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An operational concept for small remotely piloted aircraft system (sRPAS) in nuclear emergency response

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NRCan and the Federal Nuclear Emergency Plan

- Under the 5th edition of the **Federal Nuclear Emergency Plan** (FNEP), Natural Resources Canada (NRCan) is a designated federal government institution with the responsibility under function 4.1 to "**conduct and coordinate radiological monitoring and surveying"** and must maintain a response capability to "**provide aerial and/or ground based mobile monitoring data to the Technical Advisory Group***".*
- NRCan's Nuclear Emergency Response (**NER**) team is tasked to develop, maintain and exercise this capability and, and as part of the Federal Radiological Assessment Team (FRAT), is responsible for conducting **airborne, truckborne and in-situ radiation surveys**, producing reliable maps of the radiation and supporting the Technical Advisory Group (TAG) in interpretation of the results.
- The NER team has conducted surveys in support of national and provincial emergency response exercises, major events security, environmental remediation projects and various research projects.

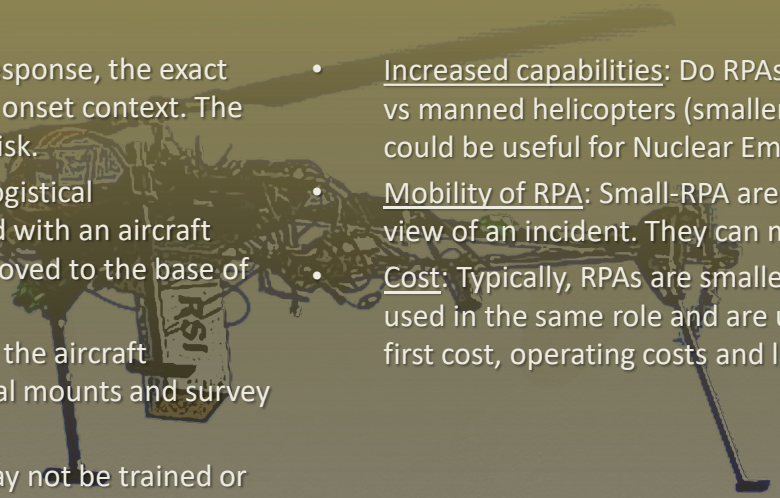
The RPAS option?

Operational hindrances to airborne emergency operations:

- Radiological risk: In an emergency response, the exact situation is unknown apart from the onset context. The safety of pilots and flight crew is at risk.
- Mobilization time: Agreement and logistical arrangements have to be established with an aircraft supplier and the aircraft has to be moved to the base of operations.
- Installation time: With support from the aircraft maintenance and flight crew, external mounts and survey system must be installed.
- Flight operations: Available pilots may not be trained or have any experience for low-level survey flying.

Can RPA provides solutions and/or added value ?

- Increased capabilities: Do RPAs have increased capabilities vs manned helicopters (smaller, more maneuverable) that could be useful for Nuclear Emergency Response?
- Mobility of RPA: Small-RPA are not limited to an aerial view of an incident. They can move *into* the scene.
- Cost: Typically, RPAs are smaller than manned aircrafts used in the same role and are usually less expensive in first cost, operating costs and labour costs of operators.



Radiometric Survey using an Unmanned Aerial Vehicle CSSP-2016-TI-2290

- Canadian Safety and Security Program (CSSP) Targeted Investment project *CSSP-2016-TI-2290 Radiometric Survey using an Unmanned Aerial Vehicle* was awarded to Natural Resources Canada and partners as a two-year project covering fiscal year 2016-17 and 2017-18.
- Followed on Technical Acquisition project *CSSP-2015-TA-2121 Rotary-wing UAV for RN monitoring*.

The two objectives of the project are:

1. Research and development of improved methods for acquisition and analysis of aerial radiometric data.
2. Development of an operational concept for less-than-25 kg RPAS in radiological emergency response.

Nuclear Emergency Response: a few definitions

- **Emergency**: A non-routine situation or event that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human life, health, property or the environment.
- A **Nuclear Emergency**: An emergency in which there is, or is perceived to be, a hazard due to:
  - The energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction; or
  - Radiation exposure.
- **Assessment**: The process, and the result, of analysing systematically and evaluating the hazards associated with sources and practices, and associated protection and safety measures.
- **Monitoring**: The measurement of dose or contamination for reasons related to the assessment or control of exposure to radiation or radioactive substances, and the interpretation of the results.

IAEA, 2007, IAEA safety glossary : terminology used in nuclear safety and radiation protection: 2007 edition, Vienna: International Atomic Energy Agency.

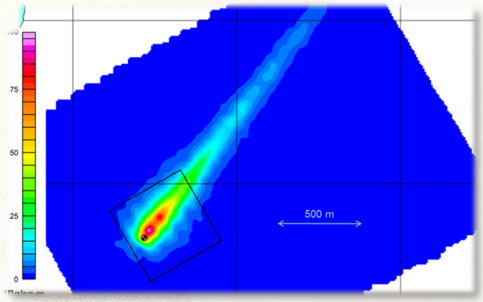
Field monitoring activities during a nuclear emergency response

mobile

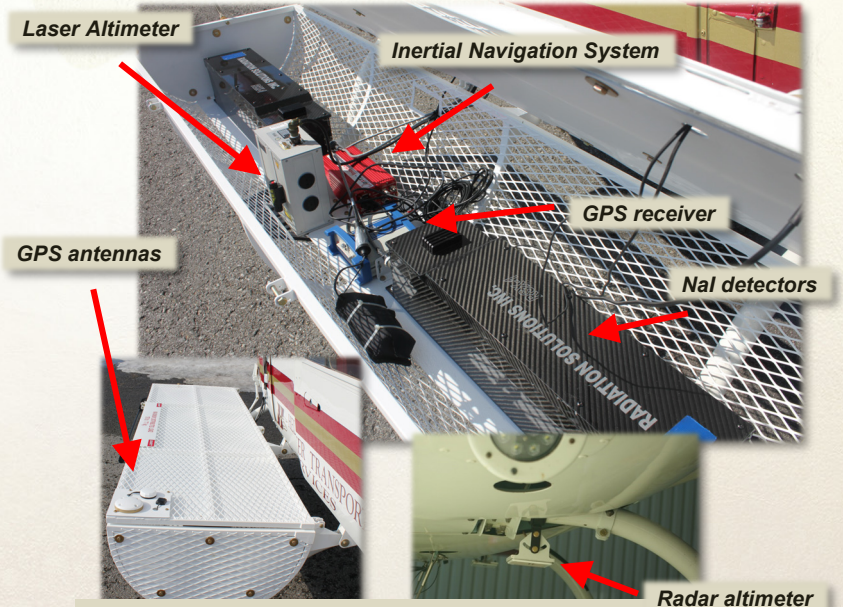
- lower resolution
- larger coverage
- lower deployment effort

- higher resolution
- lower coverage
- higher deployment effort

Nuclear emergency response: airborne mapping system

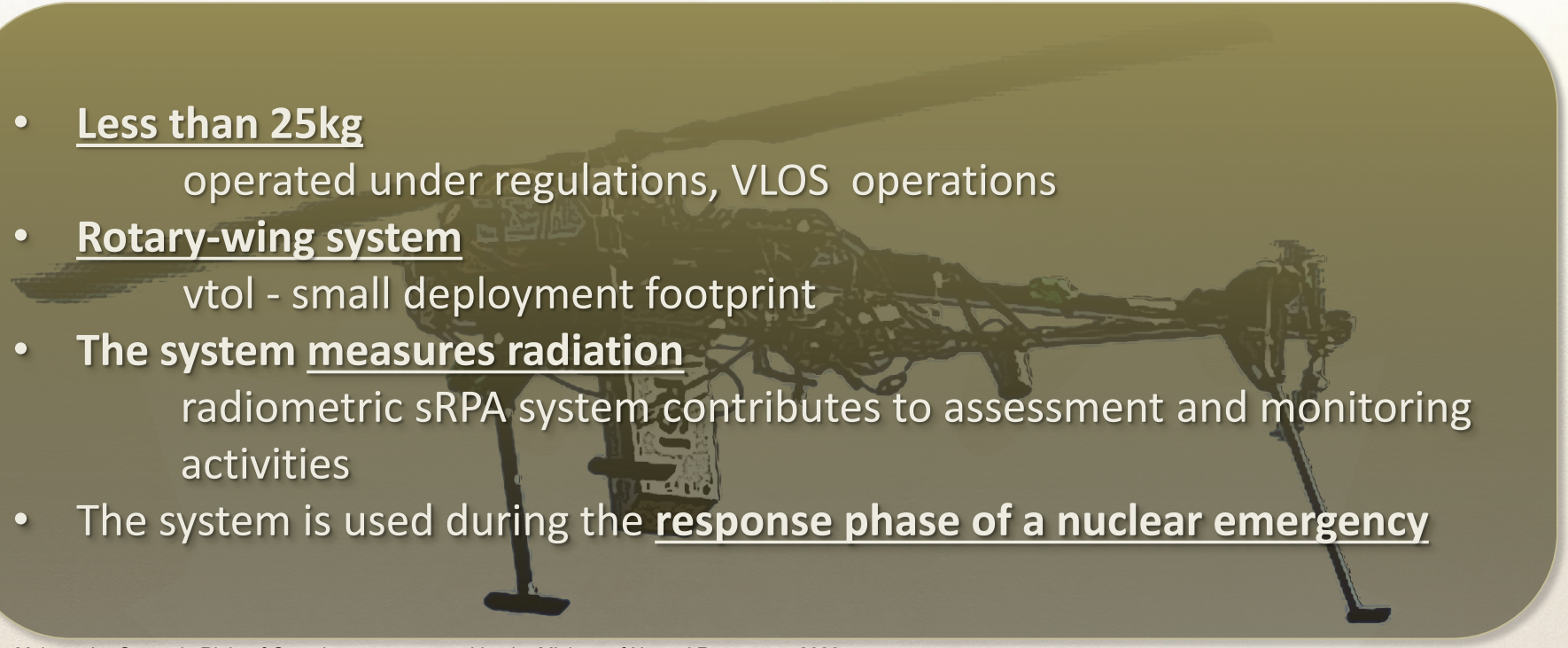


survey speed	line spacing	coverage
25 m/s (50 kts)	25 m	0.5 km^2
60 m/s (120 kts)	100 m	50 km^2



Radar altimeter (mounted on skid brackets)
Pressure/Temperature sensor (not shown on picture)

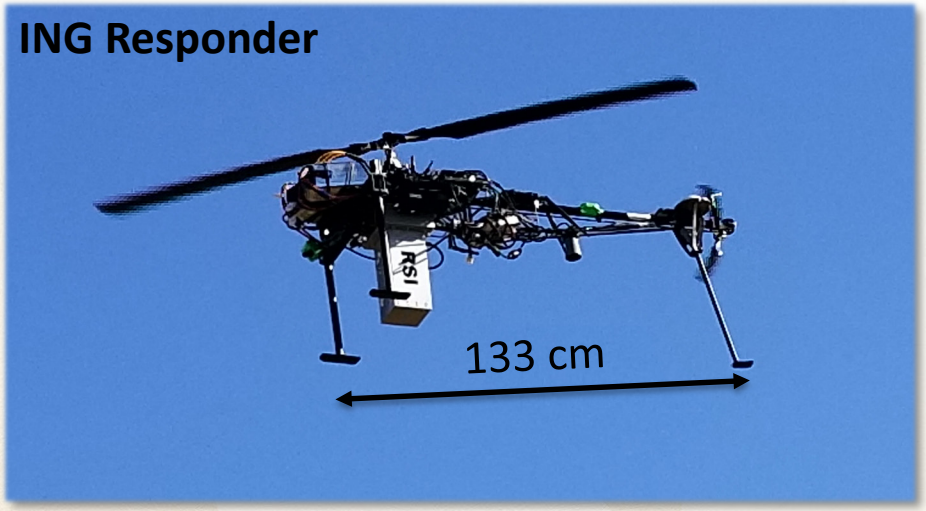
Radiometric RPA system scope



- **Less than 25kg**
  operated under regulations, VLOS operations
- **Rotary-wing system**
  vtol - small deployment footprint
- **The system measures radiation**
  radiometric sRPA system contributes to assessment and monitoring activities
- The system is used during the **response phase of a nuclear emergency**

Proof of concept – test systems

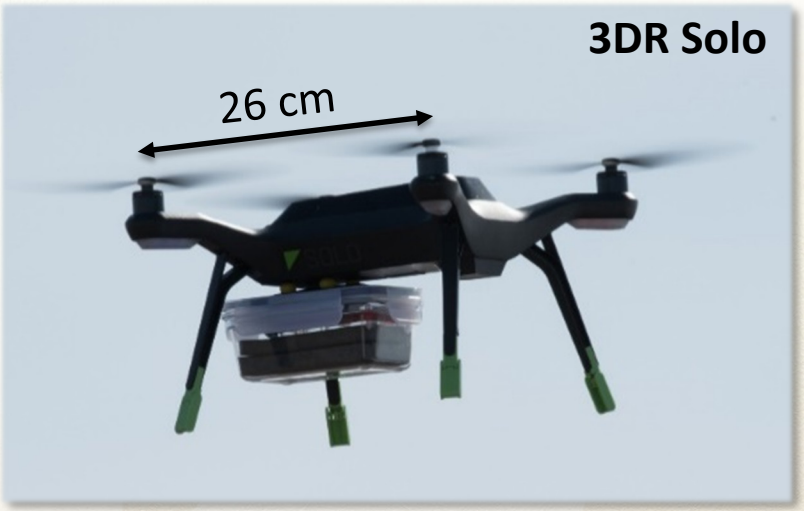
ING Responder



17.9 kg with 2 batteries
15 minutes endurance
Payload capacity: 6 kg

Radiation detector:
RSI ARDUO
8x 43.9 cm^3 CsI(Tl) (351.2 cm^3)
weight: 3.3 kg

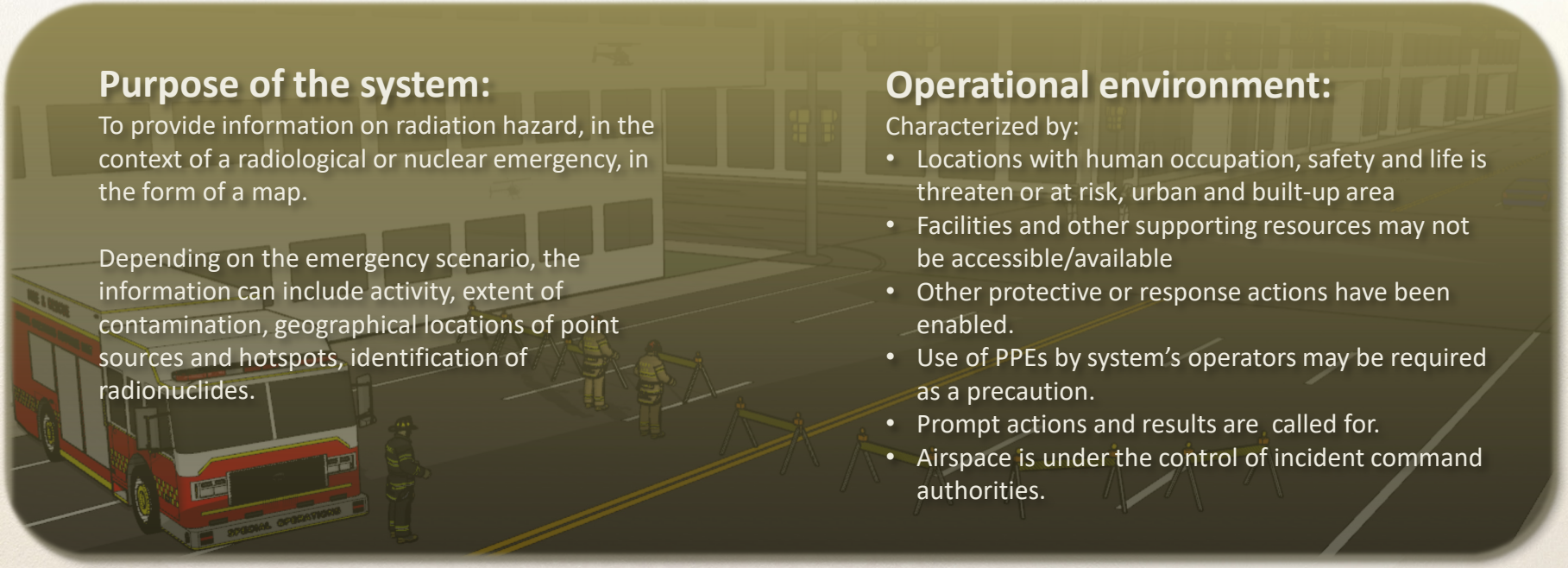
3DR Solo



1.5 kg with 1 battery
15 minutes endurance
Payload capacity: 0.5 kg

Radiation detector:
Kromek GR1
1 cm^3 CZT
weight: 460 g

System’s purpose and operational environment



Purpose of the system:

To provide information on radiation hazard, in the context of a radiological or nuclear emergency, in the form of a map.

Depending on the emergency scenario, the information can include activity, extent of contamination, geographical locations of point sources and hotspots, identification of radionuclides.

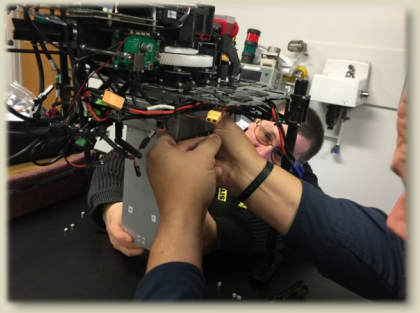
Operational environment:

Characterized by:

- Locations with human occupation, safety and life is threaten or at risk, urban and built-up area
- Facilities and other supporting resources may not be accessible/available
- Other protective or response actions have been enabled.
- Use of PPEs by system’s operators may be required as a precaution.
- Prompt actions and results are called for.
- Airspace is under the control of incident command authorities.

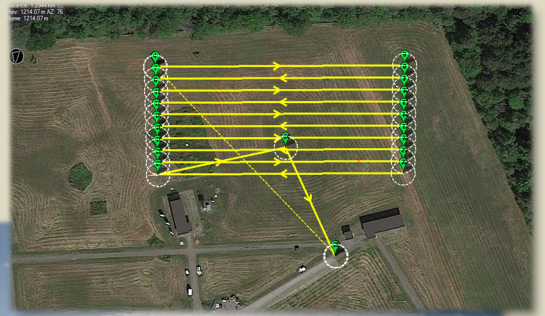
Chalk River - September 2016

Proof of concept flights



Anderson road compound - 2016-2019

Flight performance assessment in a controlled environment



Algonquin Park - November 2017

Trials in a complex 3D environment

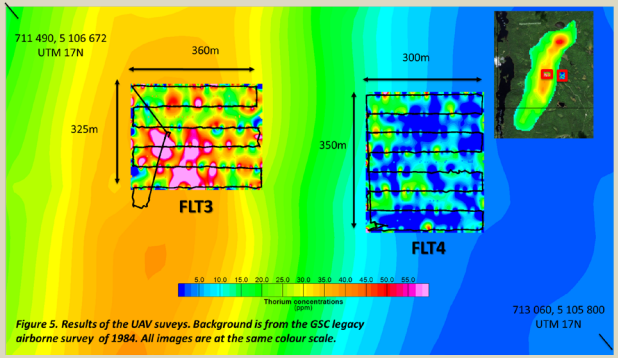
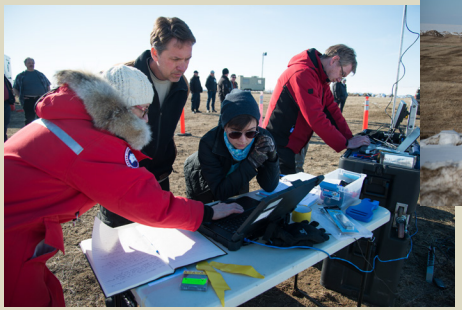
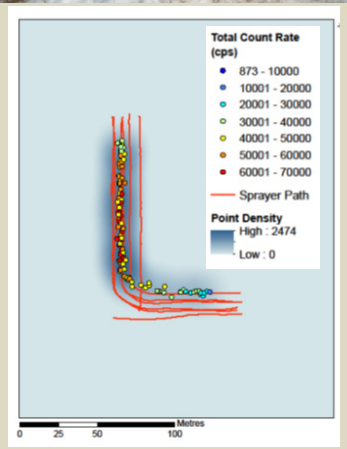


Figure 5. Results of the UAV suveys. Background is from the GSC legacy airborne survey of 1984. All images are at the same colour scale.

CFB Suffield - March 2018

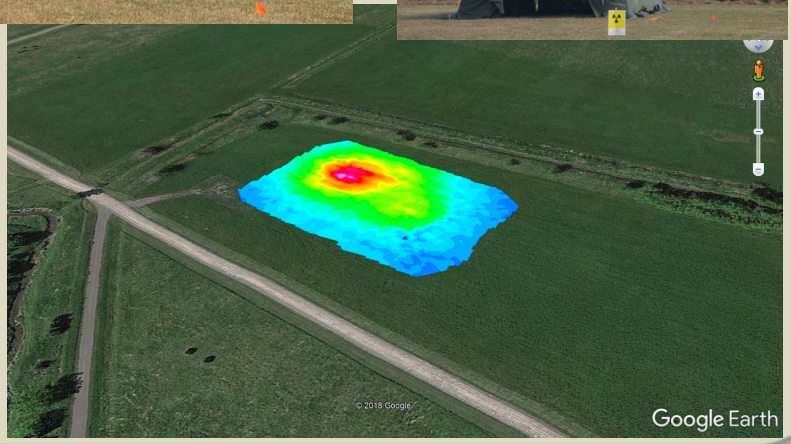
Dispersion trials





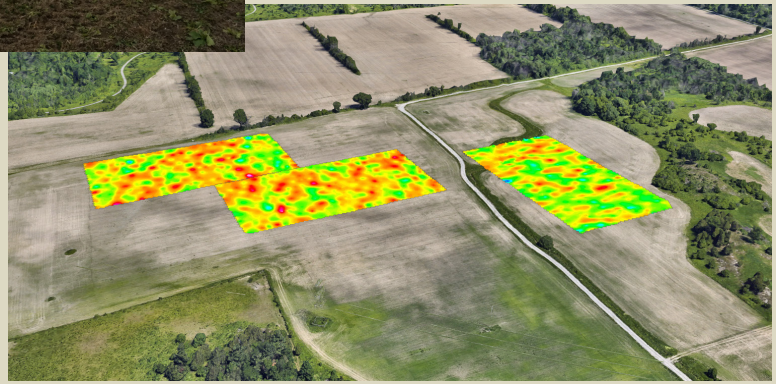
Connaught Range - October 2018

Integration of RPA operations within planned response actions



Corkstown Farm - November 2018

'Patchwork' surveying



sRPAS performances

ATTRIBUTES	RANGE
Survey speed	< 10 m/s
Altitude	< 125 m
Endurance	15-60 mins
Set-up time	10-45 mins
Radius of operation	300 – 900 m
Coverage	0.75 km^2

SURVEY SPEED	LINE SPACING	COVERAGE
UAV		
2 m/s	2 m	4500 m^2
10 m/s	10 m	0.1 km^2
25 m/s	25 m	0.75 km^2
Helicopter		
25 m/s	25 m	2.0 km^2
60 m/s	100 m	50 km^2

Limitations / Advantages

Limitations of sRPAS

- Small payload capacity
- Short endurance
- Small radius of operations

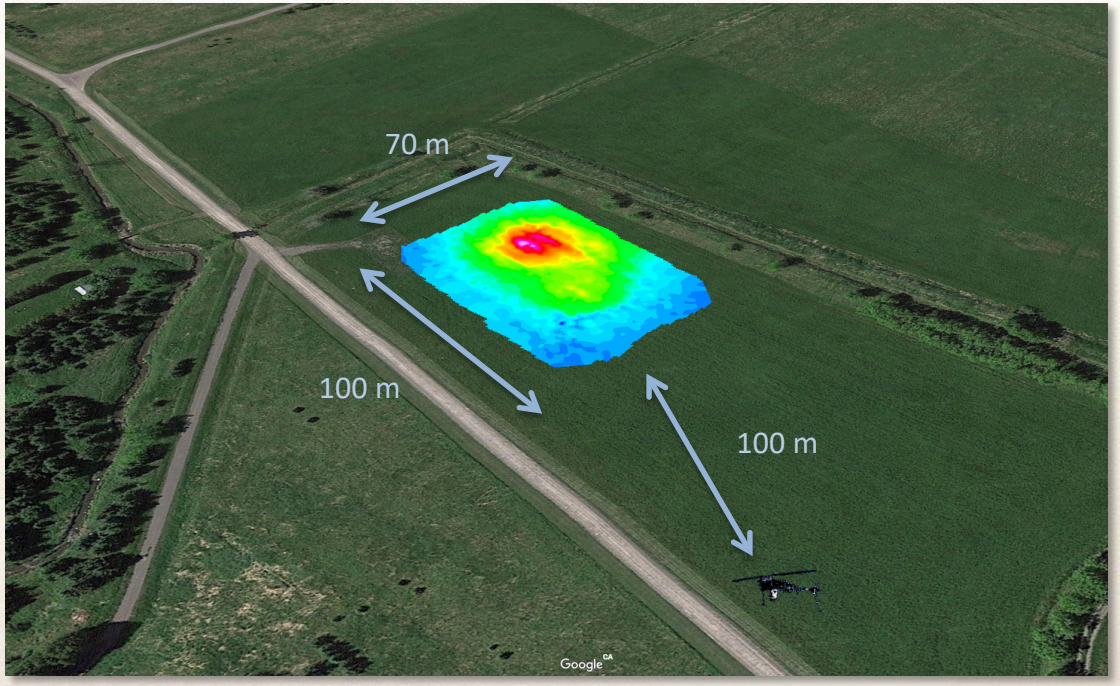
Advantages of sRPAS

- Effective three-dimensional mobility
- Increases the distance between personnel and hazards compared to in-situ measurements
- Does not require dedicated personnel

Operational concept mission: extended-range ground measurements

A sRPAS conducts a grid or patterned survey over an affected area. This represents a similar model to helicopters used in emergency response surveying but on a smaller scale and is limited by the sRPAS range and endurance. The ground operator is removed from the affected area but the standoff distance to the radiation source remains small and may require operators to wear protective equipment.

survey speed	line spacing	coverage
2 m/s	2 m	4500 m^2
10 m/s	10 m	0.1 km^2
25 m/s	25 m	0.75 km^2

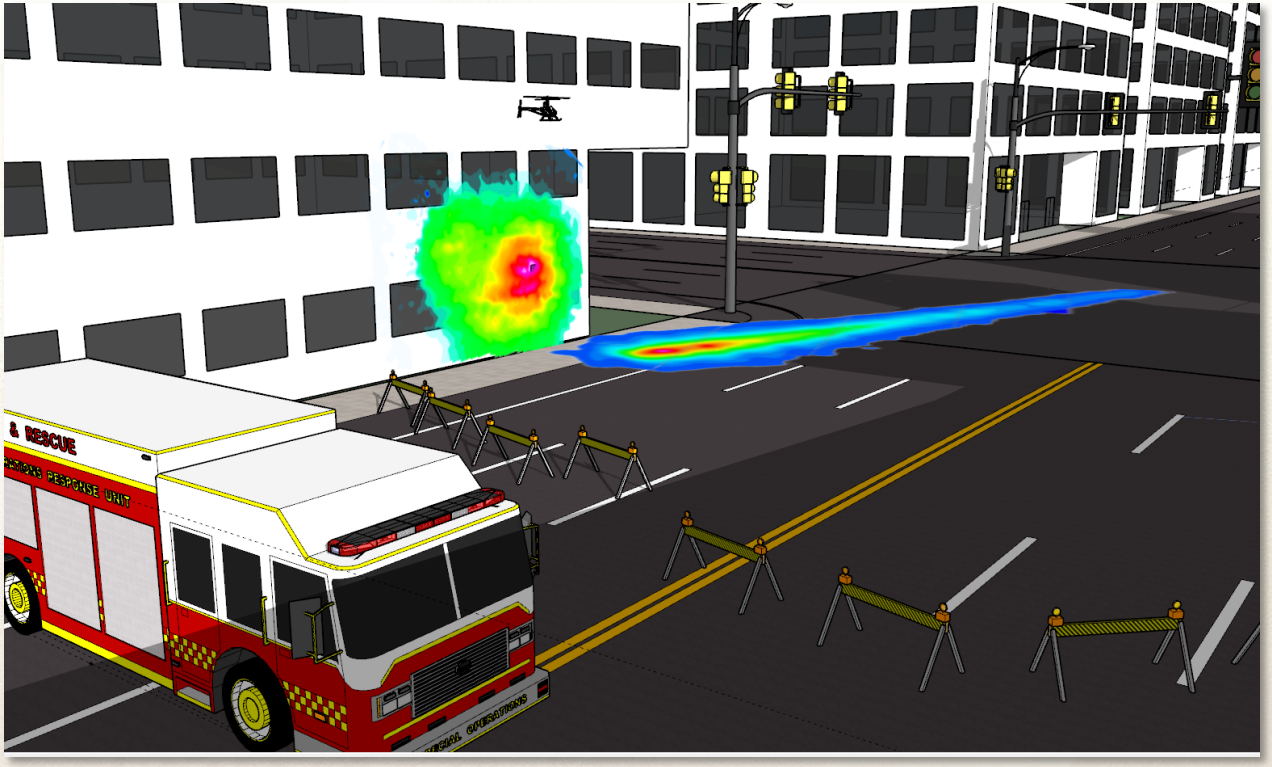


Operational concept mission: radiation monitor delivery

The radiation detector of the radiometric sRPAS can be used as a remote radiation monitor. The sRPAS provide the capability to transport the radiation monitor to a location that is physically difficult to reach, or where radiation hazards and other risks to personnel safety have been identified. When positioned, the monitor can efficiently runs off the RPAS battery and transmits measurements to a command post through a real-time telemetry link.

Operational concept mission: three-dimensional mapping

A distinctive capability of sRPAS is their ability to travel in and occupy a three-dimensional environment of similar scale to their radius of operations. A sRPAS can maneuver between buildings and through urban canyons according to a pre-planned route and scan the radiological environment to produce a 3D surface map of the contamination.



Conclusions

- Small radius of operations of sRPAS is a significant limiting factor for integration in emergency response operations.
- sRPAS do provide standoff distance for personnel to radiation sources compared to in-situ measurements.
- Applications to security and remediation operations are also promising.
- effective three-dimensional mobility provide an access to the operational space, between in-situ ground measurements and aerial ‘from above’ surveying, that is not readily occupied in typical emergency response operations and could therefore provide unique information.

what’s next…

- Integration of robust real-time positioning system for GPS-weak or denied environment.
- Evaluation of long-endurance hybrid or fixed-wing platform with higher payload capacity and larger radius of operation.

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