Research aimed at Nuclear and Radiological Emergency

Petr Kuča, Josef Koc

National Radiation Protection Institute (SURO), Bartoškova 28, 140 00 Praha 4, Czech Republic

petr.kuca@suro.cz, josef.koc@suro.cz

Abstract

Paper presents current status and selected results of security research in the Czech Republic, aimed at Emergency Preparedness and Response in case of both Nuclear and Radiological Emergency performed by the National Radiation Protection Institute. This research is founded by the Ministry of Interior of the Czech Republic.

Introduction

Security research in the CR, organized by the Czech Ministry of Interior, is aimed at development of novel approaches, methodologies, guides and equipment for monitoring and evaluation of radiation situation, preparing measures for protecting both public and responding personnel and at development of novel equipment for monitoring of radiation situation. Another part of the research is aimed at

- Increasing the level of security of citizens by exploitation of the newest technologies and knowledge according to state of national and international security;
- Improvement the quality of identification of prevention to and protection against threats endangering security of critical infrastructures, including reduction of their consequences;
- Formation and improvement of technologies, techniques, processes, approaches, practices and their application in praxis aimed at the effective crisis management and response on both national and international level;
- The research of prevention, preparedness and reduction of consequences of potential serious accidents of the Czech NPPs in connection with the up-to-date results of the stress tests going at EU NPP is aimed at selected accident scenarios

Results of selected parts of three projects, solved by SÚRO, are presented here.

Mobile and stationary radiation monitoring systems of the new generation for radiation monitoring networks (MOSTAR)

is aimed at development of a new generation radiation detection systems[1] based on experiences gained during monitoring of the Fukushima nuclear accident experiences. Mobile and stationary systems, on-line data transmission to central and local decision makers for quick a reliable decision are being developed.

The project covers

- optimised probes [2] suitable to use
  a) as fixed units for local municipalities, other public and civilian subjects, also for citizens, and
  b) as stand-alone deployable units for expanding the monitoring network within the Emergency Planning Zones of Nuclear Power Plants;
- sophisticated high-volume air samplers for monitoring of radioactive aerosols;
- new generation mobile laboratory;
- modern detection tools for remote-controlled mapping of radiation fields.

The first task - optimised probes - is presented in more details:

<u>Detection unit</u> is composed of up to three GM-tubes (see Fig.1) with overlapping measuring ranges providing total range from approx. tenths nSv/h up to units of Sv/h (see Fig. M1)

<u>Powering</u> of the units is ensured for version a) by local PC or 220V AC/15V DC adapter resp. internal accumulator charged by photovoltaic (solar) panel, ensuring up to >100 hours of uninterrupted operation (see Fig. M3).

<u>Communication</u> of the probes with central database is ensured for version a) via internet connection of the local PC or similar source, for version b) via mobile operator´s networks using built-in GSM modem. Result of monitoring can be stored in the internal memory (microSD card) of both type probes.

<u>Calibration</u> of probes is performed in SURO irradiation facility and low-background WBC chamber (see Fig.M2), using Co-60, Cs-137 and X-rays sources.

<u>Operational field testing</u> of the system is performed in 2015: probes are installed in localities in CR for long-term full operation - measuring, data transmission to and storage in the central database, presentation on webpages (see Fig. M4).

Figure M1 Multi-detector configuration

Figure M2 Probes testing and calibration in SURO

Figure M3 Stand-alone version (prototype)

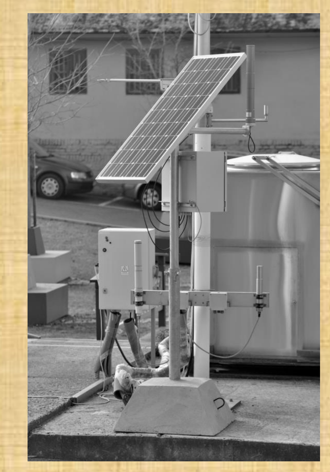
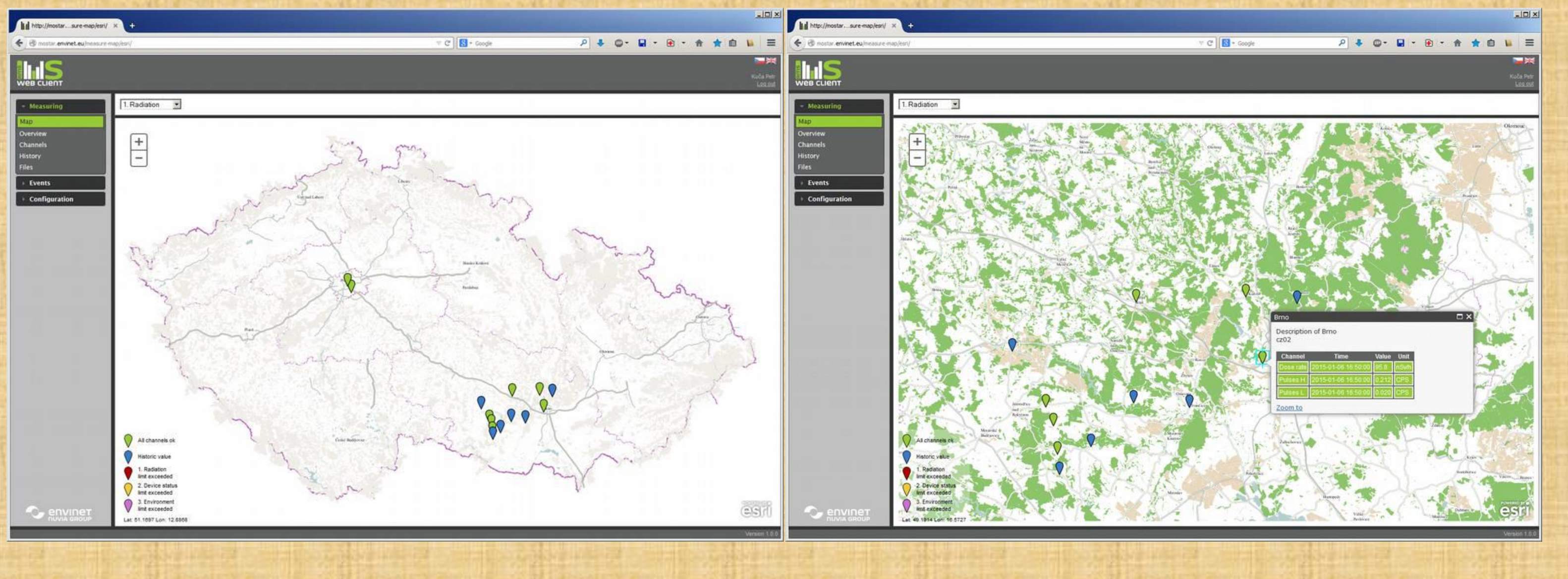


Figure M4 Central database application – examples of screens



Research of advances methods of detection, assessment and mastering of radioactive contamination aimed at modernization of appropriate parts of system for ensuring protection of public and selected critical infrastructures of the Czech Republic related to radiological attack or large-scale radiological emergency

The project covers wide range of goals from detection of radioactive matters up to early warning and information of both public and responding personnel , education public, training of responding subjects, foreknowledge of public and of touched subjects and bodies.

Task covering modern methods of analysis including field tests [3] is described in more details:

Filed tests simulated a dirty bomb attack by dispersion of radionuclide La-140 by a small-range blast in free space (see Fig.R1) and consequent monitoring of atmospheric and surface activity concentrations of La-140 (see Fig.R2, Fig. R3a) and dose-rate (see Fig.R3b) were performed. Meteorological parameters in the locality were recorded.

Results obtained during this test (are in good accordance with previous similar tests with partially driven direction of dispersion [4], [5] and confirm that (except others)

- character of such event could be expected as rather local with only a limited area affected;
- meteorological situation in time of the blast is dominant factor for determining the direction of the dispersion and the size of the affected area in comparison with blast configuration;
- fast decrease of the volume activity of the air can be considered for decision on personal protective equipment;
- further development of mobile monitoring on small-scale level is necessary, especially for formulating methodics and approaches for both UAG and UAV usage.

Experiences gained in this research will be used for solving project tasks.

Figure R1 Locality of field tests

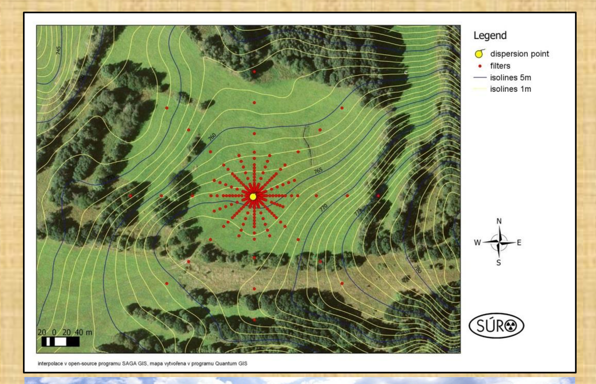


Figure R2 Scheme of monitoring points

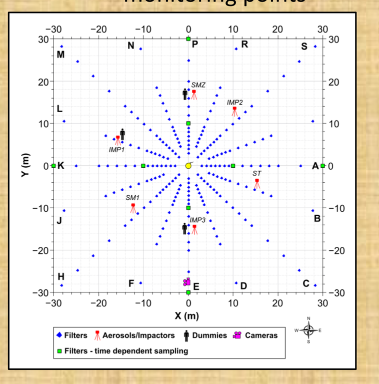


Figure R3a Equipment for air and surface concentrations monitoring

Figure R3b Equipment for mobile monitoring

Figure R4 Surface activity concentration by fallout sampling and by dose rates

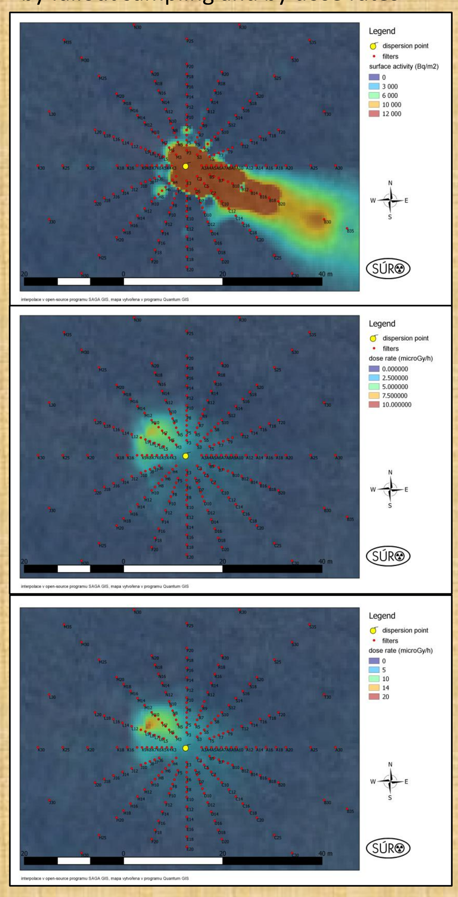


Figure R5 Time course of air concentration

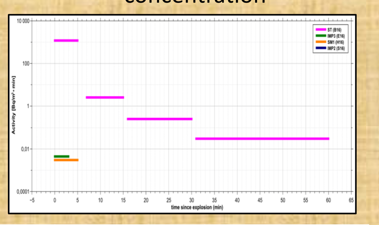


Figure R6 Mobile monitoring – GPS coordinates comparison

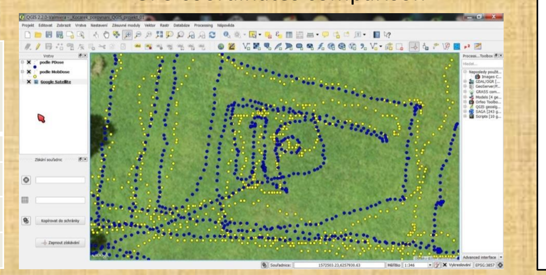


Table R1 Surface activity of figurines´ clothing

Figurine	Height of figurine	Surface area of clothing (estimate)	Distance from the blast point	Radius	Activity of front part of clothing	Activity of rear part of clothing
	[m]	[m²]	[m]		[Bq]	[Bq]
woman	1.7	0.4	16	P	<1	<1
man	1.9	0.57	16	E	5.38 ± 0.92	5.00 ± 0.98
child	1.5	0.3	16	L	0.92 ± 0.31	0.58 ± 0.25

Safety study related to the prevention and severe accident consequences mitigation was performed for the Czech NPPs in relation with the new experience obtained from the stress tests after the Fukushima accident.

This study was founded by the Ministry of Interior of the Czech Republic. The Czech National Radiation Protection Institute contributes to the evaluation of the potential radiation doses to the emergency workers in the course of severe accident and for a period of the recovery phase.

In order to optimize the emergency workers response strategy is necessary to identify potential radiation source terms in different areas of the NPP, the prevailing exposure pathways, the timescales over which the dose will be received, potential effectiveness of the individual protective measures and the data available for assessing of the radiation situation in the location of the emergency response. Knowledge of the timescales over which emergency workers will be irradiated provides to the decision makers information enable them to organize the emergency response if necessary.

In the event of a radiation accident at the nuclear power plant is likely that potential dose rates in different parts of the plant and airborne activity will vary depending up the space and the time. The doses received by the emergency workers will vary in dependence on the variations of the dose rates due to potential spread of the radioactive materials or due to atmospheric release.

Emergency workers engaged in the emergency response are usually well trained and prepared in advance in the frame of the emergency response organization. But before involving them to the actual response is necessary to evaluate radiation condition at the location of the intervention to avoid unforeseen exposure or injure. Data and information necessary for this evaluation are obtained from the unit information systems during normal operation of the nuclear power plan. But what situation arises after severe radiation accidents? This question was analyzed in the course of the above mentioned study [6] .

Potential spread part of the reactor core inventory into the rooms and corridors next to the containment or directly to the environment (see an example on the Figure P1) have been analyzed. During the early phase of a nuclear incident the exposure may come from external gamma dose and beta dose to the skin, from direct exposure to airborne materials and from deposited materials. The committed dose to internal organs may come from inhalation of radioactive material. The calculations of dose rates and volume activities as a function of the time was performed for different assessing points.

The radiological conditions in particular rooms, corridors and areas of the plant during or after accident, where the intervention is expected, has to be evaluated as the first. One example can be the areas where the device for the emergency sampling or manually operating valves are located. As a part of these analyses sets of reasonably conservative accident conditions were established and the dose rates and volume activities as a function of time were calculated.

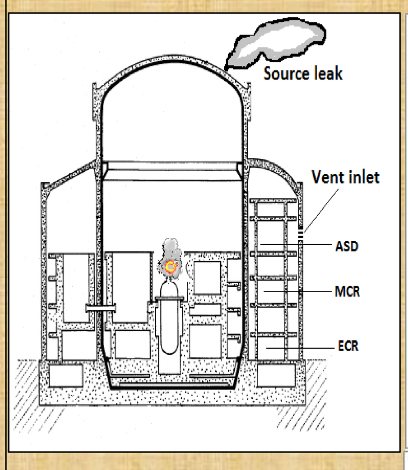
Main control room and emergency control room of the affected unit, main control rooms and emergency control rooms of non-affected units in case of the multiple units NPP, NPP main gate, locations of emergency control center, technical support center, operation support center, security control center and radiation service center at the exit from radiation control area were assessed.

In parallel with this evaluation, within changing radiation conditions in different areas of the NPP, an evaluation of the detection parts of the radiation monitoring systems dedicated for both technological and areas measurement of the dose rates has been performed. Different types of detectors used on Czech NPP which were dedicated to operate only within design basis accident were evaluated.

Each detector has been subject of the load tests [7] to determine its ability to respond correctly after being loaded above the producer declared working conditions. Each detector has been calibrated as the first to determine reference value. Then the average value of the reference response has been determined. After each steps of the load tests the reference response was measured again and the deviation from reference value was determined. Variable parameters were: dose rate, dose, temperature, temperature aging, vibration and combined effects of different previous mentioned parameters.

The following three types of the detectors including integral electronics have been evaluated: Geiger-Mueller counters, proportional counters and plastic detectors commonly used for detection of the radiation fields in the areas where the nuclear technology equipment are located or in the areas where radiation workers perform their normal working activities. Some preliminary results are presented on the figures (P2 and P3).

Figure P1: Scheme of the considered conditions



Legend:
ASD – accident sampling devise
MCR – main control room
ECR – emergency control room

Figure P2: Deviation of the reference value as a function of received dose for detector response of plastic (T1) and GM type 1, 2

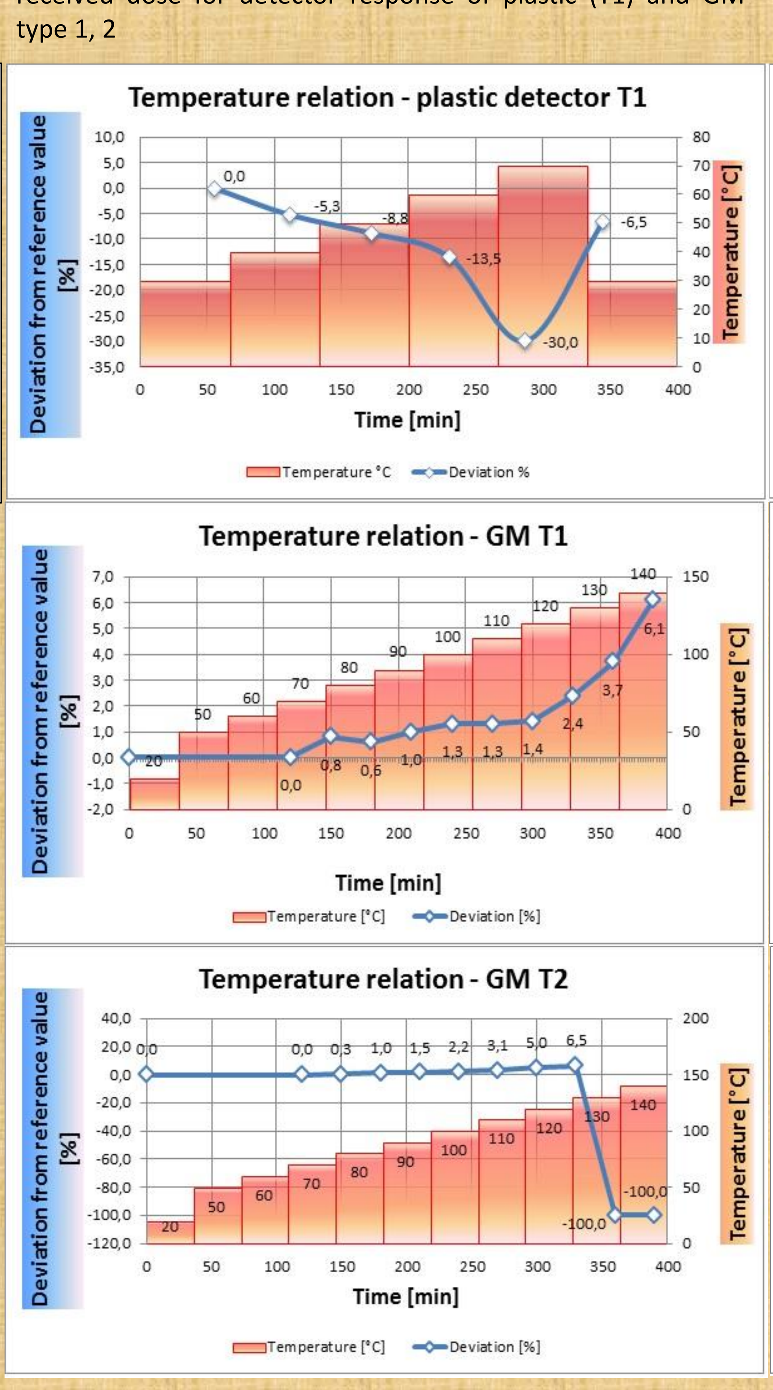
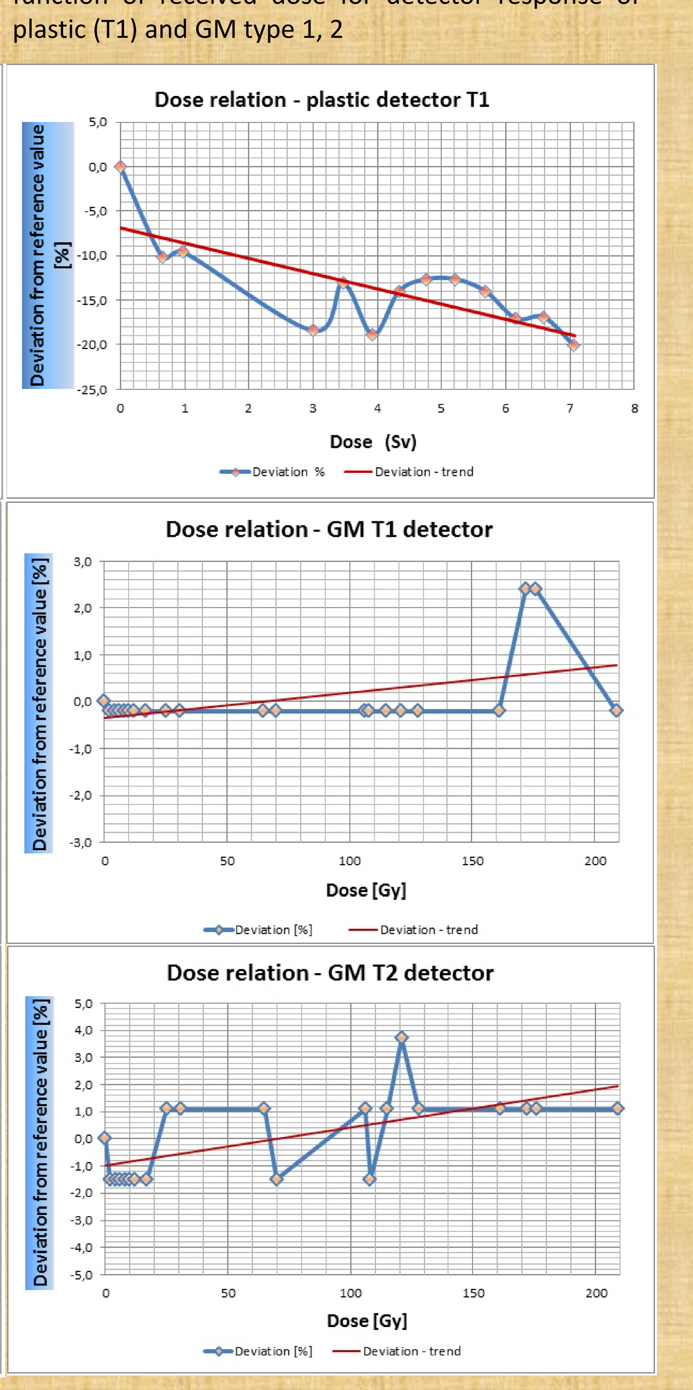


Figure P3: Deviation of the reference value as a function of received dose for detector response of plastic (T1) and GM type 1, 2



Conclusions

Activities in the frame of Security Research, aimed at development of novel approaches, methodologies, guides and equipment for monitoring and evaluation of radiation situation, preparing measures for protecting both public and responding personnel and at development of novel equipment for monitoring of radiation situation. resulting into development of novel monitoring systems and improved methodic and procedures based on deeper understanding of the problematics, contribute significantly to improvement effectiveness of Emergency Preparedness and Response to both Nuclear and Radiological Emergency in the Czech Republic.

Reference

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