

# **SINAC – Simulator Software for Interactive Modelling of Environmental Consequences of Nuclear Accidents (Second Generation)**

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## **Abstract**

The SINAC programme system was developed to follow the consequences of radioactive releases of a nuclear accident. Atmospheric dispersion, plume depletion by dry-out and wash-out, cloudshine and groundshine doses, dose consequences of inhalation and ingestion, early and late health effects are computed in the software. Effects of the introduction of countermeasures are also taken into account.

The SINAC system – developed in our Institute in the 1990's – has gone through a lot of development in the last few years according to users' needs and to the Hungarian and the international regulations and protocols of radiation protection. Continuous development ensured that the SINAC environmental simulator was used as an interactive expert system in the Hungarian Atomic Energy Authority Centre for Emergency Response, Training and Analysis in the last decade.

Since the latest requirements on the programme based on principles set forth one and a half decades ago, could have been met only by considerable compromises in the future, it was claimed in 2009, that the course of development of SINAC should be reconsidered, and a new version should be created using the potentials of the present-day information technology. The common goal of several years of development was to obtain easily usable, flexibly developable software that gives results comparable to those of other software products being developed in international collaboration.

The structure of the new programme version in the current development phase is presented in this paper.

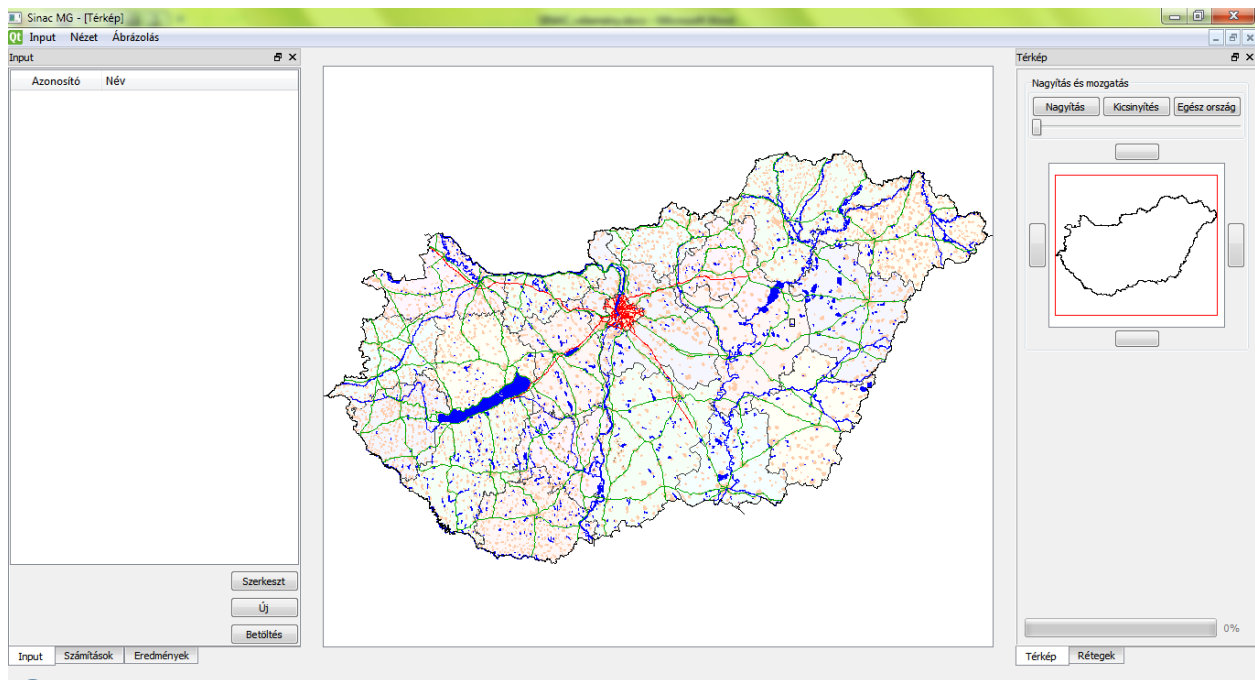
**Key words:** Environmental monitoring, Dispersion simulation, Puff modell

## **Introduction**

The SINAC programme system was developed to follow the consequences of radioactive releases of a nuclear accident. Atmospheric dispersion, plume depletion by dry-out and wash-out, cloudshine and groundshine doses, dose consequences of inhalation and ingestion, early and late health effects are computed in the software. Effects of the introduction of countermeasures are also taken into account.

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The structure of the second generation of the SINAC system has been created; the modules of the programme have been defined. The software has basically three functions: it has to handle the input data of calculations, execute the calculations, as well as visualize, and save the results. A comfortable and transparent interface to set the parameters of calculations was created. The parameters can be stored, since they might be needed when analysing the results, and they also have to be reloadable, so that new calculations can be performed using them. The module responsible for executing the calculations according to the input data and forwarding the output data to the visualization module was implemented. The programme has comfortable user interface to select the data to be displayed and way of visualization.



*Fig. 1: The start screen of the SINAC*

## Description

The common goal, as a result of several years of development, was to obtain easily usable, flexibly developable software that gives results comparable to those of other software products being developed in international collaboration. As a first step the potential directions of development were defined and a suggestion to carry out the tasks was made.

Besides of handling the input data and the results in a user interface for data input and visualization, storage and loading of input and output data structures were resolved as well.

The calculation uses a puff model for simulating atmospheric dispersion. Gaussian dispersion of the puffs is assumed with total reflection at the ground and at the inversion layer. Puff depletion is calculated at the end of every calculation step according to deposition and radioactive decay.

The time and the spatial resolution of the calculations were improved. The time resolution has changed from the former 60 minutes to 15 minutes. In this way, the emission source terms can be also set in 15-minute

resolution. On the input interface any number of calculation periods consisting 15-minute-long calculation steps with identical input data can be defined. One 15-minute-long emission step is distributed to 31 puffs, divided equally in time and in the means of activity as well. The radionuclides considered at the emission are presented in Table 1. The spatial resolution of the calculation has changed from the former 18×23 sectors to 133×61 sectors. The 8113 sectors cover the area of Hungary, the center of the calculation grid is the Hungarian Paks NPP, however the programme can be used to calculate for sources other as well. This causes an increase of a factor of 20 in the number of the sectors. Besides of sectors, control points can also be defined to calculate dosimetric data at any point on the map.

Three types of short-term countermeasures can be implemented during the simulation: sheltering, iodine prophylaxis and evacuation. Long-term countermeasures as relocation, food ban and pasture ban are also considered in the calculations. The actual decision for the implementation of the short-term countermeasures is for the user, while the long-term countermeasure actions are assumed to be taken automatically as the pre-set levels are exceeded. The user can introduce two types of countermeasure scenarios. Intervention criteria may be based on either activity concentration or dose type quantities.

*Table 1: Radionuclides considered at the emission*

Kr-88	Xe-133	Xe-135	Rb-88
Sr-90	Ru-106	Rh-105	Te-132
Cs-134	Cs-137	Ce-144	Pu-241
I-131	I-132	I-133	I-135

## **Structure**

The three functions are separated in the structure of the programme. The user has a simple interface to set the parameters of calculations. The parameters are stored and reloadable, since they might be needed when analyzing the results or performing new calculations using them. Since the input of the calculations might contain earlier results, they are also loadable as an input structure of the calculation.

The data structure of the SINAC programme is shown in Fig. 2. The calculation storage class contains all the input and output data of a calculation, the working variables of the calculation, and the data handling procedures such as saving, loading, and input data processing as well. The output data contains spatial and radioactive data of all puffs of the emission, dosimetric data for all pre-defined control points and all sectors. Besides of the control parameters and methods of the calculation, the user defined input data also holds data for each calculation period such as meteorology or source terms.

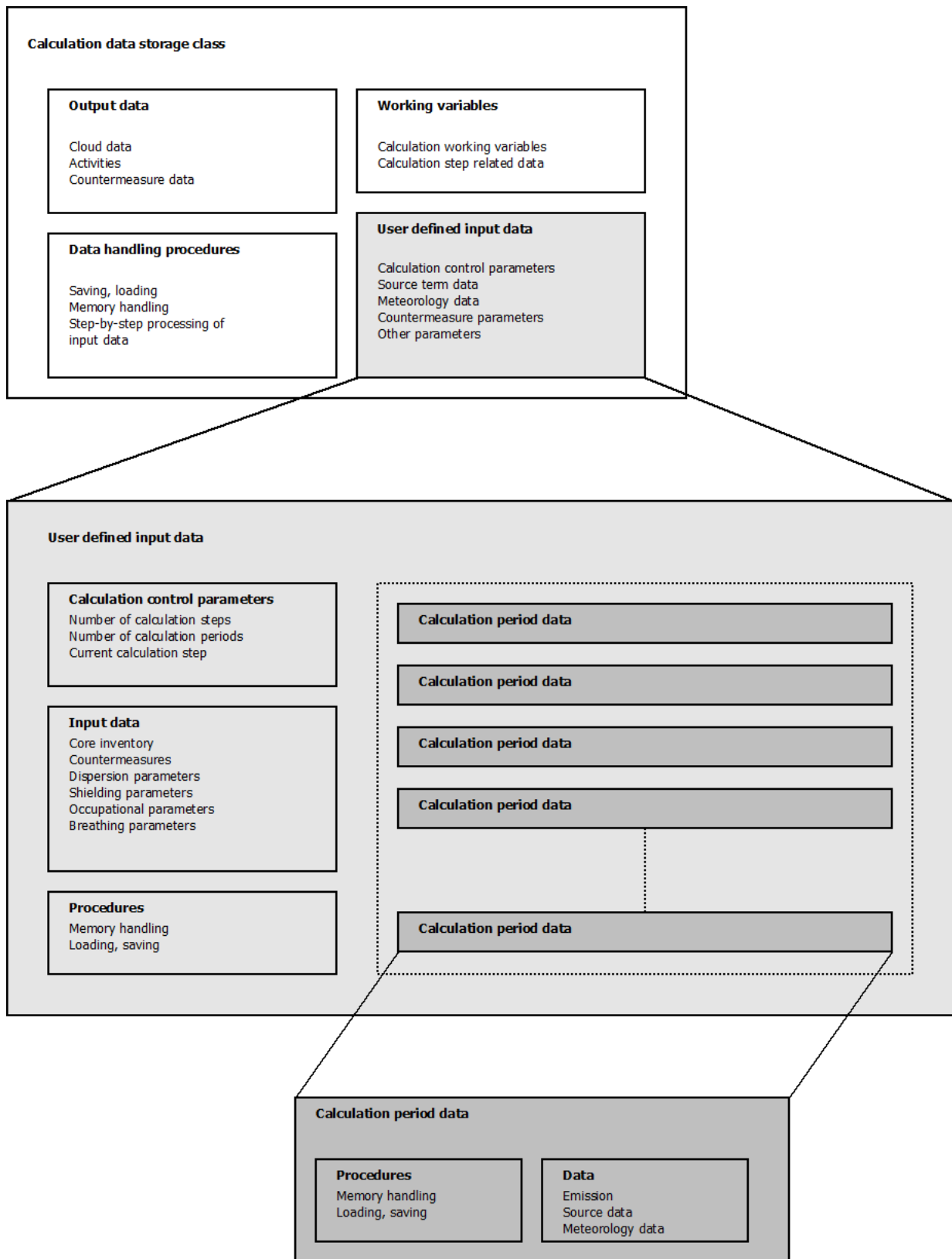


Fig. 2: Data structure

The module responsible for executing the calculations performs these tasks according to the input data and forwards the output data to the visualization module. The logical diagram of calculation is presented in Fig. 3.

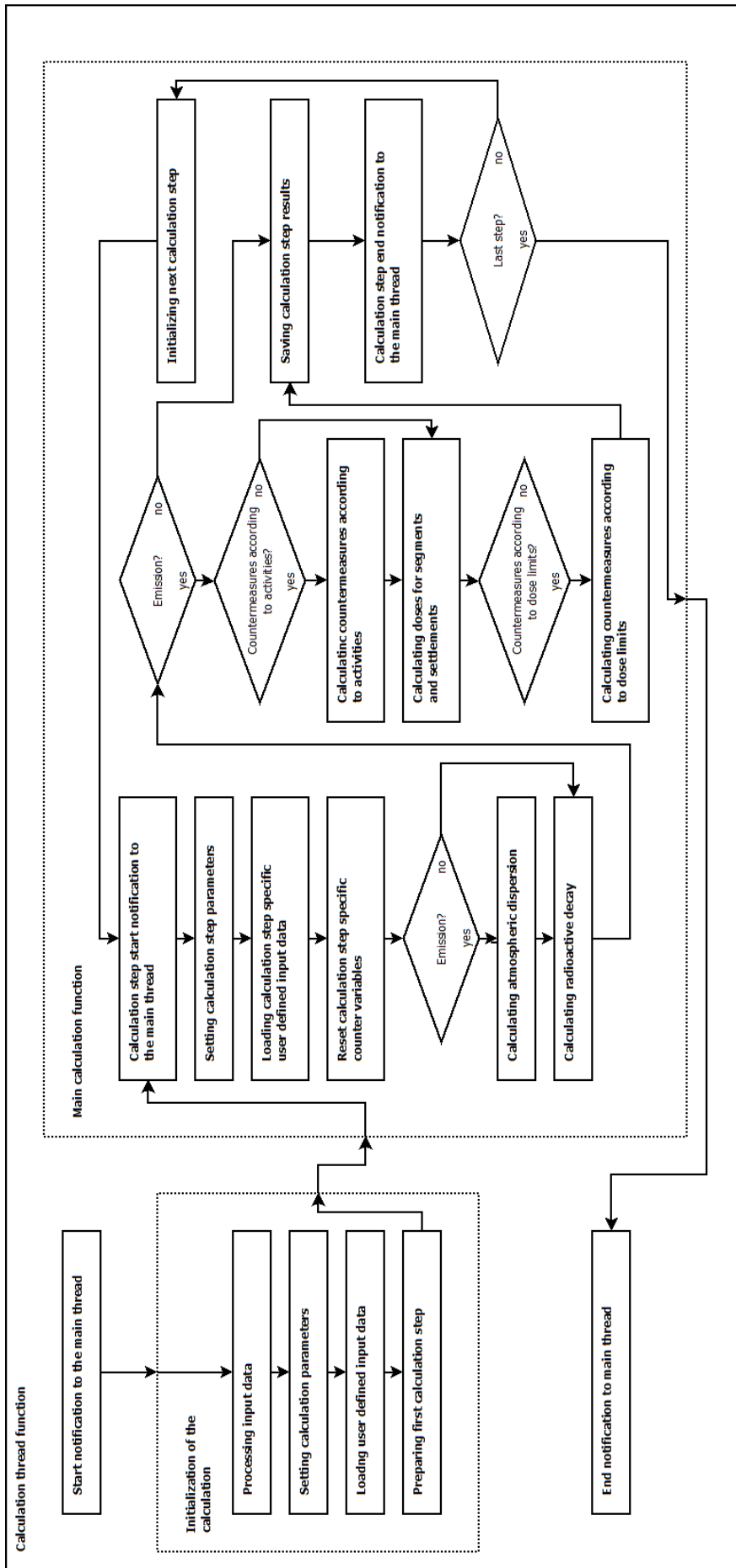
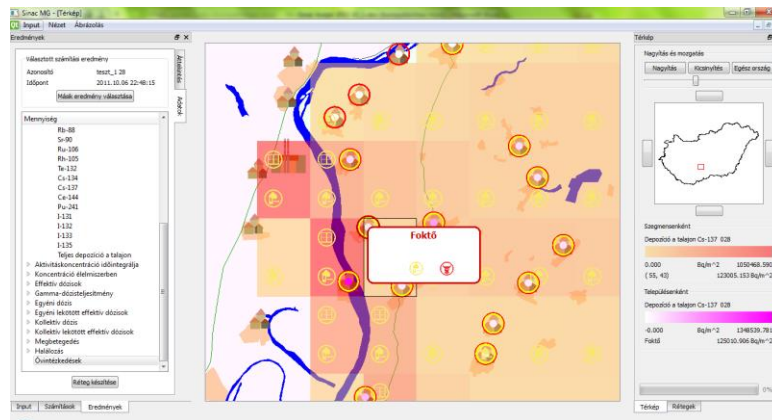


Fig. 3: Structure of the calculation module

The visualization module does not only display the calculation results but some of the input data as well. The results can be saved in different formats: binary (raw data), text (tables) and images (maps, charts). (Fig. 1 and Fig. 4)



*Fig. 4: Display of the results. The results for control points and for segments can be displayed simultaneously*

## Conclusion and further work

At the present point of the development we achieved to implement a new version of the SINAC programme system. The programme structure was revised, new GUI was created. The new version uses finer grid for meteorology data and calculation results. The results of the former and the new versions were compared and the fitting was convenient.

The next step of the development is to revise the calculator structure as well and to build in more sophisticated methods for dispersion calculation.