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# SOFTWARE FOR AIRBORNE RADIATION MONITORING SYSTEM

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## I. Introduction

The Airborne Radiation Monitoring System monitors radioactive contamination in the air or on the ground. The contamination source can be a radioactive plume or an area contaminated with radionuclides. This system is composed of two major parts: Airborne Unit carried by a helicopter, and Ground Station carried by a truck.

The Airborne software is intended to be the core of a computerized airborne station. The software is written in C++ under MS-Windows with object-oriented methodology. It has been designed to be user-friendly: function keys and other accelerators are used for vital operations, a help file and help subjects are available, the Human-Machine-Interface (HMI) is plain and obvious.

## II. The Airborne Radiation Monitoring System

The Airborne Radiation Monitoring system is illustrated in figure 1.

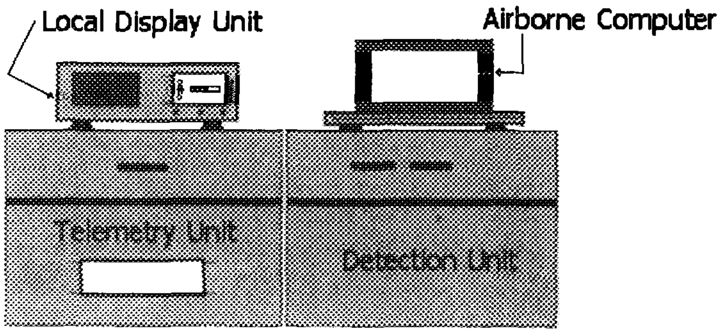


**Fig. 1 - The Airborne Radiation Monitoring System**

The main modules of the Airborne System are:

- **Local Display Unit** (LDU) - includes barometric altimeter, GPS (Global Positioning System), strip chart recorder, and a microprocessor controlled card. The microprocessor based card analyzes data received from radiation detectors, displays it on a LCD screen and prints it using the strip chart recorder. The data is transmitted to the PC for further analysis.
- **Radiation Detection Unit** - includes two 2" × 2" NaI(Tl) scintillation detectors and two Geiger-Muller tubes. The scintillation detectors are horizontally separated by a thick lead plate so that the lower one detects radiation bellow the helicopter and the upper one detects the radiation above it.
- **Telemetry Unit** - based on a transceiver and a modem, is used for transmission of real time data, as well as complete files, instructions and general information. The ground station uses the same telemetry unit.
- **Airborne Computer Software** - controls the whole system operations. Software receives the following inputs: Radiation data and detectors status from the LDU; barometric altitude from the barometric altimeter; current location, velocity and satellite's detection quality from the GPS; and instructions and data from the ground station via the telemetry system. The software capabilities are detailed in part III.

## III. The Airborne Software Capabilities

The airborne software is designed to operate under several monitoring tasks. The software displays a map, taken from data-base, where the helicopter's current location is indicated as a circle with a short line pointing out its flight direction. The map can be displayed in various scales such as 1:50,000, 1:250,000 and can be zoomed in and out. The map can be centered on the following: helicopter location, contamination source location, a site taken from a list that can be modified (new sites can be added or deleted), or any location given in UTM coordinates. The helicopter trace is marked on the map as a colored line. The trace colors change according to the detected radiation levels and threshold levels loaded from a setup file.

As the cursor moves on the map, its location in UTM coordinate system, its distance from the helicopter location, and the azimuth from the helicopter location to the cursor position, are written on the main window.

The data received from the LDU is displayed in real-time in strip chart graphs: a special graph window displays detector's reading and detectors readings combinations such as sum, ratio and difference; the lower detector is displayed separately on the main window as a strip chart graph; GPS status and current location in UTM coordinate system are shown at the display bottom, and current helicopter altitude is displayed both as text and as a bar-graph. The software allows manual correction of the measured altitude (measurement inaccuracies may occur due to atmospheric phenomenon) by letting the user to add an offset to the barometric altitude.

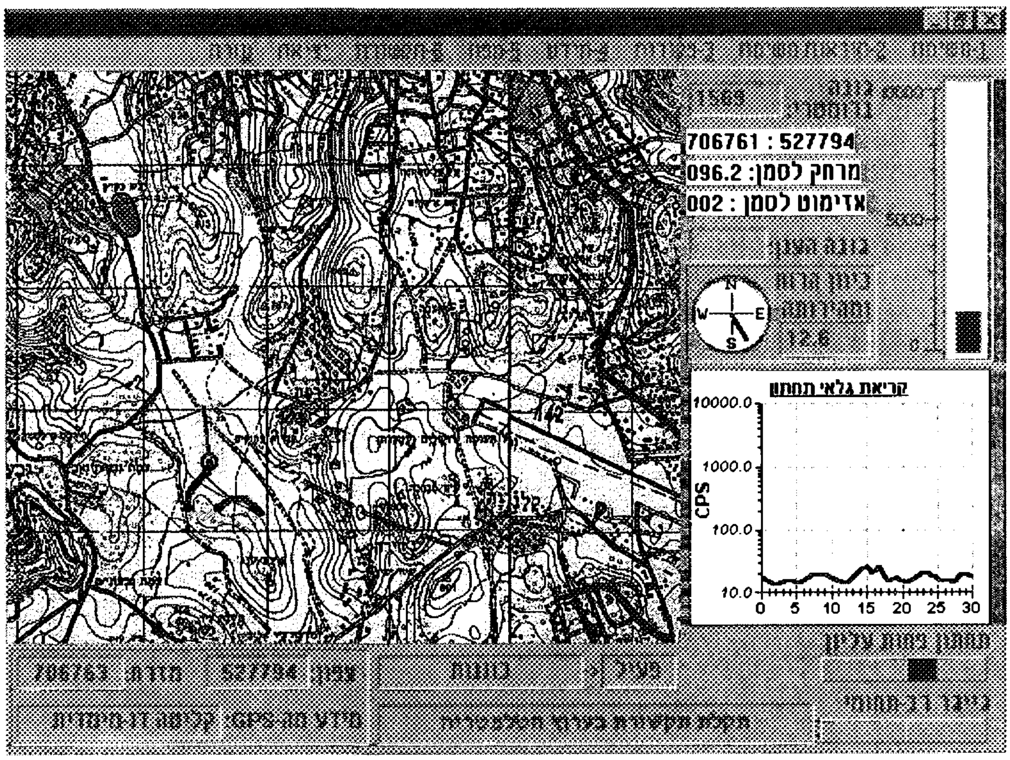


**Fig. 1 - The Airborne Software main window**

A very important feature of the software is its ability to detect system errors and provide adequate alarm messages. This automatic alarm system also informs about exceeding predefined radiation threshold-levels, detectors malfunction, communication errors, etc. A warning window displays bar-graphs of the current radiation level and the accumulated radiation. This window gives a short description of the current alarming conditions. After the user acknowledges an alarm condition by pressing the OK button on the warning window, the alarm message appears in red at the bottom of the main window if the alarm cause still exists. When several alarms are acknowledged, and their cause still exists, they will be displayed in the same field in a cyclic manner.

Current data is transmitted to the ground station and saved in files in both airborne and ground stations for later analysis. The ground station analyses this data nearly on-line, in the same way as the airborne software. Data files can be transmitted to the ground station to compensate data loss due to telemetry malfunctions during on-line data transmission. Since there is a baud-rate difference between the computer-to-modem and the telemetry channel, a file transfer protocol was written using CRC-16 algorithm plus packets numbering, so that when a packet is received damaged, the ground station software can ask for the same packet again. Both ground and airborne softwares include file-compression algorithms based on the Lempel-Ziv algorithm [1], in order to minimize the files size, thus shortening files transmission time. Text messages can be transmitted between the airborne and the ground station, and are displayed in a window divided to transmitted and received parts.
Wind direction and velocity data can be received from the ground station or typed in the airborne computer. The wind direction is displayed as a gauge while the velocity is written as text. This information can assist the flight crew in making decisions about plume drift direction.

## IV. Radiation-Monitoring Tasks

Tasks are initiated by an appropriate menu selection. Each task can be stopped at any time for any reason, can be continued later and eventually terminated. The tasks are usually performed in the following order:

1. **Emission Source Detection** - During this task the helicopter circles above the contamination source location indicated on the map (see figure 2).

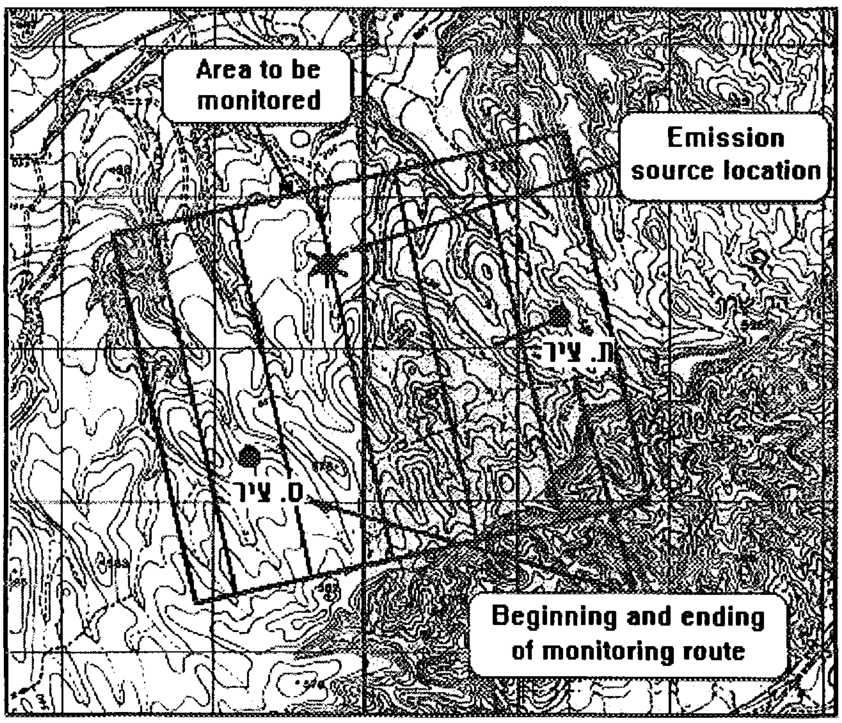


**Fig. 2. Tasks information drawn on the map.**

The helicopter trace colors indicate the plume initial direction. At the end of this task, software filters the radiation data and calculates the initial plume direction. The result is painted on the map and transmitted to the ground station.

2. **Plume mapping** - Based upon the plume direction detected in the previous task, the helicopter crosses the assumed plume axis in a rectangular wave form. The helicopter trace colors indicate the plume radiation levels.

3. **Plume altitude** - The helicopter ascends while the plume is on its right side, until it surpasses the plume top, then it descends below the plume base. During this task a real time graph window illustrates the helicopter altitude vs the difference between the upper detector and the lower detector reading. At the end of this task software calculates the plume altitude as the average of the altitudes where the difference between the upper detector and the lower detector readings is below the local radiological background:

$$(1) \qquad PH = \sum_{i=1}^{n} h_i / n \,, \quad \text{where:} \quad h_i \in \left\{ h \;\middle|\; \left( |l-u| < B \right) \right\} \text{ AND } \quad (u,l > 3B)$$

$PH$ - Plume altitude (feet).
$h$ - Helicopter altitude (feet).
$u$ - Upper detector reading (CPS).
$l$ - Lower detector reading (CPS).
$B$ - Radiological background (CPS).

4. **Ground route monitoring** - The helicopter flies close to the earth surface over a predefined route, where the starting point is drawn on the map as a blue circle filled with gray color with a short line signalizing to the ending point (see figure 2). The helicopter trace colors indicate the radiation levels along this route, and this information is the main factor in considering transportation prohibition.

5. **Area monitoring** - The helicopter flies close to the earth surface over a predefined area. This area is marked on the map as a rectangle divided by parallel lines that suggest the helicopter flight course (see figure 2). The helicopter trace colors drawn on the map perceive the radiation dispersion over the monitored area.

6. **Spectrum analysis** - The software activates a multi cannel card. This task should be done at a sufficient distance from the plume, so that the measured dead-time would be negligible and the spectral data will be reliable for spectral analysis. The data received from the detectors is displayed on a real time graph as counts-per-channel vs. 1024 channels, and simultaneously saved in files which can be transmitted to the ground station at the end of this task. This task can be performed independently, preferably adjacent to the area monitoring or plume altitude tasks.

## V. The Ground Station Software

The ground station software resembles the airborne software, but differs mainly in its inability to actually begin/ halt/ terminate a task. The ground station receives the data via the telemetry channel, analyzes and displays it on-line.
The software analyzes historic data by loading various tasks files, displays the data as graphs and as the helicopter colored trace on the map, performs plume contours calculations and draws them on the map. Results can be printed, using a colored ink-jet printer. The colors are very significant, specially when plotting the helicopter trace. The printed data includes graphs and the map with all the relevant data on it.

## VI. Summary

The software of the Radiation Monitoring System, developed at the NRCN, was mainly designed to perform the following tasks: real time processing, storage and graphical display of radioactive contamination on both, airborne unit and ground station. Software illustrates the updated information (helicopter location, colored trace, etc.) on area maps, and an alarm system is activated in case of any hazardous condition. The results obtained from the monitoring tasks are essential for risk assesment.

### References

[1] J. Ziv and A. Lempel, “A Universal Algorithm for Sequential Data Compression”, IEEE Transactions on Information Theory, vol. IT-23, no. 3, MAY 1977, pp. 337-343.