GSC Scientific Presentation 131 – Presenter's notes

Slide 3

To fulfill its responsibility with regard to the FNEP, NRCan Nuclear Emergency Response team maintains radiation measuring systems that can be deployed in fixed-wing aircrafts, helicopters and mobile vehicles. Survey results are normally presented as mapped products.

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In the course of its operations, NRCan NER team recognized some operational factors that could be improved to lower overall operational risk and to result in a better workflow.
Over the last few years RPAS have proven very useful and advantageous in a variety of survey missions. Could RPAS then help resolve these hindrances and provide new capabilities?

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In order to assess applications of RPAS technology to radiological emergency response, NRCan received funding from the Canadian Safety and Security Program (CSSP) to procure a suitable RPAS, to conduct research and development on methods for acquisition and analysis of survey data and to trial test systems under various experimental contexts.

Examples of sRPAS mounted with radiation detectors have been presented in the literature and off-the-shelf radiation detection RPAS solutions are currently offered on the market. Case studies and white papers are available but are mostly limited to proof of concept and only a few examples consider specific response scenarios in relation to sRPAS performances. One of the goal of this project was to define the operational space that sRPAS occupy and how they could support radiological assessment activities and be efficiently utilized during a radiological emergency response operation.

(At the time the project was proposed, Unmanned Aerial Vehicle (UAV) was the suggested terminology in Transport Canada documentation. In line with newer recommendations, we now use the term Remotely Piloted Aircraft System (RPAS).)

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The primary tasks that would be conducted by NRCan NER team during an emergency response are monitoring activities to inform the radiological assessment of the incident. The NER team would collect data in the field, analyse and present the data, and support assessment activities with interpretation of the data.

The nature of these operations, as part of an emergency response, provides the scope to these actions.

A few definitions are provided here to clarify these concepts and describe what do Nuclear Emergency Response operations entail.

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Various field monitoring activities are conducted during the response phase of a nuclear emergency at different scale of observations and with different goals. They imply different mobilization and deployment efforts, from small crew to large field team, from lower to higher radiological exposure and risk. With the development of an operational concept, we are trying to define where a *radiometric sRPA system* fit and how it can support efficiently monitoring and assessment activities.

Aerial survey: larger scale survey that aim to delimit and characterize the whole affected area and that is usually one of the first monitoring action to be engaged. The spatial resolution of each measurement is on the order of a few 10s of meters.

Mobile survey: vehicle-based or on-foot monitoring systems, recording continuously. The spatial resolution of each measurement is on the order of a few 10s of meters.

In-situ measurement: fixed measurement with a radiation monitor, usually a high resolution spectrometry system, to characterize accurately the radionuclides present and the surface concentrations. Spatial resolution is on the order of a few meters across.

Sampling: extraction of a surface sample for accurate analysis in a laboratory. Spatial resolution limited to the size of the sample.

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In typical operations, aerial surveys are conducted in a grid-flying mode in which parallel survey lines are flown over the affected area in order to produce a map of the radiation on the ground. (The map shown here is from the Full-scale Radiological Dispersal Device Field Trials held in 2012). The measuring system is installed in a cargo expansion that attaches to the skid of a light-utility helicopter. The airborne system includes radiation detectors, geodetic GPS and a variety of ancillary measuring instruments that provide data to correct and reduce the measurements. Considering endurance (about 2.5 hours) of light-utility helicopters and survey flight parameters, typical coverage is presented in the table.

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The operational space of RPAS is very wide and it was required to restrict the scope in order to develop an operational concept that was ready for implementation. It was chosen to restrict to less-than-25kg system since regulations exist for this class. It also appears as a natural first step in the learning and integration ramp.

Limitations to visual line of sight (VLOS) operations does not necessarily represent a very restrictive factor. Considering expected operations in grid-flying and hovering modes, the usually short endurance of sRPAS implies that the vehicle will not go far from the operators.

Also, we de facto restricted the scope to rotary-wing sRPAS as their capabilities seemed more relevant to the operational environment of nuclear emergency.

The operational concept is formally restricted to missions engaged during the response phase of a nuclear emergency, but some considerations were also given to security and remediation operations.

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Two test systems were put together as proof-of-concept and for assessment during field trials. The ING Responder is at the higher end of the less-than-25kg class in term of weight. A platform-optimized gamma-ray directional detector, the ARDUO detector, was developed in collaboration with an industry partner. On the other hand, the 3DR solo is a small ‘prosumer’ quadcopter. It was equipped with the commercially available Kromek GR1 gamma-ray detector.

Gamma-ray detectors are required in this type of applications because gamma rays can travel long distances, compared with alpha and beta radiation.

The weight of radiation detector is a challenge for RPAS integration. Dense and heavy material is required to stop the highly energetic gamma radiation. The weight and volume of detectors were optimized in these two test systems.

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Literature research, consultation with project’s partners and testing under various operational situations was conducted to provide the required metrics to develop an operational concept for a sRPAS in nuclear emergency response. The following 3 slides briefly present various field trials that were conducted as part of this project:

Chalk River: ‘proof-of-concept’ demo. First flight of the integrated system.
Anderson road compound, Ottawa: location where we had a standing SFOC to complete various performance evaluation trials in a controlled environment.

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Algonquin Park: trials in a complex 3D environment, limiting VLOS and C&C communications.
CFB Suffield: well controlled trials over a short-lived radionuclide (La-140) surface dispersion to provide data for R&D on data processing methodologies.

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Connaught range, Ottawa: trials over a short-lived radionuclide surface dispersion as part of wider monitoring and assessment field operations with interoperability considerations.
Corkstown Farm, Ottawa: surveys conducted in partnership with OMAFRA to measure soil properties.

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Values were compiled to characterize typical sRPAS performances for survey operations. Comparison of the coverage obtained by a sRPAS with coverage achieved by manned helicopters demonstrate that theses systems occupy distinct operational spaces.

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During the urgent phase of a nuclear emergency, assessment activities are directed toward the whole affected area, in order to provide an overview of the situation. Long-range radiation mapping systems, e.g. manned aircrafts, are optimally used at that time, and systematic mapping at the scale of the radius of operations of sRPA may not be required during the urgent response phase of the emergency response to a nuclear emergency.

The limited endurance and small radius of operations limits the scale and the applicability of sRPAS in radiological emergency response, but their effective three-dimensional mobility is a unique capability.

Three types of missions were defined for the use of sRPAS in nuclear emergency response, considering their limitations but taking advantage of their unique capabilities. These mission types in turn encompass a variety of scenarios, and are presented in the following 3 slides.

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high resolution and high density characterization may not be required in the urgent phase of an emergency response, but possible scenarios for which it could, include:

1) characterizing the maximum dose rate, locating hotspots and identifying radionuclides in support of ground assessment operations.
2) clearing areas with tactical benefits for response measures, in advance of occupation by responders.

This mission type could also be useful to non-emergency scenarios:
1) inspection of suspicious package, at distance.
2) locating the precise location of an abandoned source.

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sRPAS 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.

Complex 3D environment like urban canyons can easily cause GPS obscuration and are challenging for sRPAS navigation . Off-the-shelf solutions for real-time positioning in GPS-weak and GPS-denied environment are available and use a variety of technology (vision-based, beacons, pseudolites…) but will require integration and testing before implementing this type of mission.