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Outline for the Operational Use of Unmanned Aerial Systems During a Radiological Emergency

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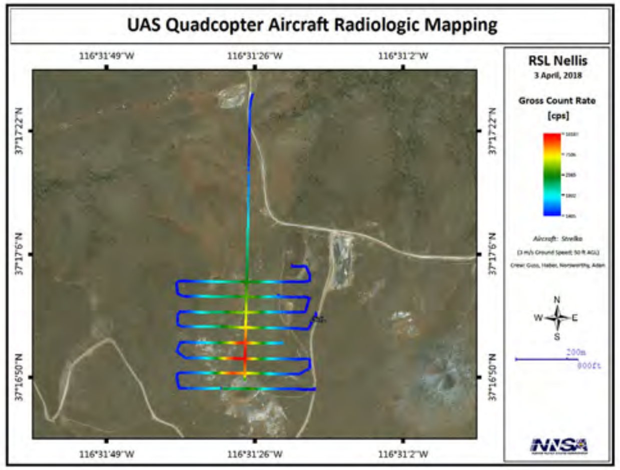
Overview

- The goal of measurements during emergency response is to obtain actionable information and relay it to decisionmakers
- UAS can be a complementary asset, filling in a mission space between aerial measurements (large area, fast, imprecise) and ground teams (small area, slow, precise)
- General operational considerations for UAS are the same as aerial and ground:
    - Sensitivity (matching detector to radiation of interest)
    - Access (getting the detector in position)
    - Data collection (collecting usable information)
    - Analysis (producing actionable results)



Aerial Radiological Measurements

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Aircraft

+

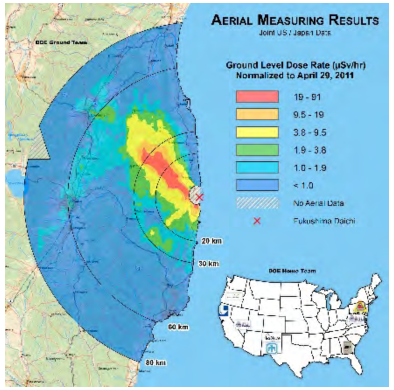
Radiation Detection Equipment

+

Trained Personnel

=

Aerial Radiation Detection Asset



DOE Aerial Measuring System

Two redundant 6 L NaI(Tl) systems

Typical survey parameters:
Altitude: 300 m
Speed: 300 km/h

25 L of NaI(Tl) mounted in external pods

Typical survey parameters:
Altitude: 45 m
Speed: 130 km/h

#AreWeReady

Altitude and Spatial Resolution

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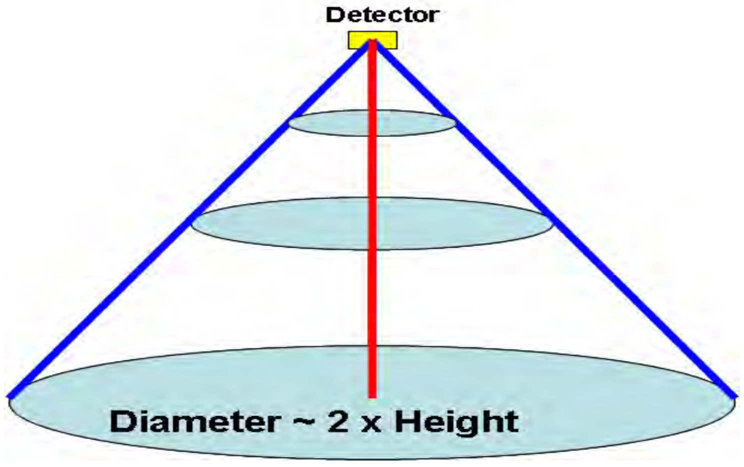
High altitude detector

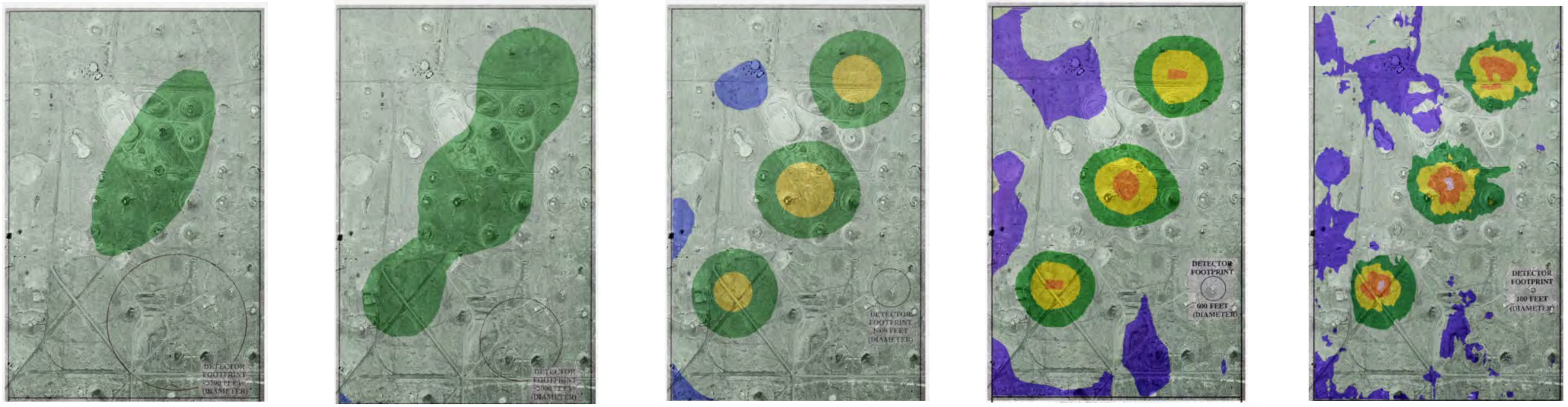
- Low resolution
- Area averaging
- Rapid coverage
- $1/R^2$ significant loss
- Atmospheric attenuation is large



Low altitude detector

- High Resolution
- Discrete sampling
- Slow coverage
- $1/R^2$ minor loss
- Atmospheric attenuation is small

535 m | 300 m | 150 m | 60 m | 15 m



Sensitivity and Rate of Coverage



	Airplane	Helicopter	UAS	
Survey altitude	300 m	45 m	15 m	100 m
Survey speed	300 km/h	130 km/h	30 km/h	
Detector volume*	6.29 L	25.17 L	0.13 L	
Distributed Minimum Detectable Activity (arbitrary units / m^2)	1	~0.03	~0.25	~1
Rate of coverage**	180 km^2/h	12 km^2/h	0.9 km^2/h	6 km^2/h

* NaI(Tl), 5.08 cm thick
**neglecting turn time, transit time, and time changing batteries/refueling for UAS

Operational Considerations – Detector and Aircraft

- What sensitivity is required? At what rate of coverage?
  - Affects: detector size, altitude, speed trade-offs
- What is the size of the area to be surveyed or searched?
  - Affects: required type of UAS operation (Visual Line-of-Sight (VLOS) or Beyond Visual Line-of-Sight (BVLOS)), required UAS endurance
- Is there a UAS available that meets specifications?
  - Consider: payload, endurance, range, speed, maneuverability and obstacle avoidance, control mode (autonomous or manual), regulatory requirements, cost

Operational Considerations – Access

- How to safely get the UAS (and detector) to where it is needed?
- What safety, autonomy, control, and navigation systems are needed?
  - Autonomous terrain and obstacle avoidance systems
  - Autonomous traffic avoidance systems
  - Air traffic control required equipment (e.g. Automatic Dependent Surveillance – Broadcast (ADS-B), Remote ID, etc)
  - Emergency systems and failsafes (parachutes, geofencing, emergency landing)
- VLOS, Extended-VLOS (EVLOS), BVLOS
  - Where will the pilot(s) be located?

Operational Considerations – Data Collection

- How will the data be collected and retrieved?
  - Real-time telemetry
  - Multi-path communications (line of sight, cell network, satellite, mesh network)
  - Telemetry from stationary sensor (landed, dropped)
  - Relay drones
  - Detector power supplies
  - Cameras, other imaging or detector systems
  - Retrieval after flight
    - Return to base
    - Remote landing

Operational Considerations – Analysis

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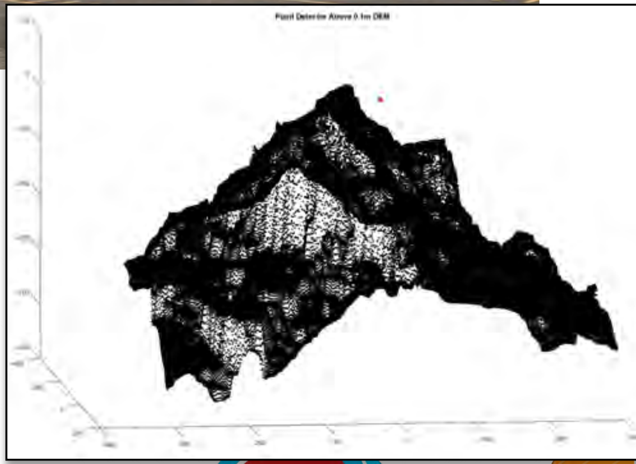

- How will the data be analyzed and communicated?
- Calibration should be done ahead of mission
  - Calibration facility (e.g., Grand Junction pads)
  - Well-characterized area
  - Known sources
- For emergency response simple calibration may be sufficient (count rate to exposure rate conversion)
- Simple altitude correction may not suffice
- Complicated topologies (urban canyons, building interiors) may require multi-dimensional deconvolution of data

Conclusions

- UAS capabilities and regulations are evolving rapidly
- Operationalization requires assessing mission requirements and identifying a capable detector and UAS combination
- Fully realizing the potential of UAS will require advanced analysis techniques to take advantage of high resolution data in complex topologies
- UAS will play a valuable role in radiological emergency response in the future, complementing traditional aerial and ground team assets