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AIRBORNE RADIATION MONITORING SYSTEM

Y. Kadmon, A. Gabovitch, D. Tirosh, M. Ellenbogen, T. Mazor, and D. Barak
Nuclear Research Center-Negev, P.O.Box 9001, Beer-Sheva 84190, Israel

Abstract

A complete system for tracking, mapping, and performing a composition analysis of a radioactive plume and contaminated area was developed at the NRCN. The system includes two major units: An airborne unit for monitoring and a ground station for analyzing.
The airborne unit is mounted on a helicopter and includes the following. Four radiation sensors, two 2" x 2" NaI (Tl) sensors horizontally separated by lead shield for mapping and spectroscopy, and two Geiger Muller (GM) tubes as part of the safety system. A multichannel analyzer card is used for spectroscopy. A navigation system, based on GPS and a barometric altitude meter, is used to locate the plume or ground data. The telemetry system, consisting of a transceiver and a modem, transfers all the data in real time to the ground station. An industrial PC (Field Works) runs a dedicated C++ Windows application to manage the acquired data. An independent microprocessor based backup system includes a recorder, display, and keypad.
The ground station is based on an industrial PC, a telemetry system, a color printer and a modem to communicate with automatic meteorology stations in the relevant area. A special software controls the ground station. Measurement results are analyzed in the ground station to estimate plume parameters including motion, location, size, velocity, and perform risk assessment.
The system prototype was tested and satisfactory results were obtained.

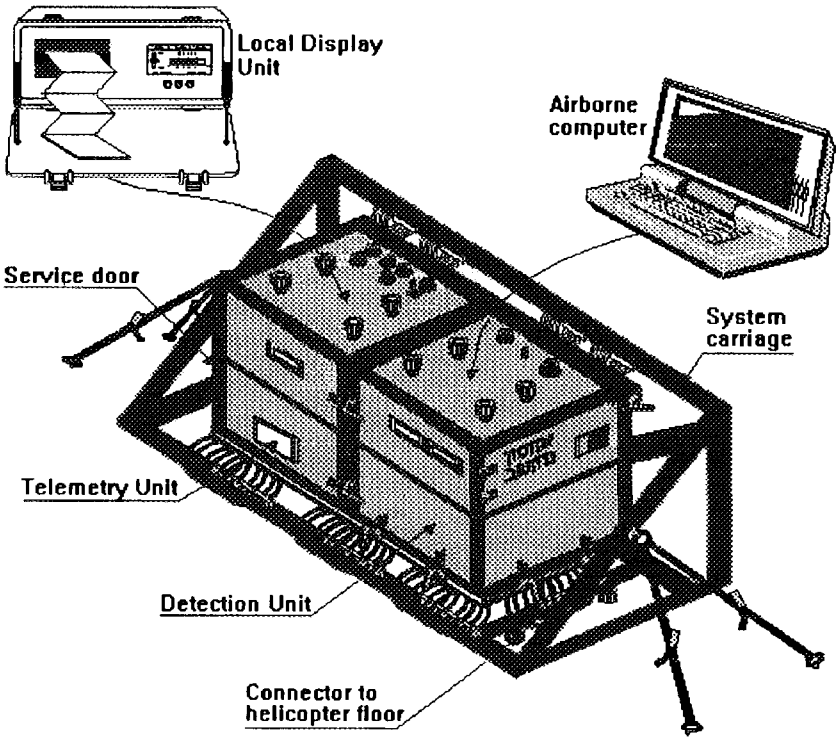

Fig. 1- Airborne Station

Introduction

The Airborne Radiation Monitoring System main goal is to provide a real time solution to the estimation and damage control following a dispersion of radioactive materials. In such an event, the first step to be taken is mapping of the contaminated zone. If the materials are liquids, aerosols or gas, the event will result in a contaminated plume which should be mapped and analyzed in terms of location, direction, velocity and composition.
Furthermore, short and long term hazards have to be predicted. Nuclear events involve dispersion of abundant nuclides with various half life time. Analyzing of the materials spectrum and quantity is utterly important for hazards assessment, and for making the best decisions in order to minimize the population exposure to radiation.
The airborne system was developed to monitor and analyze radioactive data coming from a contamination source on the ground or in a radioactive plume. The system consists of several modules described bellow.

Radiation Detection Unit

The most important part of the airborne system is the radiation detection unit. In order to collect data from a distance and enable training on low radiation fields, the detection unit is based on high sensitive detectors: Two horizontally isolated PM 2" x 2" NaI (Tl) scintillation detectors with a lead collimator in between. The radiation measuring frequency is 0.5 Hz . To sample a spectrum, the detectors' signal is sent to a 1024-channel PCAP board installed in the computer. The spectrum energy is 200 to 5000 keV, with a resolution of 6% (660 keV).
Usage of an HPGe detector has been considered and rejected, since the resolution profit compared to its cumbersome handling and size proved non-beneficial.
For most tasks a single detector is needed but two horizontally isolated PM detectors were installed for the following reasons:

- Finding the plume altitude. This is performed by flying beside the plume and finding the altitude where the measured radiation level in the upper and lower detectors is equal.
- Safety reasons. The helicopter should be above the plume during most of the data acquiring time. Radiation increase in the upper probe alarms the crew to prevent lowering the flight to the plume altitude or below it.

In addition to the data collection PM detectors, the detector unit includes a two range GM detector for back-up and safety reasons. One GM is for fields up-to 300 mR/h, and the other operates from this range on. The GM field measurement is redundant to the PMs and vise versa. Furthermore, the GM operating range is much higher than the PMs.
In order to operate the different detectors, a dedicated electronic control system has been developed. The detection unit consists of a power supply (high and low voltages), a signal shaper, an amplifier, and a B.I.T. (Built In Test) that offers logic indications sampled by a micro-processor in the Local Display Unit (LDU).

Airborne Computer and Software

The airborne computer controls all the airborne system operations. The airborne software collects real time data from the detectors, performs preliminary processing for safety reasons, saves the data and transmits it to the ground station. The basic sample frequency is 0.5 Hz and includes data from: both PM scintillation detectors, GM detector, altimeter, GPS, and clock that is used to synchronize data.
In addition to the sensors data, the airborne software receives commands and data from the ground station via telemetry. These include updated data concerning the incident location, wind direction, survey area or route, tasks commands, etc.

Software analyses the data and alarms in case one of the following preset thresholds is exceeded:

- Upper detector reading, n times over predefined radiological background.
- Lower detector reading, n times over predefined radiological background.
- Sum of lower and upper detector readings, n times over predefined radiological background.
- Upper detector reading higher than lower detector reading.
- Detector reading equals zero, indicates detector failure.

Local Display Unit (LDU)

The main task of the local display unit is to constitute a backup to the computer. In case of hardware or software failure, the LDU provides the minimal data required for executing most of the airborne monitoring tasks.
The LDU is based on a self developed 80186 micro-controller card that controls in real time the following components:

- Thermal recorder records on paper the radiation intensity versus time and the system status.
- Graphic LCD displays radiation levels and system status.
- Push-buttons for data input and user operation.
- Communication with the computer : receiving operational commands and transmitting data via a serial communication channel.

The LDU includes also a Global Positioning System.

Global Positioning System (GPS and Altimeter)

Mapping the contaminated area is achieved using Trimble's SV-SIX GPS (Global Positioning System). The GPS accuracy is about 50 meters in the horizontal axis and 150 meters in the vertical axis. Improvement of the accuracy in the vertical axis is achieved by using an altimeter whose accuracy is 10 to 15 meters. Data from both devices is transferred to the computer and added to the radiation measurements.

Telemetry Unit

The measured radiation data is transmitted to the ground station in real time. The telemetry system is based on a MOTOROLA VRM 100 modem connected to a Maxtrack radio transceiver, to which an air cooling system was added in order to improve the transmission to stand-by ratio. Communication rate of 300 baud enables real time transmission of data. In case of communication failure, the entire files may be transmitted to the ground station at the end of the task. Another telemetry unit on the ground receives the data and sends it to the computer for analyzing and display.

Ground Station

The airborne system operates in parallel to the ground station. The latter is based on two computers, one for data collection and helicopter communication and the other for data processing.
The data communication computer is in fact an integral part of the airborne system. The displayed data is identical to that shown in the helicopter (delayed by a few seconds). The ground operator can communicate with the helicopter operator by sending free text bursting messages or by delivering preset commands for the diverse tasks. The ground operator who is not exposed to the radiation hazards, can have a better judgment than that of the flight crew and thus warn them in case of erroneous decisions.

The processing computer receives the information from the communication computer and its task is to analyze the data, communicate with a local meteorological station from the incident zone, predict the plume expansion and radiological intensities, and perform hazards estimation.

Ground Station Software

The ground station applications are divided between the communication and processing computers. The communication computer MMI is almost the same as in the airborne computer, but differs in the following: the data source is the telemetry channel instead of sensors, the ground operator can send operational commands or data to the airborne system. The processing computer receives the data from the communication computer, runs an additional application to receive data from meteorological stations, calculates the type and amount of contaminating material, and forecasts hazardous zones.

Operation Tasks

The airborne monitoring system has been designed to the following predefined tasks:

Emission Source Detection - flight is performed in circles around a suspicious contaminated spot source. The helicopter starts flying in high altitude and descends constantly in a spiral track (trajectory). When a contamination spot is detected, a preliminary plume progress direction is calculated by a connecting line drawn on top of the map between the incidence spot and the highest radiation spot level measured.

Plume mapping - the helicopter flies perpendicular to the plume axis and forward in the wind direction, as shown in the figure below (see figure 2).

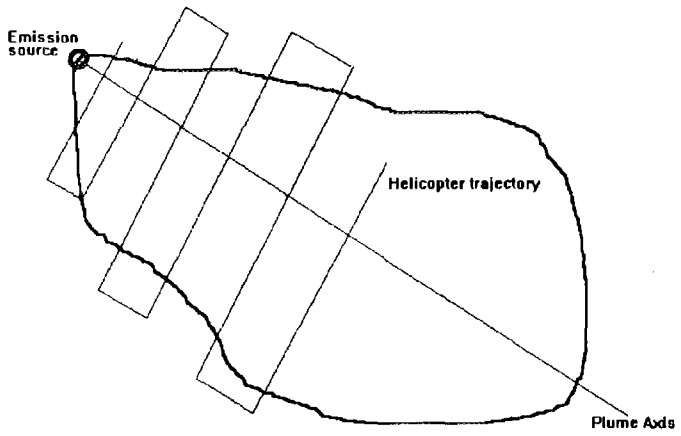

Fig. 2- Plume Mapping Task

Plume altitude - the helicopter descends beside the plume until the two horizontally separated PM detectors show the same radiation values.

Spectrum analysis - spectral samples accumulation for contamination, composition and quantity analysis.

Area Monitoring - survey of a ground area from 300 feet height for computation of the radiation field one meter above the ground.

Ground Route Monitoring - flight above a ground route for safety traffic approval.

Summary

An Airborne Monitoring System has been designed to collect, analyze and display radioactive contamination data. The system enables radiation data analysis on the ground station in real time as well as hazards estimation for present or future planning.