


Coverage comparison – multirotor vs fixed wing sUAS

Multirotor maximum coverage



Fixed wing coverage using same battery capacity





DE wing financed a fixed-wing test vehicle

- Compared apples to apples
 - Used the same batteries, ground control station, autopilot, camera
- Built and tested a RiteWing DRAK
 - 60” wingspan, 10.6lbs with batteries and payload
 - Constructed from expanded polypropylene – tough and repairable
 - Flies at 32kts vs hexacopter 12kts
 - Lower power consumption 14A vs 40A (*think airplane vs helicopter*)
 - Launched by bungee catapult, lands on belly
- Fixed-wing DRAK covers 10x area compared to F800 hexacopter
- Several test flights were made to
 - Tune autopilot parameters
 - Measure current drawn and battery capacity
 - Evaluate automatic takeoff and automatic landing
 - Check camera capability in fixed-wing vehicle



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Demonstration flight



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Composite image after processing



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What next?

- Fixed-wing sUAS was shown at Winter Command Council
 - Great interest from DO and USAF
 - Question: Should CAP build and deploy such systems?
- Suggested commercial system
 - Several companies are in the business
 - Backed by strong sales or parent companies
 - Continuing supply and support



Sent out a Request for Information

- List of possible vendors was derived from trade show attendees
 - Our evaluation hexacopter system cost approximately \$10K: that is the benchmark price
 - Limited to systems in the \$5K - \$20K range
 - No military systems
 - Suggested CAP would purchase 10-15 systems per year for several years
- Working with DO, an RFI was sent to 15 companies
 - Team of 6 reviewed all responses
 - Follow-up questions regarding size and financial stability were sent to 6
 - 3 companies were chosen for close consideration
- Since we have not sent out a RFQ or done the other legally required steps, I will not identify the companies by name
 - Following slides show what we consider to be the best solutions for CAP



Recommendation 1

- Inexpensive but very capable system
 - Less than \$6K / system
 - 6.2ft wingspan, 5.6lbs
 - Cruise 26kts
 - Up to 90 minutes endurance, 1000 acres/flight
 - Excellent for deploying to multiple CAP wings, great for Aerospace Education and cadet involvement
- Financially stable company
 - 7 employees, self-funded by sales revenue
 - Over 400 systems sold to many countries
 - Used for land surveying, agriculture, conservation, archaeology etc..
- Other products
 - Higher end aircraft with laser rangefinder for better autoland
 - Data management system for automated image stitching
 - Provide imagery in .kmz format for easy inspection by disaster relief organizations





Recommendation 2

- Very professional response to RFI
 - \$22.7K - high priced but top end performance
 - 9ft wingspan, 17lbs
 - 90 min endurance
 - Stable in up to 30mph winds
 - Kevlar, carbon fiber
 - Recommend for regions, or as funds permit
- Stable company funded by system sales
 - Supplier to USG and USACE
 - Second source to military procurements for RQ-11B and RQ-20A parts
 - Water-landing version available





Recommendation 3

- Alternative to Recommendation 2
 - \$19.5K, high priced but capable system
 - 8ft wingspan, 12lbs
 - Recommended max wind 25kts
 - Launch by bungee, parachute landing
 - Sophisticated C&C communication, video
- Subsidiary of \$38M company
 - 400 employees, 19 locations
 - Supplier of aviation services to USAF





Future steps – Part 107 exemption

- CFR14 Part 107 has constraints which may affect CAP
 - Must fly Within Line of Sight (WLOS)
 - No flying over uninvolved people
 - Max altitude 400 ft.
 - Daytime
 - ... others
- Waivers may be granted, but only if CAP can demonstrate to FAA that we can fly safely; FAA wants to see experience under normal 107 operations first
 - What happens in the event of a power or control failure?
 - How will we see and avoid manned aircraft?
- We recommend that initially CAP flies WLOS up to 1 mile in each direction
 - Absent tall trees, this is still WLOS
 - In the case of a rectangular reconnaissance area, this exceeds the battery endurance anyway
 - Additional area is covered by relocating and launching again
- For future BLOS we are investigating sensing technologies
 - ADS-B is the most promising
 - But ADS-B only detects aircraft equipped with transponders or ADS-B (out)
 - What about ultralights, powered parachutes etc.?
 - May have to rely on FAA declaring a TFR to keep encroaching aircraft away
- Cameras for night options are already available and will likely be in some of the next tests once Part 107 day experience is gained



Current Status

- We have a test F-W sUAS with endurance of 75 minutes, photo coverage ~1000 acres
- DE-Wing has 4 active pilots with FAA sUAS licenses
- Can deploy and fly demonstration sorties as hobbyists, but waiting for CAP input before we deploy under Part 107 on A or B missions
- Have identified 3 strong contenders for general deployment to CAP wings. Must wait for funding input before we issue RFQ; all vendors will be considered in the future either way as new products are being released every day
- Indications are CAP NHQ will likely fund another lower cost unit to gain experience with first, and look at demonstrations or fly-offs for others
- For the moment we can fly without Part 107 waivers, but are working on technologies for future deployment BLOS and over people.