ERMS – Environmental Radiation Monitoring System

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Abstract. A new Environmental Radiation Monitoring System (ERMS) [1] has been developed in the NRCN as an extensive tool to be applied in case of nuclear malfunction or Nuclear Disposal Device (NDD) incident, as well as for routine radiation monitoring of the reactor's vicinity. The system collects real-time environmental data such as: gamma radiation, wind speed, wind direction, and temperature for monitoring purposes. The ERMS consists of a main Control Center [2] and an array of monitoring stations. Fixed, environmental, gamma radiation monitoring stations are installed at the reactor's surroundings while portable stations can be posted rapidly along the wind direction, enhancing the spatial sampling of the radiation measurements and providing better hazard assessment at an emergency event. The presented ERMS, based on industrial standards for hardware and network protocols, is a reliable standalone system which upgrades the readiness to face a nuclear emergency event by supplying real-time, integrated meteorological and radiation data.

KEYWORDS: Environmental Radiation Monitoring

Figure 1: Deployed Radiation Monitoring Station

1. System Overview

The ERMS main and topmost feature is the ability to monitor continuous gamma radiation fields through remote stations. In the event of emergency, transportable stations are rapidly deployed along the wind direction, in addition to the existing fixed positioned stations.

A Control Center server continuously collects the data from the stations, stores it in a local database for future processing and transmits it to a Graphical User Interface (GUI) on remote PCs. Communication between the Control Center server, the stations and the GUI PCs is performed using User Datagram Protocol (UDP) data packets over a Virtual Private Network (VPN), based on a combination of cellular, DSL and local Ethernet networks.

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The GUI displays the received data on geographic maps (GEO), enables to view various types of graphs, activates alarms whenever a radiation threshold level is crossed or a station failure occurs, and creates reports over different cross sections. The GUI remotely controls the stations operation mode and maintenance parameters. In addition, a simulation software module is included for training the system operators and radiation safety inspectors.

2. Radiation Monitoring Stations

2.1 Main Features

The radiation monitoring stations [3] (Fig. 1 and Fig. 2) were developed in full compliance with the IEC 60846 International Standard [4] for radiation dose rate monitors. Each station comprises of:

(a) Internal RAM R-200 [5] γ-detector with two Geiger-Muller tubes for high and low radiation rate measurements. The radiation detection characteristics are:
- Measurement range: 0.1 μSv/h to 1 Sv/h
- Accuracy: 15% (about 95% of the readings)
- Energetic response: ±25% at 16 keV to 13MeV
- Sensitivity: 1000 cpm/μSv/h → (0.1 μSv/h ÷ 200 μSv/h)
  10 cpm/μSv/h → (200 μSv/h ÷ 1 Sv/h)

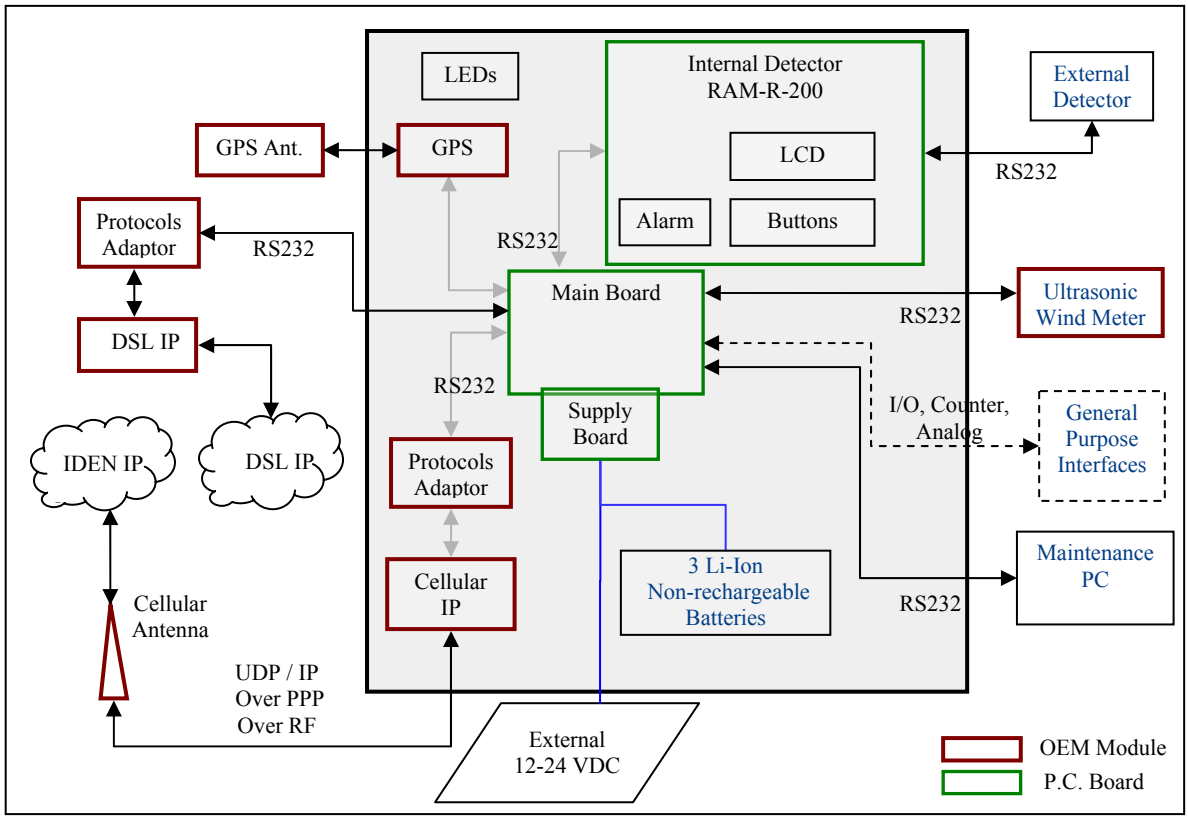
(b) Interface with a wide range of external detectors like RG-12 (β and γ contamination probe) or RP-11 (scintillation detector for low γ fields measurement).

(c) GPS for automatic position acquisition to enable tracking of portable stations.

(d) Internal cellular modem and RS232 interface for external DSL modem. The station utilizes a commercial network adapter that establishes network connection and creates UDP packets. The ERMS can be easily adapted to various modems and networks by minor configuration changes.

(e) Each station supports several serial communication interfaces for internal and external modules, see Fig. 2.

Figure 2: Station Block Diagram



(f) Local robust WindSonic [6], an ultrasonic wind sensor providing wind speed and direction (optional).
(g) LCD for local radiation field display and LEDs for simple local status indication.
(h) Power supply:
- Automatic switching between internal batteries and external DC power supply
- Long shelf life of up to 10 years using three 3.6V Li-Ion non-rechargeable batteries.
- The batteries enable station full operational mode with data transmission rate of a message per minute, for more than 48 hours!

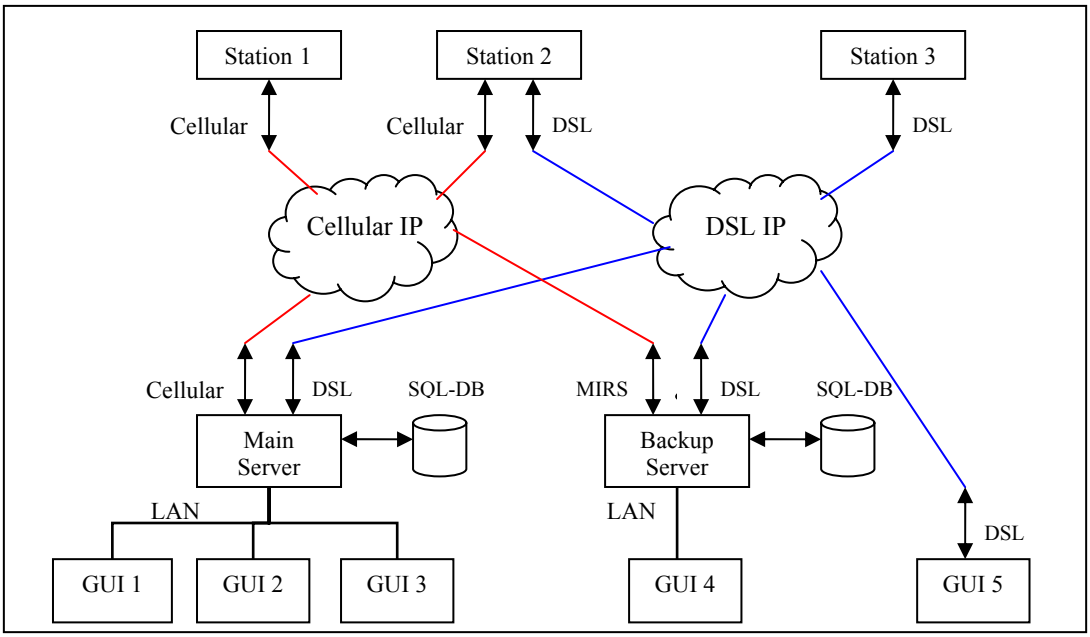
(i) Casing:
- Sealed rugged case, meets IP65 [7] standard
- Easy decontamination
- Operating temperatures -20°C to 80°C

3. The System Network

The ERMS communication network is a VPN that consists of three IP Networks: IDEN™ (cellular), DSL (over phone lines) and Local Area Network (LAN), to provide redundancy and flexibility. Since all networks are IP based, transferring a station between networks is transparent to the Control Center enabling automatic switching in case one of the networks crashes in an emergency event. Since IP network is in the mainstream technology, it is highly supported and unlikely to disappear in the near future. The UDP was preferred over the Transmit Control Protocol (TCP) since it has far less bytes overhead per packet. This feature is useful when sending small data packets over relatively slow cellular data link, which already incorporates a built in link control. Since UDP is a "connectionless" protocol, a message hand-shake is included at the high level ERMS protocol.

With old dial-up technology, connection to the stations was sequential and slow. Today, IP networks enable simultaneous connection to all the stations, achieving data retrieval cycle from 30 stations once a minute, even with a slow cellular IP network. This sample frequency is more than sufficient for routine environmental radiological monitoring and for emergency needs.

Figure 3: The ERMS Network Structure



At the control center proximity a fast LAN (100 Mb/sec) is used to transfer data from the main Communication Server to the GUI PCs, thus allowing to install as many GUI PCs as necessary. A GUI PC or a backup Communication Server can be installed anywhere using DSL network. The communication server acts as a gateway and connects all three networks as shown in Fig. 3.

4. Control Center

The Control Center uses powerful server hardware with redundant power supplies and hard drives. The Control Center software contains two modules: (1) Collector - controls all communication to the stations and GUIs, (2) Structured Query Language (SQL) Data Base (DB).

The Control Center software main functions are:

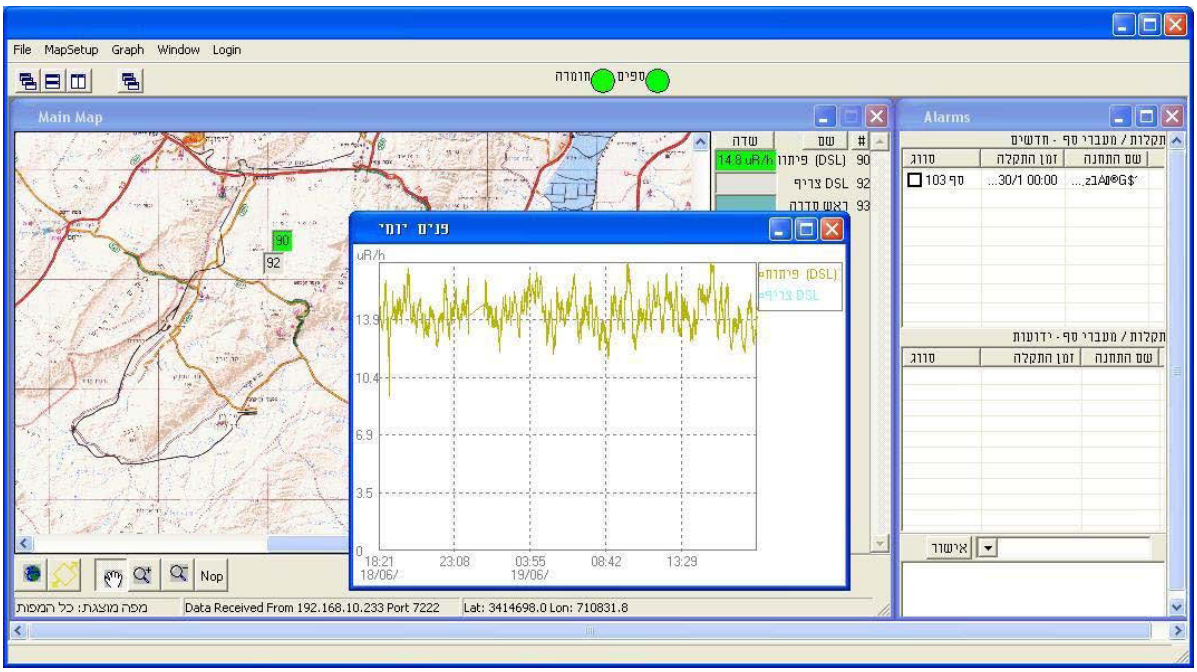
(a) Polling and Collecting environmental data from the stations
(b) Retrieving Built In Test (BIT) results for maintenance needs
(c) Sending alarms and current readings to the GUI
(d) Sending reset commands to the stations upon request
(e) Managing the SQL DB
(f) Sending history records to the GUI upon request, using SQL queries
(g) Data synchronization with the secondary server
(h) DB backup

5. GUI Software

The operator front-end interface to the ERMS is the GUI application, based on Windows XP™. The GUI communicates with the Collector application at the main or secondary server (to the active one) retrieves the data and displays it on screen (Fig. 4). The collected radiation dose rate measurements are displayed using three different visual aids: (1) a table of all the stations and their current dose rate, (2) an electronic map - Geographical Information System (GIS) with each station location colored according to the radiation level, and (3) real time graphs of the dose rate across a chosen time period for selected stations, with the intervals' calculated statistics.

The GUI simulation software module generates real-time synthetic dose rate values per station. These readings are produced by generating time dependent radioactive plume and sampling the radiation field of the plume at each station location. The plume is simulated with respect to parameters such as: sampling and eruption locations, wind properties, time and eruption rate as explained at [8]. In the simulation mode the GUI retrieves the data from the simulation software module instead of the Control Center.

Figure 3: GUI Screen Shot



The GUI application tasks are:

(a) GEO (geographic map) presentation of data received from the stations, including standard operation tools like zoom-in, zoom-out and pan.
(b) Table displaying all the active stations and current readings.
(c) Updating data in real time
(d) Visualizing the dose rate level by colors corresponding to predefined thresholds.
(e) Alarms:
    - Threshold alarms - activated according to predefined settings per station (within the DB).
    - Maintenance alarms - for malfunctions such as: communication failure, low battery, detectors malfunction, etc.
    - Audio and visual alarms activated until the operator's confirmation.
(f) Log the actions done by the operator for every alarm, e.g. confirmation, notifying the maintenance team or ignore.
(g) Enable the user to view the collected data from several stations on graphs.
(h) Executing cross sectioned reports with ability to export to Excel™ or text files, such as station maintenance (BIT) or radiation rate per location.
(i) Designating operation privileges like: threshold changes, alarms confirmation and remote station reset. A view-only mode of the GUI can be installed for non-privileged users.

6. Summary

The ERMS provides a modern solution for environmental monitoring in routine and emergencies, by employing a flexible and easily deployed stations array for harsh weather conditions, with redundant communication channels and standard components. The proposed system was designed to replace and upgrade the previous radiation monitoring system. The ERMS is in the end of its development and testing phase and should be operational by the end of 2008.

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