RADIOACTIVE PLUMES MONITORING SIMULATOR

I. Kapelushnik, M. Sheinfeld, R. Avida, Y. Kadmon, M. Ellenbogen, and D. Tirosh.
Nuclear Research Center - Negev, P.O.Box. 9001, Beer-Sheva 84190, Israel

Abstract

The Airborne Radiation Monitoring System (ARMS) monitors air or ground radioactive contamination. The contamination source can be a radioactive plume or an area contaminated with radionuclides. The system is based on two major parts, an airborne unit carried by a helicopter and a ground station carried by a truck. The system enables real time measurement and analysis of radioactive plumes as well as post flight processing.

The Radioactive Plumes Monitoring Simulator purpose is to create a virtual space where the trained operators experience full radiation field conditions, without real radiation hazard. The ARMS is based on a flying platform and hence the simulator allows a significant reduction of flight time costs.

Main features

The simulation process begins by a computerized generation of virtual radiation plumes. These plumes are stored on the hard disk, and loaded in real-time for the simulation. The generated data is a basis for practicing ARMS failures simulation in high radiation conditions and populated areas, letting the user experience and handle such situations.The simulator requires no changes in the airborne system hardware and software, except for few additional cables.

Overview

The simulation starts by creating a radioactive space according to a pre-generated contamination plume in addition to environmental parameters such as wind speed and direction, inversion altitude, pollution dispersion time, etc. Due to the computer memory limitations, the model can not use unlimited estimation grid at the plume vicinity. This enforces a limited grid density for the radiation estimation.

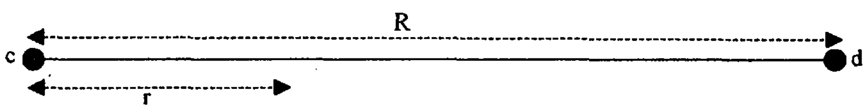

Figure 1 - Schematic description of distances needed for radiation estimation

The radiation estimation for points between grid lines is demonstrated in Figure 1.

Where:

R - distance between *c* and ***d***.

The radiation level at point *c* is less than the radiation measured at point ***d***.

The radiation at any point between these two end points is then calculated as follows:

$$(1) \qquad F = \frac{a}{(r - b)^2}$$

Where:

F - estimated radiation.

r - distance between point **c** and the estimated point.

a, b - are given by:

$$\text{(2)} \qquad a = c \cdot R^2 \cdot \frac{\left(d - \sqrt{d \cdot c}\right)^2}{(c - d)^2} \quad , \qquad b = R \cdot \frac{d - \sqrt{d \cdot c}}{(c - d)}$$

The simulator is also capable of simulating the helicopter movement by generating GPS (Global Positioning System) data. Route parameters are supplied similarly to the commands given to the helicopter's pilot in a real flight. The simulated flight speed is determined by the operator. Crossing a given distance at a given velocity will take the same time as in real flight. The simulator enables to train real time decisions such as escaping high radiation locations or dealing with other extreme hazard conditions.

The simulator program continuously changes the radiation data according to the airborne unit location. Concurrently, the helicopter site coordinates are sent once per second according to the GPS protocol. The altitude simulation data is added to a random error as shown in Figure 2.

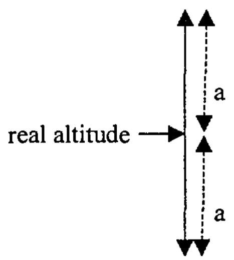

Figure 2 - Schematic description of altitude error range

Where:
real altitude - true simulated altitude according to the helicopter route.
a - maximum random change allowed.

Uniform random distribution was chosen to calculate the error as follows:

$$\text{(3)} \qquad P(x) = \frac{1}{2a}$$

Where:

P(x) - probability of x.
Calculating the new height is simply done by adding x to the given real height.

The horizontal X-Y location remains without an error but the course has a slight change. For example, instead of a strait line with azimuth 50 degrees there will be a new azimuth with uniform random error. Cosmic radiation was also added to the estimated radiation using Gaussian distribution as given in the following formula:

$$\text{(4)} \qquad G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} \cdot e^{\frac{-(x-\mu)^2}{2\sigma^2}}$$

Where:
G(x) - is the Gauss distribution probability of x.
σσ- is the standard deviation of the cosmic radiation.
μ - is the cosmic radiation expectation.

The energy spectrum histogram is loaded from a previously prepared file. It is then transformed into analog pulse amplitudes and scrambled to create an effect of realistic energy spectrum created by real detectors. The analog pulses are generated using a computer controlled DAC (Digital Analog Converter). A scheme of the simulator program is shown in Figure 3.

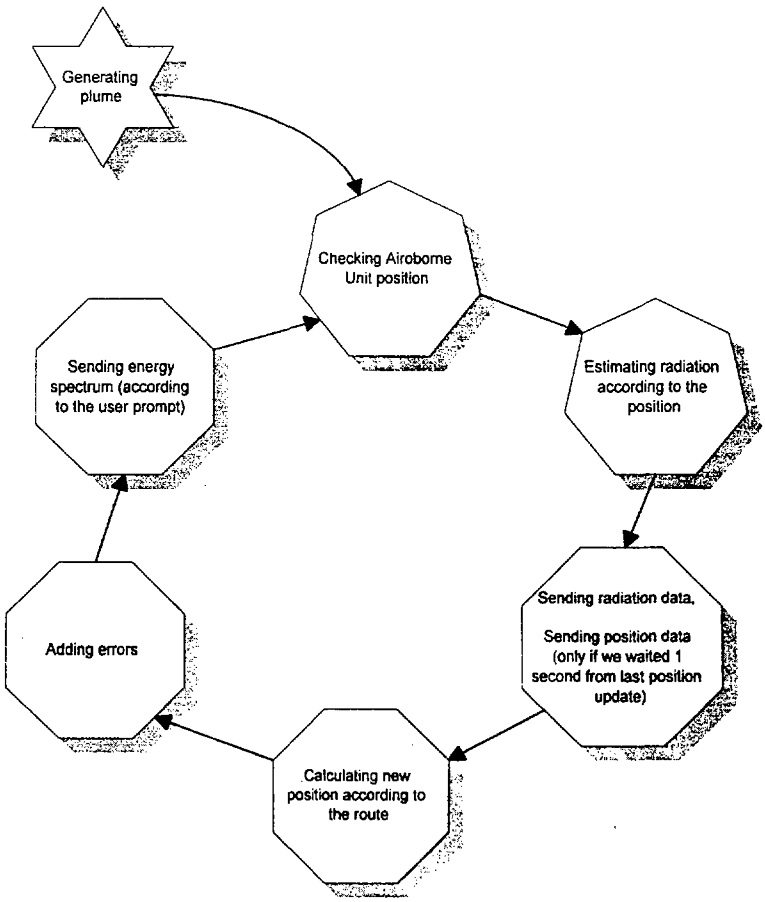

Figure 3 - Program operation schematic description

The simulation starts by generation of the radioactive plume. The radiation is estimated using the helicopter location relatively to the plume and both the radiation and location data are sent to the airborne unit.
At the next step, the errors are added to all the simulated data and the energy spectrum is transferred to the airborne unit, followed by reassessment of the airborne unit position. The process repeats itself indefinitely until the user quits the program.

Figure 4 depicts the connection between the simulator and the airborne system. Data from the simulator is transferred to the airborne system using dedicated cables (detectors, control, spectrum and computer serial cables). These cables enable to take control over the data flow in order to handle all of the parameters required by the airborne unit. The spectrum is sent directly to the airborne computer.

The GPS and the altitude meter data is transferred to the airborne unit computer via RS-232 multi-channel serial communication connector. The pulser and the data lines (digital I/O) are transferred to a local display unit which analyses and sends the information to the airborne unit computer.

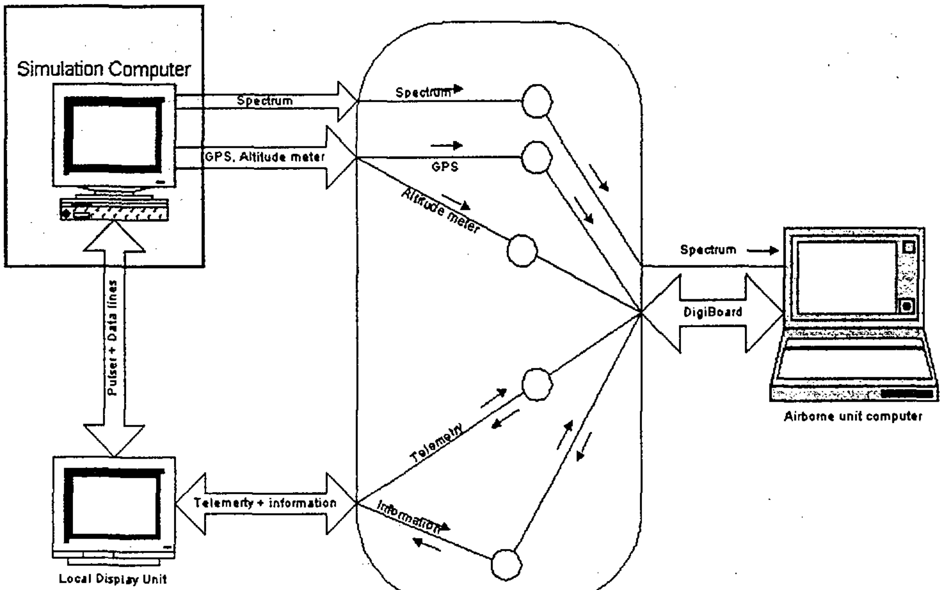

Figure.4 - Schematic description of the system

Summary

The simulator main goal is to enable the ARMS health physics operators a training virtual environment. Contaminated areas or plumes are generated in the virtual space in order to experience the operator with real contamination monitoring. The simulator was developed with minimal changes in order to give the operator the same surrounding conditions as in a real ARMS monitoring. A prototype was built and tested successfully.