Aerial Radiological Measurement Compatibility in Emergency Incident Response

C.E. Okada, P.T. Wasiolek
National Security Technologies, Remote Sensing Laboratory, PO Box 98521, Las Vegas, NV 89193

Abstract

In the event of a large atmospheric release of radioactive material, aerial radiological measurements (aerial gamma spectroscopy) may be employed to show where the activity has deposited on the ground. If there are multiple organizations conducting aerial measurements, there will be certain requirements for the detection systems and data collection procedures that should be considered, so that the data from all systems can be effectively combined to present a unified map of the contamination. The presentation will detail some of these requirements.

Introduction

Aerial radiological measurements have been demonstrated as an effective method for quickly mapping widespread radioactive contamination [1,2,3]. The data from these systems must be quickly analyzed to produce maps of dose rate or deposited concentration of radioactivity so that they may be used to help make decisions on the actions appropriate to prevent the general population from receiving unnecessary doses of radiation (e.g. evacuation or relocation).

The systems used to collect the aerial data are typically composed of one or more sodium iodide (NaI) scintillators for gamma ray detection, a global positioning system (GPS) receiver for location reference, and a computer to combine and record the data. Size and number of the NaI crystals typically will depend upon the individual mission requirement and the lift capability of the aircraft. The collected radiation data are synchronized in time and GPS location and usually recorded in second-by-second samples. A number of corrections need to be applied to each sample to obtain a map of the ground-level activity. For an individual sample, the ground-level activity, A (mSv h^{-1} or Bq m^{-2}), is given by the following equation

$$A = K_0(h_0, t)\left(\frac{N}{t_L} - B(h,t)\right)e^{\lambda(h-h_0)},$$

where N is the count rate in a segment of the gamma ray spectrum, t_L is the measurement live time, t is the time when the measurement was performed, $B(h,t)$ is the background in the spectrum as a function of the measurement height (equal to flight altitude) and time, λ is the apparent signal attenuation (via air attenuation and detector enclosure), h is the actual measurement height above the ground, and h_0 is the nominal height above the ground. $K_0(h_0,t)$ is a factor to convert from counts per second in the detector at the nominal height to the ground-level activity [4,5].

Additionally, there are some specific measurements which should be performed. These requirements will become even more important if multiple organizations are conducting aerial measurements in support of an incident, and consistent results are to be produced from the combined data.

Compatibility for Aerial Measurements

To transform aerial measurement data to ground-level activity, there are some data elements which must be recorded. Table 1 lists the critical elements. The measurement time may be needed to adjust the ground-level conversion factor if the contamination may change due to decay or transport. The height (aircraft altitude) is best when provided by direct measurements using radar or laser altimeter however, the GPS derived altitude (height above ellipsoid) can also be used if it is combined with digital elevation models (DEM's)to get the relevant height [4]. A system which records only total gamma ray counts or dose rate may be used (for example plastic scintillators), but these will not allow discrimination between background radiation and contamination, or separation of different radionuclides in the contamination [4].

Table 1: Critical elements for aerial radiological measurements.

Data Element	Comments
Date & time	GPS/UTC time
Location	GPS Latitude & Longitude; GPS Northing & Easting
Height above ground	GPS Height above ellipse; radar/laser altimeter height above ground
Gamma ray spectrum	
Detector times	Sample time, dead time

When conducting aerial radiological measurements, beside the data collected over the area of concern, a number of special data sets should be collected. Some of the data sets are for quality assurance purposes, while others are used to derive the parameters used to correct the data. Most important among these special sets, is data collected at a calibration line. The calibration line is a 2-5 km long over an area that is at least 1 km wide, flat, uniform in radioactivity, and can be accessed from the ground. An area that has some contamination from the release is preferred. For operations where multiple aerial teams are mapping the contamination, it is best if all groups can use the same calibration area to ensure consistency when results are combined.

Table 2: Some of data sets which are used for quality assurance and determination of analysis parameters for aerial radiological data.

Special Data Set	Comments
Pre- and Post-flight background	Collect at the same location on the ground; quality assurance to confirm the system is operating correctly; determine if changes (lost detectors, contamination) occurred to the system during the flight
Pre- and Post-flight test line	2-5 km flight line at the nominal altitude; quality assurance to determine if changes (background, contamination) occurred to the system during the flight; may contribute to time dependence in the background assumption
Calibration line	2-5 km line flown at multiple altitudes over an area characterized from the ground (dose rate and deposited activity concentrations); determine attenuation coefficient (λ), count rates at the nominal altitude and conversion coefficients ($K_0(h_0,t)$); determine detection threshold
Water line	2-5 km line flown at multiple altitudes over a large body of water (lake); determine the background ($B(h,t)$)

The nature of making any measurements with a moving detector will results in diminished spatial resolution as the detectors integrates the signal from an area rather than from point. With an aircraft speed of 70 knots, the detector moves 36 meters every second. For that reason most of the aerial radiation data are presented as a contour maps rather than point data. To merge data collected from multiple systems the format of the system output files needs to be agreed upon. However, so far there is no single common file format used in aerial (mobile) measurements. An attempt by Scottish Universities Environmental Research Centre to promote a single standard for aerial spectral data (ERS) was not very successful and may need to be revisited in the future.

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