UAVs in SAR/Disaster Response

Regulations, Missions, Requirements, and Operations

Who Am I

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Reality Check

cville

They're here: Search and rescue drone registered in the county

SkyRanger Used in Police Search for Missing University Student

By Press - 3 October 2014

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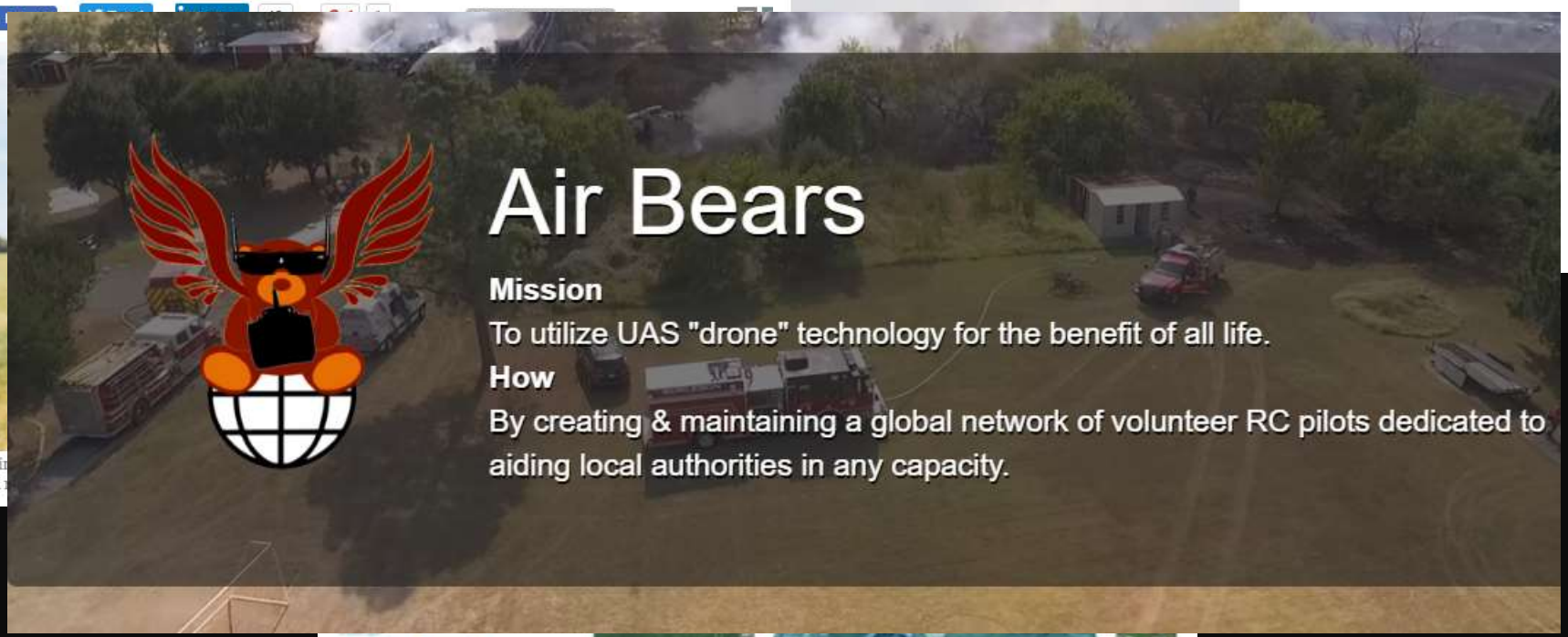
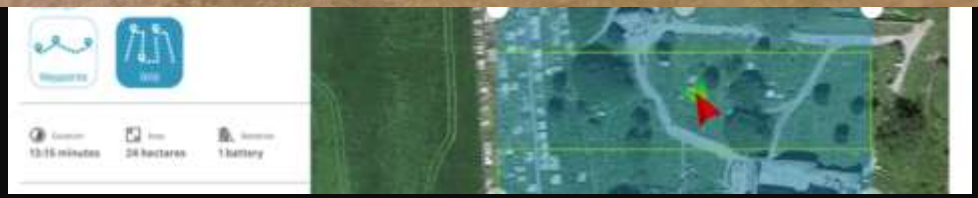




David Kovar - National Association of Search and Rescue

Reality Check - Challenges

- Regulations prevent flight beyond visual line of sight
- Most multi-rotors are limited to ~20 minutes of flight time at 20 mph
- Cannot see through vegetation
- Detecting a human at altitude via screen on mobile device is very difficult
- Hills, buildings, dense vegetation interfere with control and data links

Types of Search and Rescue Missions

- Wilderness
- Mountain
- Wide Area Search
- Urban

- Swiftwater
- Flood
- Surf
- Maritime

- Missing Aircraft

- Mine
- Cave

- Mudslide
- Earthquake

- Damage Assessment

- HAZMAT
- Technical rescue

UAV workflow

Mission Planning

- Criteria
- Airframe
- Payload
- Operator
- Location
- Time frame

Approval

- Business
- Site logistics
- Safety
- Legal
- Risk
- Flight operations

Execution

- Logistics
- Flight crew
- Weather
- Flight operations

Analysis

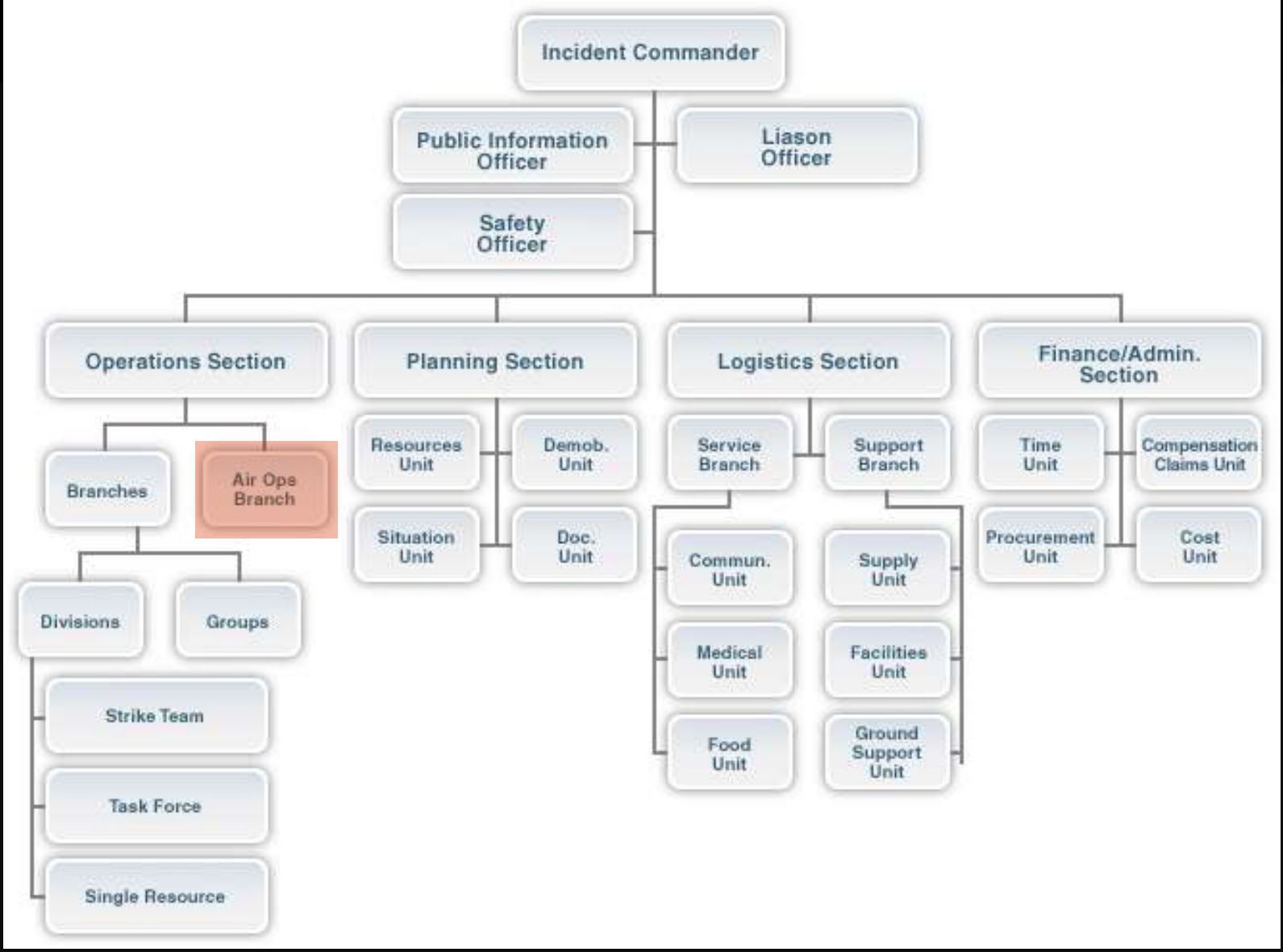
- Data validation
- Product generation
- Quality assurance

Delivery

- Product delivery
- Product support
- Lessons learned
- Reporting
- Billing

Who Manages the Workflow? AIROPS

Air Operations



Air Operations Responsibilities

- Organize preliminary air operations.
- Participate in preparation of the Incident Action Plan (IAP) through the Operations Section Chief (OPS).
- Perform operational planning for air operations.
- Supervise all air operations activities associated with the incident.
- Determine coordination procedures for use by air organization with ground Branches, Divisions, or Groups.
- Evaluate helibase locations.
- Establish procedures for emergency reassignment of aircraft.
- Report to the OPS on air operations activities.
- Report special incidents/accidents.

Air Operations Responsibilities

External Coordination

- Request declaration (or cancellation) of restricted air space area, (Federal Aviation Administration Regulation 91.137).
- Coordinate with FAA.
- Schedule approved flights of non-incident aircraft in the restricted air space area.
- Resolve conflicts concerning non-incident aircraft.
- Arrange for an accident investigation team when warranted.

Temporary Flight Restrictions

- A TFR and positive control over air assets should be established at the start of the incident
- The Air Operations branch should be established at the start of the incident
- Air operations component of IAP must be established before commencing air operations
  - Minimize pilot workload
  - Include all possible types of air assets
- De-conflicting options must be established:
  - Operational areas
  - Vertical distance
  - Horizontal distance
  - Timed access

What is The Right UAV for SAR?

What Are The Mission Requirements?

Aircraft

- Range
- Speed
- Duration
- Useable payload
- Operational requirements (landing/takeoff)
- Logistics requirements

Payload

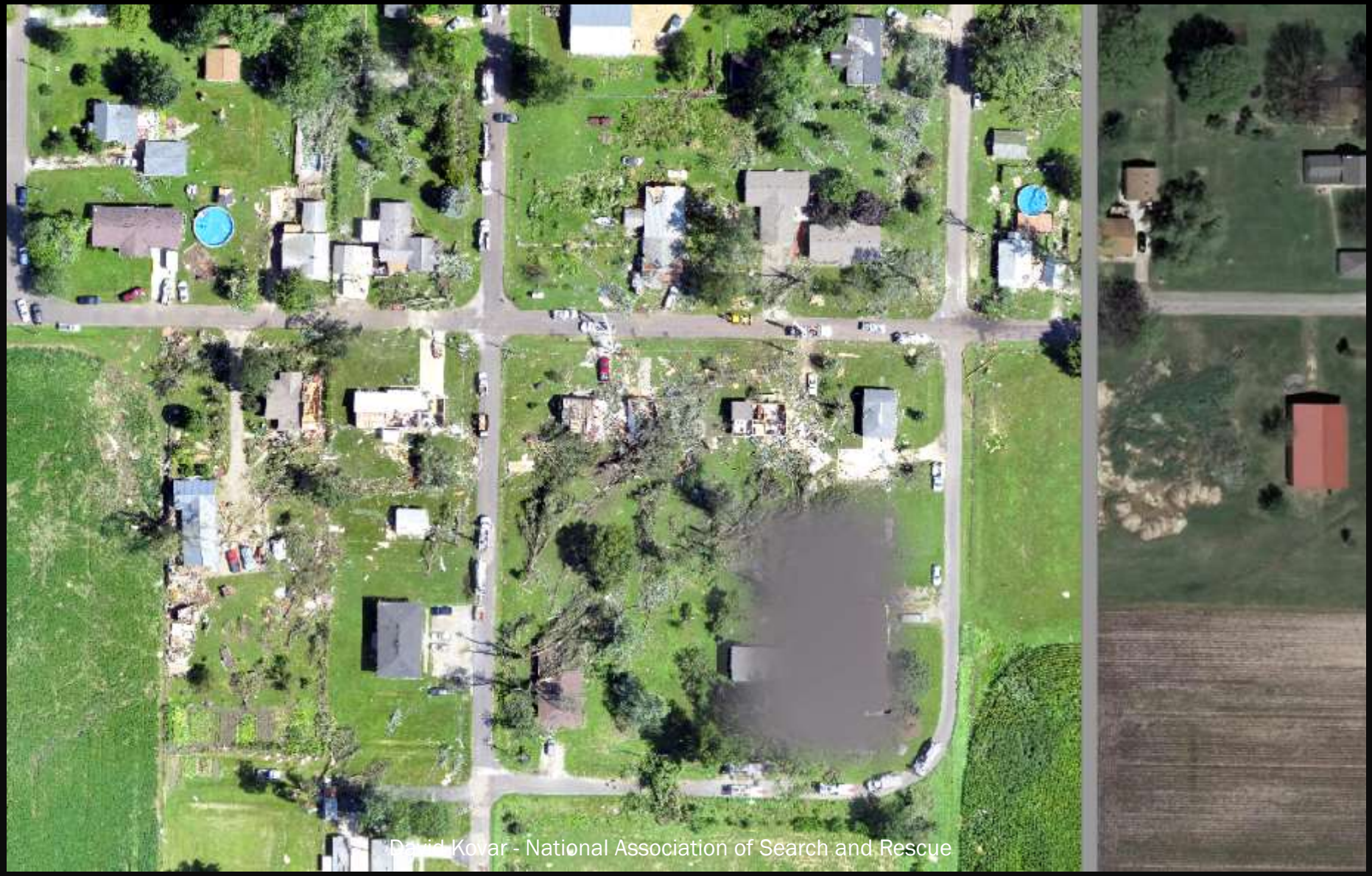
- Delivery
- Imaging
  - IR
  - Optical
  - Hyper-spectral
- Resolution
- Speed
- Post processing requirements

Requirement Examples

- Resolution:
  - What resolution do you get with a 12MP sensor at 300 feet and 75% overlap?
  - What resolution do you need?
  - How much time do you want to spend?
- Endurance
  - How far is the best launch point from the area to be searched?
  - How much time on station will you have?
  - How many missions will it take to cover the area of interest?
- Sensor selection
  - What are you looking for?
  - What is the terrain? How much tall vegetation?

Requirement Examples

Requirement Examples



Mission Plan Examples

Situational Awareness

- Acquire high resolution imagery for entire search area, land, process, and deliver.
- If confined area, shoot 360’s at various elevations
- If terrain component, consider printing a 3D model. (Mudslide, earthquake, collapsed structures)
- If complex terrain, may need to do vertical slices following contours

Structural Inspection

- Generally 3 stories and up, viewed straight on. (Elevation views)
- Favors real time video with structural specialist in the loop
- UAV will need to be in close proximity to structure. RF & GPS likely affected
- Engineers will not know what the best angle is, or what they are looking for, until they see it
- Current 3d models introduce artifacts that confuse the situation. Video likely best for the moment. LIDAR and laser better but expensive

Search

- Search for persons in distress or missing
- Take high resolution geotagged imagery and process with trained experts. (Mechanical Turk)
  - Studies show that it is difficult for field personnel to see clues due to screen size, glare, motion
  - Experts can tag points of interest for follow up missions
  - Formal methods exist for rating coder accuracy
- Infrared usefulness is limited to specific situations
- No current non-military sensors penetrate foliage and detect humans

Search – Hasty/Initial

- Preplan flight routes along trails and to likely locations
- Execute plan on a schedule
- Include attraction component
- Real time and post flight analysis

Search - Grid

- Preplan grid – most ground control stations (GCS) will do this
  - If not building orthomosaic, overlap can be reduced
- Consider sensor field of view and desired resolution
  - Higher resolution, longer flights, less area covered
  - Looking for clues, not subjects

Search - Evidence

- Specialized sensors may be required
- Unmanned ground vehicles may be more appropriate
- Good for scene documentation

Platform Selection

Primary Platform Considerations

- Does the payload and control style match the mission data needs?
- Does the platform match the environment?
- Is still imagery geotagged? Can telemetry be matched to video?
- Can the system be transported to the sites?
- Does the GCS capture a copy of the imagery or is it all on board the aircraft?
- Is the data in a proprietary format or require Internet access?
- Can the system be recharged, refurbished, repaired in the field?

Chose a Fixed Wing When ....

- Large areas need to be covered or area is a long distance from landing zone
- Extended time aloft is required
- Operations are over people and property and ability to glide away in the event of failure is desired
- Good landing zone is available

Chose a Rotorcraft When ....

- The landing zone is small or heavily obstructed
- The search area boundaries are small, or area of interest is next to a boundary (fence, tree line, cliff face)
- The terrain is too complex for an automated flight planner
- Real time reconnaissance with man in the loop is required
  - “Wait, go back!” is hard in a fixed wing

In Some Ways, Very Similar

- Visual Line of Sight (VLOS) rules limit fixed wing's extended duration capabilities
- As batteries improve, rotorcraft are able to fly longer though UAVs will still win on energy efficiency
- Parachute recovery systems help fixed wings in tight spaces
- Fixed wing will always have a better power/payload ratio

UAV workflow

Mission Planning	Approval	Execution	Analysis	Delivery
Criteria	Business	Logistics	Data validation	Product delivery
Airframe	Site logistics	Flight crew	Product generation	Product support
Payload	Safety	Weather	Quality assurance	Lessons learned
Operator	Legal	Flight operations		Reporting
Location	Risk			Billing
Time frame	Flight operations			

Regulatory Framework

Public Agencies – COA vs Part 107

- **Part 107:**
  - Enables public agencies to operate without obtaining a CoA, providing all of their operations can be done within that set of regulations
  - Less overhead to establish and manage
  - Some risk and liability shifted to the FAA
- **Blanket CoA:**
  - Opportunity to utilize the emergency CoA process.
  - Allows for flights over people provided they remain within an incident perimeter. (Not allowed under Part 107)
  - Facilitates faster mutual aid requests and easier integration of other non agency entities, like SAR organizations to operate anywhere in the area under the agency's CoA

Public Agencies – COA vs Part 107

- **Use Part 107 if:**
  - You are a small agency
  - Your requirements fit under Part 107 restrictions plus waivers
  - Someone else (county, state) will handle multi-jurisdictional events
- **Use a COA if:**
  - Your requirements exceed Part 107
    - Flying at night, flying over people outside of incident boundary
  - You are responsible for multi-jurisdictional events
  - You may need emergency changes to your restrictions
- **Belt and suspenders – use both**

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Flight Crew

Flight Crew:

1. Pilot in Command (PIC)
2. Visual Observer (VO)
3. Logistics, Communications, Data Management, Mission Specialist, Safety

Equipment:

- Man portable
- Capable of multiple iterations without resupply
- Self sufficient for food, water, medical, transport, some comms

Need a standard, guideline, or operational manual

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UAV into GIS Workflow

- **Basic workflow is:**
  - Flight planning
  - Flight(s)
  - Image download to review platform
  - Image validation
  - Load images into suitable platform – DroneDeploy (cloud), Pix4D (local or cloud), Drone2Map, etc.
  - Generation of orthophotos / digital surface models
  - Export data and deliver to GIS

Data Validation

- Did you collect imagery of the area specified in the assignment?
- Is it complete?
- Any flaws in the imagery?
- Is supporting documentation complete?

Product Generation Questions

Is image analysis an Air Operations function? (No)

Is image analysis the responsibility of the UAV operator (Yes)

Who receives the final product? (GIS in Situation Unit under Plans)

What products are needed?

When are they needed?

How best to get them done on schedule?

Who owns the data?

Why UAV Teams Generates Product

- UAS Team/Unit should have the best understanding of the capabilities of their sensor(s)
- Data processing likely requires specific, probably custom, workflow
- Data processing likely requires custom or platform specific tools
- Data processing likely requires more computational power than is available in the GIS unit (if there is a GIS unit)

Requirement helps ensure that UAV team has thought through entire workflow rather than focusing on just flying

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Delivery & Data Policy

- **If flying for an agency then the agency controls the data and all press goes through their PIO.**
- **Establish written policy in advance – UAV operator turns over all data and meta data to agency. Option - operator may keep a copy but may only release it with approval from agency.**
- **<u>Chain of custody is crucial as it is impossible to know who will use the data and what is in the data</u>**
  - Agencies may have public accountability issues
  - There may be legal or forensics data in the data set
  - There may be deceased individuals or personally identifiable information in the data that is not initially obvious

Lessons Learned

- What Points of Interest (POIs) produced actionable results?
- What was the effectiveness of each UAV platform for each mission?
- What worked and did not work in the processes?

Document and share what you can.

R&D + actual experience is crucial to us all

How to Get Involved in SAR with UAVs

David Kovar - National Association of Search and Rescue

How To Get Involved

Volunteering during an incident with no established relationship will likely not be effective.

AFTER the incident is over and everybody has had time to recover:

- Make professional, concise presentation with handout
- Make an appointment
- Show up looking neat and professional
- Remember that we may not have your enthusiasm about UAVs so keep it oriented towards emergency services and "what can I do for you”
- Leave out all the neat bells and whistles about UAVs
- Have a video presentation ready on a laptop or tablet
- Be prepared to do a demo, then to participate in training exercises

Introducing UAV Capabilities to SAR

Questions that an Incident Commander might ask an unknown UAV pilot who wanted to volunteer to assist.
This should occur before an incident, not at the incident.

- Are you a 501(c)3, private company, or individual?
- Are you insured?
- Are you covered by workman's compensation insurance?
- Have you taken ICS-100, ICS-200, ICS-700 and ICS-800?
- Are you interoperable with our agency?
- Have you been NIMS resource typed in the local and state EMA?
- Do you have a agreement of mutual aid for us to examine?

Based on discussion with Daniel P Dolata (former fire chief)

- Is this free, or do you charge?
- Who pays for lost or damaged equipment?
- How do we contact you, and are you committed to a certain maximum response time?
- Do you have an FBI criminal background check?
- Do you have a doctors examination and statement of health?
- Do you have a FAA N number?
- What logistical support would you require?
- Do you understand that all images (data) you collect belongs to the incident?

Build Relationships Early

Rescue robots are typically deployed fairly late, toward the middle of the response phase or later. My analysis of robot deployments worldwide in 2010 (Murphy, 2011b) showed that the average time between an incident and the actual use of a robot was 6.5 days. If the analysis considers only the five deployments where the mission was clearly to search for survivors (e.g., Upper Big Branch Mine; Wangjialing Coal Mine; Haiti earthquake; Prospect Towers; Pike River Mine), then the average was 4.2 days for a robot to arrive, well after the 48-hour peak in the mortality curve—too late to be of value. The biggest predictor of whether a robot would be deployed and how quickly was whether the agency in charge had a robot or a partner with robots. In four of the 2010 deployments, the agency or industry that held incident command responsibility either already used the robots in day-to-day operations (BP at Deepwater Horizon; Italian Coast Guard for a missing balloonist) or prior lines of authority were already in place [MSHA for Upper Big Branch Mine; New Jersey's regional Urban Area Security Initiative (UASI) teams at Prospect Towers]. In those four cases, robots arrived on the scene and were put to use in one-half day on average. (Credit: CRASAR)

Questions

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