RadiaCopter – UAS Gamma Spectrometry for Detection and Identification of Radioactive Sources

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Abstract. With an unmanned helicopter (UAS), known as drones, equipped with a gamma spectrometer, one can achieve both a high spatial resolution and good range, and be able to approach a radioactive source closely. Linköping University, Sweden, is proposing a microdrone system that will fill a gap between man-portable measurement systems and full-sized airborne systems, complementing the car-driven measurement systems. The system may play a unique role in many of our contingency scenarios in terms of accessibility, versatility, efficiency, and is advantageous from the viewpoint of radiation protection as it can be controlled at a safe distance.

KEYWORDS: helicopter, radiac, preparedness, gamma spectrometry

INTRODUCTION

This project was initiated by Linköping University emergency preparedness laboratory, a part of the Swedish RN preparedness organization. The project aims to develop a measurement system for airborne detection and identification of radioactive sources from an unmanned helicopter (UAS – Unmanned Aircraft System). This system may fill a gap between man portable measurement systems, and full-sized airborne systems, and complements the car driven measurement systems. The system may play a unique role in many of the scenarios authorities have identified and can ensure that measurements can be made by the human operator from radiation safe distances.

The scenarios listed for RN preparedness (MSB, 2008; Rojas-Palma et al, 2009) includes among other orphan sources and Radiological Dispersal Devices, RDD (Dirty Bombs). In the search and identification of these sources we currently use handheld, automotive or airborne instruments of various kinds. These measurement units have the following strengths and weaknesses:

- Hand-held systems provide good spatial resolution, but cover a relatively limited area and require many man hours. In situations with strong sources there are limitations due to the radiation risk for the operator.
- Car driven systems have the advantage of using large detectors which provide good sensitivity and cover large areas, but is hampered by the vehicle's limited off-road mobility and the risk of contamination of the vehicle, as well as the radiation hazard for the operators.
- Aircraft and helicopters cover large areas in a short time, but require a great effort and considerable cost. Measurements are typically along straight lines with 200 - 800 meters apart, normally 30 - 60 meters above the ground and a reading is obtained every 16th meter (SGU).

With an unmanned helicopter, known as drones, one can achieve both a high spatial resolution and good range, and be able to approach a source closely. Proximity provides good sensitivity with a relatively small instrument and combined with the camera, it is also possible to visualize and identify the objects.

The range allows for measurements to cover a larger area in less time than e.g. man-portable measurement systems, while the human operator is at safe distance from the radioactive source.

The scenarios that can be solved with this system include customs duties, threats, orphan or dispersed radioactivity on ground surface. The surroundings of the NPP site at Fukushima can be an example on a suiting scenario to survey with this measurement system. The system can contribute to these scenarios, even in urban terrains and in some cases, even indoors e.g. in sports arenas.

Internationally, airbourne gamma spectrometry is well established, both for geological mapping and for measuring the deposition of radionuclides (IAEA, 1991). STUK (Kettunen et al 2002) in Finland and SGU (SGU) in Sweden have developed and performs airborne gamma spectrometry by helicopter or aircraft for mapping of the ground surface after a nuclear leak, but also for scenarios with "dirty bombs", contamination in areas such as water, food or paper production as well as intentional or accidental transportation accidents.
In searching for sources, man held or motorized spectrometry is also well established, both internationally (IAEA, 2003) and in Sweden (Finck 1992, Boson 2008, Mellander et al 2002, Hjerpe et al 2003). The authors have contributed to research in so-called in situ backpack-mapping (Kock et al 2011).

METHOD

The proposed helicopter system MD4-1000 (microdrones 2009) is a quadrocopter (four rotors) equipped with compensating software, which gives a stable ride and relatively simple operation, considerably easier to control than a traditional R/C helicopter. This microdrone is operated by a pilot on ground or by a pre-set route based on GPS track points.

Figure 1 The RadiaCopter in air. The orange markers indicate the forward direction. Photo by Marie Carlsson

The detector choice is limited by the payload weight 1200 g. For gamma spectrometry, commercial mini-detector systems, such as type CZT, could fill the need, in terms of weight, spectrometric performance, robustness and sensitivity. As these systems are small and light weight, it opens the possibility of supplementing with collimator, (e.g. rotating collimator, hemispherical lead shield with slits, or rotating detector jig) to enable measurement of very strong radiation fields (high dose rate). Another application

could be air filter sampling of airborne particulates and gaseous effluents from strongly contaminated areas.

The first test flight was performed a cold, sunny day in February 2011[1]. The performance of the helicopter was very convincing, letting the pilot leave the microdrone hovering in free air while he was talking and gesturing with both his hands off the controls. A detector system was also tested, and a good spectrum of the I-131 test source was retrieved. At that point, no efforts had been made on the communication and data management software for the detector system.

Figure 2 Third author by the microdrone illustrates the size. The microdrone's rotor arms are folded for transportation. Photo by first author.

Validation of the system will be done partly by comparison with calculated gamma fluxes from calibration point sources and by comparison with previously measured radiation field in southern Sweden.

The calculations are performed by Monte Carlo simulation from the modification of a computer code, previously developed at Linköping University for HPGe in-situ gamma spectrometry (Ullman, 2009).

[1] A movie clip of the test flight can be seen at www.youtube.com/watch?v=HTlUOIsDbio

An established way of presenting real-time spectrometric data is by using so-called waterfall chart, but there are also further developments on the same theme, such as deviation display (Kock et al 2010). Tools to evaluate and present the data collected should be evaluated and validated carefully to ensure that measurements are reliable and easily accessible.

EXPECTED RESULTS

The resulting measurement system may fill a gap between man-portable measurement systems and full-sized airborne systems, complementing the car-driven measurement systems. The system may play a unique role in many of our contingency scenarios in terms of accessibility, versatility, efficiency, and is advantageous from the viewpoint of radiation protection as it can be controlled at a safe distance.

The flying measurement system can be controlled by a single person with a short pilot training in one day. The measurement system will cope with measurement tasks up to one hour at a time, and with several battery sets at hand, it is only required to change batteries between mission sessions. This provides a good stamina. If the helicopter is controlled manually, this gives a technically limited search area of approximately 3 km^2, pilot standing still.

The Swedish Civil Contingencies Agency (MSB) stipulates six possible emergencies involving radioactive substances (MSB, 2008). These concern the Swedish and international emergencies at nuclear facilities or other radiological emergencies. Emergencies are categorized based on whether they arise by accident or deliberately. Foreign incidents affect Sweden if radioactive materials disperse over Sweden or affecting Swedes abroad. In all these scenarios, possibly except scenario 6 (affecting Swedes abroad), a small unmanned helicopter, carrying a gamma spectrometry system, would be useful in the detection, identification and computation of gamma radiation.

Project funding is pending.

REFERENCES

Boson, J. (2008) *Improving accuracy of in situ gamma-ray spectrometry*. Doctoral dissertation, 2008. Umeå university. ISBN 978-91-7264-621-6

Finck, R.R. (1992) *High resolution field gamma spectrometry and its applications to problems in environmental radiology.* Doctoral dissertation, 1992. Lund university. ISBN: 91-628-0739-0.

Hjerpe, T., Samuelsson, C. (2003) A comparison between gross and net count methods when searching for orphan radioactive sources. *Health Phys*, 84(2), 203-211.

International Atomic Energy Agency (IAEA). (2003) *Guidelines for radioelement mapping using gamma ray spectrometry data. IAEA-TECDOC-1363*, Vienna.

International Atomic Energy Agency (IAEA).(1991) *Airborne gamma ray spectrometer surveying. Tech Rep Ser 323*, Vienna.

Kettunen, M.; Nikkinen, M. (2002) *GAMMAJET—Fixed-Wing Gamma Survey for the Detection of Radioactive Materials*, STUK-YTO-TR 185, JUNE 2002, www.stuk.fi/julkaisut/tr/stuk-yto-tr185.pdf

Kock, P, Samuelsson, C. (2011) Comparison of airborne and terrestrial gamma spectrometry measurements – evaluation of three areas in southern Sweden. *Journal of Environmental Radioactivity*, 102(6), 605-613, DOI 10.1016/j.jenvrad.2011.03.010

Kock, P; Finck, Robert R.; Nilsson, J. M.C.; Östlund, K.; Samuelsson, C.(2010) A deviation display method for visualising data in mobile gamma-ray spectrometry. *Applied Radiation and Isotopes* 68 1832–1838

Mellander H., Aage H.K., Karlsson S., Korsbech U., Lauritzen B., Smethurst M. (2002) *Mobile gamma spectrometry. Evaluation of the Resumé 99 exercise.* NKS-56. Roskilde: NKS. ISBN 87-7893-111-8.

microdrones GmbH (2009) *Flyer microdrone md4-1000*, 2009-07-27, www.microdrones.com/downloads/md4-1000/md4-1000_Flyer_englisch_web.pdf, accessible 2011-08-20

Rojas-Palma et al (eds), (2009) *TMT Handbook - Triage, Monitoring and treatment of people exposed to ionising radiatioon following a malevolent act*.

SGU (2011) *Flyggeofysisk verksamhet Radioaktivitet* www.sgu.se/dokument/service_sgu_publ/fakta_flyggeofysik.pdf, accessible 2011-08-20

MSB (2008) *Den svenska beredskapen för radiologiska och nukleära olyckor 2015*, Räddningsverket, Karlstad, Enheten beredskap mot farliga ämnen, ISBN 978-91-7253-397-4, Beställningsnummer R79-303/08, 2008 års utgåva

Ullman, G. (2009) *A general Monte Carlo based model for calibration of the HPGe detector "Detective EX 100".* NKS-B GammaSem seminar - Nordic seminar for users of gamma spectrometry, Kjeller, Norway, 16-17 September, 2009. www.nks.org/dk/seminarier/praesentationer/nks-b_gammasem_seminar_september_2009.htm