RACON 3.01 – SOFTWARE TOOL FOR FAST RADIATION CONSEQUENCES PREDICTION AND FOR CRISIS MANAGEMENT OPTIMISATION

Jan Svanda, Jiri Tschiesche and Vladimir Fiser
Nuclear Research Institute, Rez near Prague, Czech Republic

INTRODUCTION

Emergency situations with release of radioactive material into atmosphere can be induced by many causes. Potential sources of such accidents are:

- Nuclear facilities
- Installations with radioactive source of high activity
- Legal transport of radioactive material
- Smuggling of radioactive material
- Terrorist actions with "dirty bombs"

Such situations need fast and efficient tools for evaluation of contaminated area, radiation doses to population and emergency teams and immediate decisions for urgent countermeasures. The earlier the countermeasures are practised the efficient they are. The RaCon 3.01 (Radiological Consequences) system, developed by NRI Rez, is one of the representatives of advanced supporting tools, which allows fast prediction of radiation consequences at such situations and gives support to decision makers in organizing countermeasures and actions of mobile emergency teams.

MAIN GOALS OF RACON PROGRAM SYSTEM

Computer program RaCon is designed for radiological impact prediction in the case of a radiation or nuclear emergency connected with a accidental release of radioactive materials into the environment, prediction of the radiological consequences in the affected locality, formulation and optimisation of the population protection actions as well as for their monitoring optimisation. The programme system gives possibility to evaluate wide range of radiation accidents. Programme module for evaluation or making more accurate source term based on field radiation measurements is part of the system. The tool is focused on the early stages of an accident, especially on the prediction of size of contaminated area, expected population doses, and on evaluation of excess over the dose guidance levels when urgent population protection measures must be implement. The software proposes these measures and their implementation in a shortest possible time after the accident when they are most efficient.

USER'S INTERFACE AND DIALOGUE WINDOWS FOR DATA INPUT

Evaluation of radiation threat during wide range of accidents is achieved by three independent program modules:

- Short radioactive releases into atmosphere
- Long lasting radioactive releases into atmosphere
- Accidents of nuclear facilities

User's friendly interface is used for all input data. Predefined source-terms for large, medium and small radioactive releases are part of the system. Input tables of measured radiation data in affected area serve for correction of source term. For nuclear facilities the pre-calculated source-term database is part of the input system in accordance with selected accident scenarios. Regime when the own source-term selection is possible, however only after the failed installation measured data are available, as a rule – after the radioactivity release into the atmosphere, which limits the advantage of early prediction. Inputs of immediate and forecasted meteorological data are supplied by interface tables or by user interface dialog. The

program provides a fast prognosis of the radioactive cloud transport, dispersion in atmosphere and deposition, consequential exposures of population and proposal for the immediate mitigation measures.

SOURCE TERM CORRECTION OR EVALUATION

Based on field radiation measurements a step-by-step method is used for correction or evaluation of source term. In the case of short radioactive releases the field measurements can be done only after the end of accident. Dose rates and values of surface contamination in affected locality are the available radiation data in this case. Input interface tables containing time of measurement, GPS geographical position and measured radiation values are used for the evaluation. List of identified released radionuclides is part of input table. If no identification of released radionuclides was done the ^{137}Cs radionuclide is used for calculation as a conservative approach. In long lasting releases the volume concentration of released radionuclides in air can be part of input measured data and used in the method of source term correction. Interactive cooperation of monitoring mobile teams and user of RaCon 3.01 program tool would be the best way for source term correction method. In the first run pre-calculated or pre-defined values of source term are used for calculation. In the next runs of calculation better and better approximation of the values for source term are used.

MODEL OF RADIOACTIVITY TRANSPORT AND DISPERSION

The program module for evaluation of transport and dispersion of radioactivity released to the environment uses for calculations modified Gauss segmented model of atmospheric dispersion. The individual release phases of radioactivity are divided into a series of consecutive short time releases (e.g. 10 minutes as a maximum), and their transport and dispersion is evaluated under changing meteorological conditions. Corrections on the effective release height, wind velocity changes along the height, roughness of the terrain and relative elevation above sea level are included. Radioactive contamination of the terrain is computed taking into account dry and wet deposition processes. Computations of the individual isotopes volume activity in the atmosphere and surface activity on the contaminated terrain include corrections taking into account their radioactive decay.

CALCULATION OF POPULATION EXPOSURE

This calculation covers effective doses and equivalent doses on thyroid for adult persons and group of children from 2 up 7 years age. The following ways of exposure are taken into account:

- External exposure from radioactive cloud
- External exposure from contaminated terrain
- Internal exposure from inhalation of radioactive substances.

There are included corrections on the final dimensions of radioactive cloud. Computations of the doses without protection measures are different for daytime and night: For day-time the doses are calculated for non-shielded terrain, for the night – it is assumed that people are within buildings, so the corresponding shielding factors are included. The effective doses and equivalent doses on thyroid are also computed for the cases when the urgent protection measures have been taken:

- Sheltering
- Iodine prophylaxis
- Evacuation

At the same time averted doses are computed, and the comparison with the guidance levels for implementation of urgent protective measures is made, in accordance with the State Office for Nuclear Safety Decree. In the first run of the programme the pre-selected time for

implementation of the iodine prophylactic and sheltering is used. Evacuation is not included in the first run. On the basis of the calculated radiation values the user of the software can in the next runs subsequently enter the proposed new time for evacuation, sheltering, iodine prophylactic and optimise countermeasures. Computed doses are presented graphically in the form of map sheets showing in different colour places where intervention levels were exceeded (Fig. 1). Values for adults and children, without and with protection measures are displayed separately. One window shows effective doses map sheets, the second one – equivalent doses on thyroid. Map sheets for the nuclear installation vicinity are displayed in three map scales.

This calculation covers effective doses and equivalent doses on thyroid for adult persons and group of children from 2 up 7 years age. The following ways of exposure are taken into account:

- External exposure from radioactive cloud
- External exposure from contaminated terrain
- Internal exposure from inhalation of radioactive substances.

There are included corrections on the final dimensions of radioactive cloud. Computations of the doses without protection measures are different for daytime and night: For day-time the doses are calculated for non-shielded terrain, for the night – it is assumed that people are within buildings, so the corresponding shielding factors are included. Splitting the day into day and night hours is different for adults and children and for individual months of the year. The effective doses and equivalent doses on thyroid are also computed for the cases when the urgent protection measures have been taken:

- Sheltering
- Iodine prophylaxis
- Evacuation

At the same time averted doses are computed, and the comparison with the guidance levels for implementation of urgent protective measures is made, in accordance with the State Office for Nuclear Safety Decree requirements. In the first run of the programme the pre-selected time for implementation of the iodine prophylactic and sheltering is used. Evacuation is not included in the first run. On the basis of the calculated radiation values the user of the software can in the next runs subsequently enter the proposed new time for evacuation, sheltering, iodine prophylactic and optimise countermeasures. Computed surface activities and doses are presented graphically in the form of map sheets showing in different colour places where intervention levels were exceeded (Fig. 1).

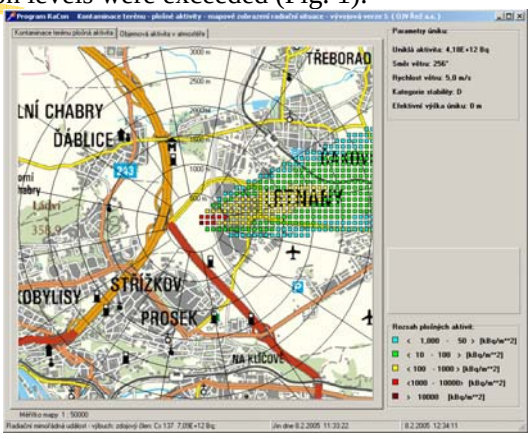

Fig 1; Map presentation of surface activities in affected area after simulated release of 4 TBq Cs137.

Separate windows are used for display of surface activities maps, effective doses and the thyroid equivalent doses map sheets. Values for adults and children, without and with protection measures are displayed separately. Map sheets for the nuclear installation vicinity are displayed in three map scales. The main output of the system is an immediate table presentation of the affected settlements (Fig. 2) which includes also radiation doses without protection measures, after their implementation, averted doses, proposal of the urgent interventions, number of inhabitants affected, and distance of a settlement from the nuclear installation. The table can be arranged in accordance with different criteria, for instance – dose value, number of affected inhabitants or distance from nuclear installation. Movement of the radioactive cloud under changing meteorological conditions is presented in the separate map window and time of the first and the last radioactive cloud appearance in the place elements is recorded (Fig. 3).

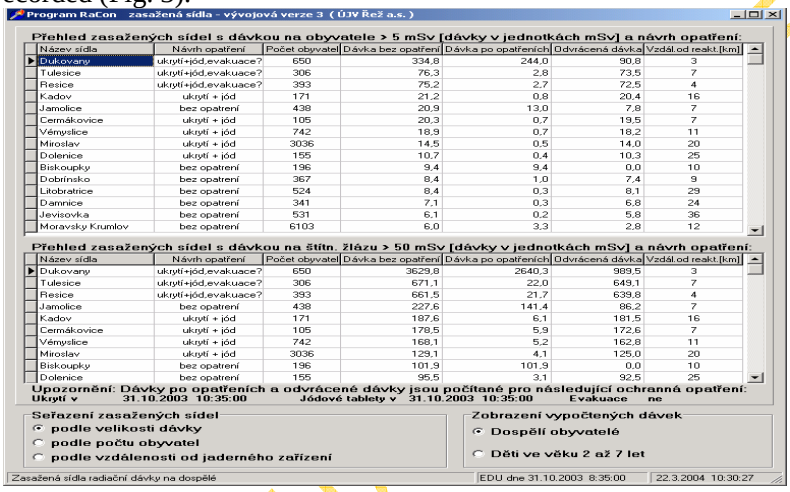

Fig 2; Table presentation of affected settlements and proposed countermeasures in the case of simulated accident at nuclear power plant

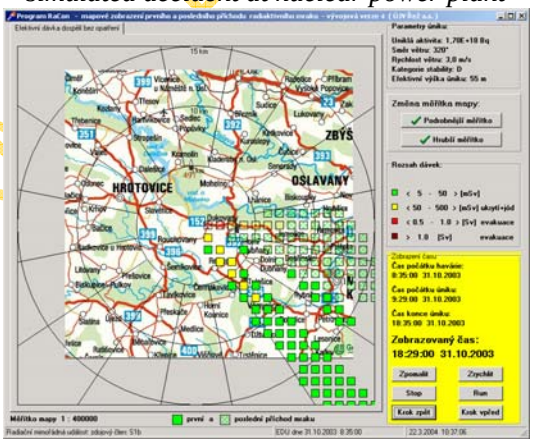

Fig 3; Map presentation of effective doses and movement of radioactive cloud (the first and the last appearance of radioactive cloud in the places are recorded and displayed).

EVALUATION OF EXPOSURE FOR THE INTERVENING MOBILE TEAMS

Integral part of this software tool is the possibility of simple selections of localities (using mouse in the map presentation) for which the expected dose rates and doses for the monitoring and intervening personnel will be computed and presented in a table form (Fig. 4 and Fig. 5). Dose rates and doses are computed for non-shielded persons and persons in motor