Dose Assessment after an Explosive Dispersion of Radioactive Material in Urban Surroundings. A Decision Support System for Use by Radiation Protection Authorities

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1 Introduction

Local or federal government authorities might face an explosion with radioactive material involved released somewhere in public urban areas. It is the task of the radiation protection authorities to assist the executive authorities (e.g. police, intelligence service,...), supporting forces (e.g. fire fighters, special forces providing technical support,...) which are responsible for measures at the scene as well as the population in the surroundings to eliminate or to minimise this kind of threat.
The minimisation of such threats can be planned e.g. by simulating the explosion and the possible dispersion of the radioactive material, which will lead to a clear picture of possible radioactive contamination in the surrounding areas or the main contamination pathways, leading to the exposure of the population and the possible counter measures, where these might be necessary.
Conducted by the German Federal Office for Radiation Protection (BfS) and in charge of the German Federal Ministry for Environment, Nature Preservation and Reactor Safety (BMU) a systems programme has been developed which is able to give a first overview of atmospheric dispersion, ground activity, deposition and inhalation dose after an instant or continuous release of radioactive material. The systems programme can be used by nuclear emergency authorities that are responsible for emergencies within the different German States (Länder). The systems programme has been developed in the year 2000 and is under testing in the BfS since beginning of the year 2001.

2 Dispersion procedures

An existing systems programme [LASAT] (Janicke, 1983, 1985), based on Lagrangian particle simulation has been adjusted to meet the requirements of the nuclear emergency authorities [LASAIR, Lagrangian Simulation of Dispersion and Inhalation of Radionuclides]. It is able to handle initial explosion of an IED (improvised explosive device) with additional radioactive material or the continuous release from a source.
It simulates the transport and dispersion in the atmosphere, deposition on the ground and activity of radionuclides close to the ground. As the main pathway of exposure to the population, the inhalation dose to individuals can be computed.
The model can be run in a “fast“ and an “detail“ mode, to be able to react immediately to a given situation or within a longer period of time, using more or different meteorological and site specific measurement data and in consequence consuming more computation time.
Furthermore, a possibility of varying the measured wind direction data has been implemented to take into account uncertainties within the measurement of the wind direction, extracting e.g. the maximum of the air concentration activity of a certain radionuclide lateral to the drift direction according to the

different wind directions. This feature allows a quick overlook on possibly affected areas as consequence of varying wind directions or uncertainties within the wind measurements.

The data flow within the systems programme can be seen in Figure 1; the user controls the system via the ASBAIR menu, which allows him to feed the model with necessary input data, control the computations and store or print the results.

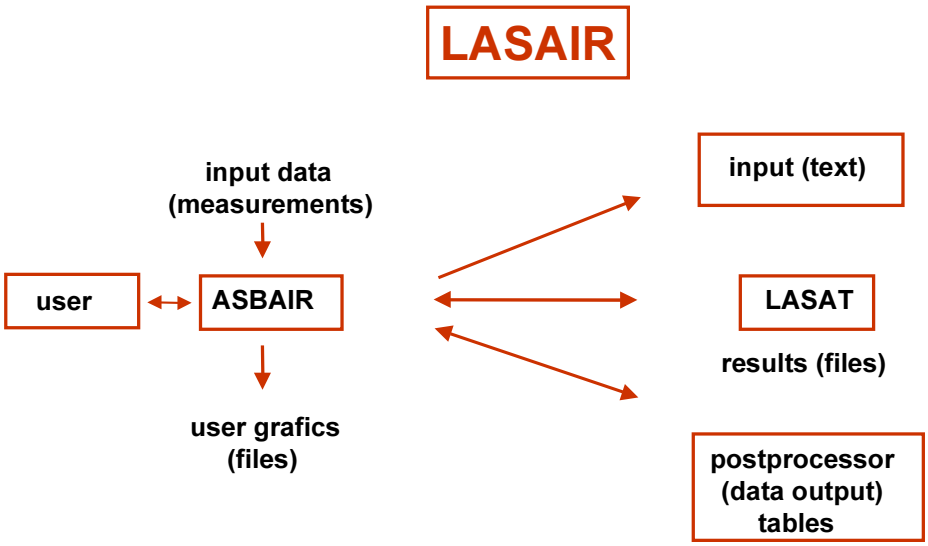

Figure 1 Data transfer within the systems programme LASAIR.

3 Basic meteorological measurements and topographical information

The systems programme has been developed to accomplish computations even with rare meteorological information. Basic needs are:

- wind speed
- wind direction
- diffusion category

Wind speed and wind direction have to be measured on the scene or the information must be collected via available communication means from remote sources. The diffusion category can be estimated from the following table:

Table 1 Diffusion categories estimated from synoptic observations [Grunst, M., 1995 after Slade, 1968].

wind speed	day			night	
	sunshine			radiation	
ms^{-1}	Strong	medium	weak	weak	strong
				clouds	
				greater 3/8	less or 3/8
$\bar{u} < 2$	A	A - B	B	(E - F)	(F)
$2 \leq \bar{u} < 3$	A - B	B	C	E	F
$3 \leq \bar{u} < 5$	B	B - C	C	D	E
$5 \leq \bar{u} < 6$	C	C – D	D	D	D

$6 \leq \bar{u}$	**C**	**D**	**D**	**D**	**D**

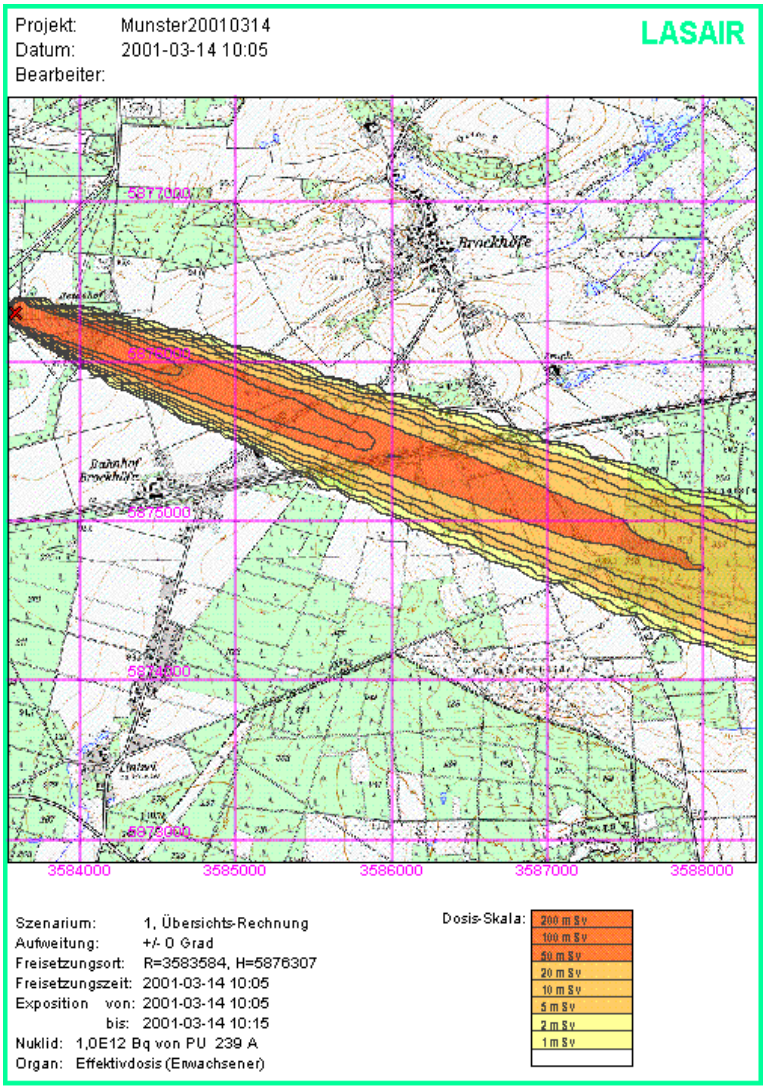

Figure 2 Simulation of the inhalation dose after a postulated instantaneous release of 10^{12} Bq of Pu 239; high windspeeds (on the ground around 5 m/s) and stable stratification of the atmosphere disperse the cloud downwind within a short period of time.

The topographical information (land or urban use) can be collected from the topographical maps that are available together with the system. The information of the land use (e.g. rural areas, houses etc.) are transferred into LASAIR as roughness lengths. The user can identify certain areas, define these areas via mouse clicks on the topographical maps and assign different roughness lengths in order to assess the influence of these structures to the atmospheric dispersion.

4 Computation of the inhalation dose

The inhalation dose is considered to be of most importance during an emergency as this is the pathway which can not or only with greatest difficulties be influenced by counter measures. As for this, it is the only pathway that is regarded within the systems programme as it is in the present state. Other pathways, e.g. ingestion or irradiation can be handled either by immediate counter measures (e.g. stay within a house until the cloud has passed) for the irradiation or by probing the soil if ingestion is concerned (ban on contaminated food). The inhalation dose can be computed according to (1):

$$H_{Inh} = g_{Inh} * V * T * A \qquad (1)$$

H_{Inh}	inhalation dose	Sv
g_{Inh}	inhalation dose factor, effective	Sv/Bq
V	breath rate	m^3/s
T	time spent in cloud	s
A	activity	Bq/m^3

An example of on of the first tests of the systems programme is shown in Figure 2. A field exercise has been conducted on a German military training area in March 2001, which was used for testing the new system. Strong winds and stable stratification, as have been found in reality, where combined with a

theoretical release of 10^{12} Bq of Pu-239, leading to a theoretical inhalation dose straight downwind of the release point as can be seen in Figure 2.

5 Geographical information system and GPS usage

Additionally, GPS information can be used online in the systems programme to inform the non-resident user online about the exact actual location and provide him with necessary topographical maps as background information which are included within the system. The maps included are provided by the German "Bundesamt für Kartographie und Geodäsie" (BKG) ranging in scales from 1:200.000 down to 1:10.000; they give a good overview as well as the possibility to identify clearly the focal point, from where the emission is assumed to be emitted, on the maps.

6 Computer platform

For reasons of mobility the whole system has been developed to run on a high-performance laptop. This gives the possibility to install the system LASAIR on different laptops in order to require only short travel time to the scene and quick as well as independent response after arrival.
The number of particles in the Lagrangian model was adjusted to 30.000 after several test in order to enable sufficient statistical results together with acceptable computation time; the computation time for the "fast" run is approximately 1-2 minutes on a laptop with 366 MHz processor, approximately 5 minutes for a "detailed" run, but increases intensively for runs with different topographical information included because of the time consuming computation of the complex wind field.
To run the complete system with the detailed map of Germany in the scale down to 1:10.000 it is necessary to have a mass storage of minimum 16 GB.

7 Outlook

The systems programme is under test conditions at the Federal Office for Radiation Protection in Germany since the beginning of the year 2001. A first real exercise on a military training area has been conducted successfully in March 2001. It is planned to deliver the systems programme to responsible German authorities during 2001. The basic systems programme LASAT, on which LASAIR is based, allows further and more detailed computations (e.g. irradiation) but these features have been neglected during this state of development of the systems programme in order to provide a simple tool for a first dose assessment. Further extensions to the system are planned and will probably turn into reality after an sufficient experience has been collected from the first tests of the first users.

8 References

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