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Simulation Programs to Education of Crisis Management Members

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***Abstract*—**This paper deals with a simulation programs and technologies using in the educational process for members of the crisis management. Risk analysis, simulation, preparation and planning are among the main activities of workers of crisis management. Made correctly simulation of emergency defines the extent of the danger. On this basis, it is possible to effectively prepare and plan measures to minimize damage. The paper is focused on simulation programs that are trained at the University of Defence. Implementation of the outputs from simulation programs in decision-making processes of crisis staffs is one of the main tasks of the research project.

***Keywords*—**Crisis Management, Continuity, Critical Infrastructure, Dangerous substance, Education, Flood, Simulation Programs.

I. Introduction

THE times when we are living is characteristic by the stately technologies development. These technologies and especially communication technologies should be making easy our approach to information and especially to their most effective utilization. Awareness, education and protection of technology secure environments are currently highly serious and relevant topics.

The computer support of crisis management interferes in many various sectors in human activity. At the present time there are many systems and technologies at disposal which facilitate the formulation of crisis plans, cooperation of the state with private subjects, monitoring of critical infrastructure entities and other necessary services for crisis managers in various organizations at various levels of management. This topic became a much discussed subject in professional community. Informational systems and technologies are possible to use both in crisis management of public administration and crisis management in the private sector [5], [7].

A number of emergency events and crisis situations are solved at the level of Crisis Staff. The aim is to develop a comprehensive information and communication system that will cover these situations. For this reason, an interactive approach, that allows implementation of the system of entities by parts, was selected. Design of the system is illustrated on chosen situation, which is the leak of chemical hazardous substances.

Paper is divided into two parts. The introduction describes approaches and methods of crisis management, which have been selected to create the simulation program. Later, the development of simulation program is described in terms of the different phases of chosen methodology and currently the software architecture is presented. The final part of the paper presents the obtained results and outputs of the simulations and possibilities of implementation this result for education of crisis management members.

The outputs of the simulation programs and information systems are used within the communication processes specialized center for crisis management. Currently, requirements analysis is made on the implementation of the outcomes of simulation programs in the simulator for the management of emergencies and crisis situations of critical infrastructure entities [3], [4], [9].

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II. Problem Formulation

Large-scale accident caused by selected hazardous chemical substances and chemical products is extraordinary event manifested by uncontrolled flows of energy and leaks of toxic substances. These are partially or totally uncontrollable, time-and space-bounded event which was created or whose inception is imminent in connection with the use of the building or facility where the hazardous substance is manufactured, processed, used, transported or stored, and that leads to immediate or delayed serious damage or threat to life and health of people, livestock, environment or for damage to property [1], [2], [6]. To solve large-scale emergency, it is appropriate to use the corresponding Informational technologies.

Informational systems and simulation technologies can serve for successful and effective solution of crisis situation. One of the spheres where these technologies are used is education institutions that focus on staff training emergency department. Higher education institutions form the highest level of Czech education. They offer accredited study programs at three levels: bachelor, master and doctoral. Except public and private higher education institutions are in the Czech Republic the state institutions. One of the state institutions is University of Defence which is under the responsibility of the Ministry of Defence. This university prepares military professionals and other specialist, the scope of work is defined with focuses of education, formation and training these professionals as required by the Army of the Czech Republic and research projects in favour of the Ministry of Defence department, Public Administrations and members of crisis management staff [4], [5], [8].

The main purpose of education and training programme is to prepare highly-qualified and specialized experts for basic and

applied research, research workers, education and practice of civilian protection in accordance with requirements and needs of NATO. The scientific activity is directed at the following areas:

- crisis management in civil protection in non-military crisis situation;
- logistic support of non-military crisis situation especially solution of material standard for civil protection in crisis situation and coordination of human aid with utilization non-profit-making organizations;
- raising of environmental safety at the level of advanced armies of NATO;
- dangerous substances detection at industrial accidents and natural disasters;
- optimization of informational and software support for prevention and solution of the consequences of extraordinary events and for simulation of these processes;
- interoperability in crisis management in dealing with emergencies.

There is not only an educational process but also research activities both in defence technology for the Army of the Czech Republic as well as in the field of information technology and crisis management systems. The focus is on systems that support analysing, planning and solving emergency and crisis situations.

Preventive measures protect critical infrastructure elements are the most effective but they require the availability of necessary technologies, economic resources and personal qualities. Expert analysis with are using simulation tools and methods which identifies the appropriate ways of goals achievement, and person-oriented leadership that supports the creative work and mutual collaboration [7], [9].

III. Information Technologies Used for Education Members of Crisis Management

First it is necessary to realize which simulation tools and technology need members of crisis management to prepare and subsequent response of emergency or crisis situation. The simulation programs and information systems support all phases necessary for the good preparedness of an organization or crisis staffs of critical infrastructure entities to handle emergency and crisis situations.

- Analysis – Evaluation of assets and associated threats and risks;
- Planning – Development of operating plans containing measures to optimally handle all predictable situations, mapping all the resources available to resolve problems;
- Management – Automatic notification of predefined personnel or organizations, searching and deployment of personnel and resources, situation monitoring – current status of active procedures and measures, task management and compilation of situation reports for various management levels. Access to various information resources on the network;
- Training of personnel – Together with the ESIM (Simulator for Crisis Management Training and Exercising) system allows the training of the personnel in various agencies based on the predefined scenarios (in Table I).

The Crisis Management Department provides education with the problems of information technologies in the subjects Public Administration Informatics System. In this subject they can obtain information not only about it but also information with their support made up information systems of public and state administrations [10].

TABLE I
Simulation Programs and Information Systems for Crisis Management

Area	Information System	Description
Analysis	RISKAN (Risk calculator for Managers)	It is used for organization security of governmental and public sector as well as strategic companies from telecommunications, utility and financial sectors.
Planning	EMOFF (Emergency Office)	It is technology to help in emergency planning and management and business continuity. The system integrates software tool for analysis, planning and emergency situation support.
Simulation	TerEx (Terrorist Expert)	The tool for immediate forecast of explosions and chemical release hazards.
	WAVE	Program for simulation of the dam destruction.
	SYMOS´97	The tool for dispersion simulation of emissions from sources of pollution.
Monitoring	MONIS	This system monitors critical infrastructure.
	PREMIS	This system, which is sponsored by the department of informatics of the Prague municipality, provides public information about the quality of the air of Prague. These systems were made especially for Czech market and monitor not only air but also road practicability, river level etc.
Civilian Emergency Planning	ARGIS	Information system for Planning of Civil Resources, which is important for self-solution of extraordinary events in the Czech Republic
Simulation of Emergency Event	ESIM (Emergency Management Simulator)	Simulator for Crisis Management Training and Exercising. It is made for obtaining of skilled staff and preparedness to deal with various situations.

The aim of these courses is to educate crisis management members for principal work with chosen informational systems that are closely linked with crisis management. Members learnt to use computer programs for simulation possible impacts and consequences of industrial accidents with the dangerous substances release. Informational systems are products for effective decision making support of crisis manager. For solution of the scheduled objective are especially geographic information systems used. The overview of the most important information systems that are divided into particular areas is in the Table I.

The aim of this paper is introduce to simulation programs that are used for members of crisis management education in the Department of Crisis Management.

A. Simulation Program TerEx

This program is designed for rapid estimation of the consequences of accidents and terrorist or military attacks. He has extensive use for the operational units of the Integrated Rescue System, both on site emergencies and in the crisis staff. It is also suitable for risk analysis in planning, designing buildings in the vicinity of roads and factories, insurance etc. Program provides results even in the absence of precise input. Prediction effects are based on a conservative forecast - results correspond to conditions in which there is a maximum possible effect (the worst scenario) [11].

The model includes connectivity to graphic information system for direct results display in the map. TerEx is aimed mainly for flexible use by rescue units during the operation to quickly determine the range of area under risk and to manager measures to protect inhabitants. It is possible to use TerEx by the operation commander directly at place or by operation officer in Command and Control Centre. TerEx is also very effective for planning and risk analysis. TerEx provides evaluation of four basic incident models that are:

- TOXI model – dangerous toxic substance release – evaluates range and shape of cloud. Its shape depends on quantity and concentration of released material;
- UVCE models – release explosive temper material – evaluate incidental range of blast wave caused by detonation of escaped explosive material mixed with air, the following basic types are available:
  - PLUME:
    - Continuous gas release into the cloud;
    - Continuous release of boiled liquid with rapid cloud evaporation;
    - Slow pool evaporation into cloud;
  - PUFF:
    - Single gas release into cloud;
    - Single release of boiled liquid with rapid cloud evaporation;
- FLASH FIRE models – evaluate risk area of heat radiation caused by fire:
  - BLEVE – fire threat of reservoir;
  - JET FIRE – continuous massive gas release with blazing up;
  - POOL FIRE – pool fire or boiling liquid fire;
- TEROR model – application of explosive – evaluates incidental range of blast wave caused by detonation of explosive system.

The program TerEx is characterized by high comfort and easiness in use. It is possible to select parameters from menus of program. TerEx Wizard enables to achieve highly reliable results both for specialist and the person who is not an expert in chemistry or pyrotechnics (e.g. crisis manager). When entering input data, you can choose one of three ways. Choosing the right path depends on the information that is available for the simulation. In Fig. 1 are the individual ways which named as follows:

- Wizard;
- Dangerous substances;
- Incident models.

Fig. 1 The homepage signpost in the program TerEx

Via simple questions and menus the user is guided to accurate and unambiguous specification. There are three steps to follow:

- damaged equipment specification;
- incident type specification;
- dangerous substance specification.

For a practical demonstration of the calculation in the simulation program TerEx was chosen extraordinary event, which has become in the ice stadium in the Czech Republic near Brnotwo years ago. Cooling pipe ruptured and before the system was closed, spread approximately 50 kilograms of liquid ammonia. It was a cold autumn day, with cloudy skies and air temperature of 15 degrees Celsius, wind speed 1meter per second. For more information about the incident are shown in Fig. 2.

TerEx calculation results are arranged in a very easy, comprehensive and unambiguous format, which helps to make quick decisions. This effect is achieved by minimizing output items just to important ones and by displaying results on the map. It is possible to save simulation of situation into „Incident database“. TerEx meets NATO messaging standard ADatP-3. It offers also the output in text format or in XML (shown in the lower section Fig. 2.).

The simulation tool is also equipped with the asynchronous stepping feature to support visual animation or connectivity to simulation system Simulator for Crisis Management Training and Exercising. More details of this simulation system are shown in Table I.

The program is user-friendly and takes advantages of basic knowledge of Internet users. This type of interface allows many useful well-known internet information resources. Extensive usage of Geographic Information Systems technology brings a clear overview about situations, resources, and current status on the territory.

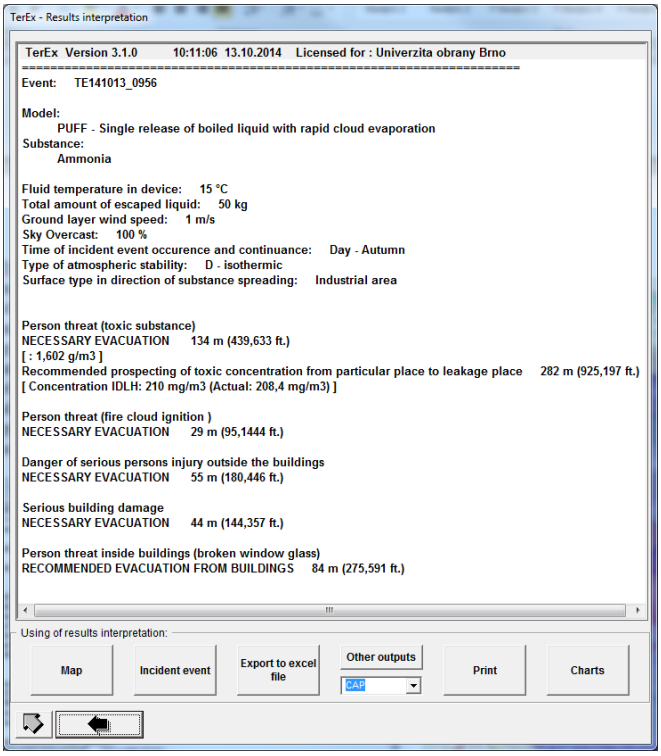

Fig. 2 The simulation of spread of liquid ammonia in the program TerEx

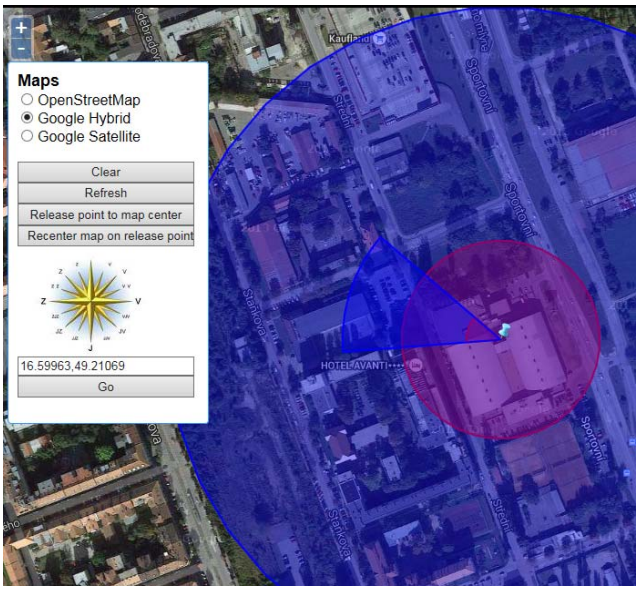

Fig. 3 Danger Zones in the spread of ammonia

On the basis of meeting all of criteria are the ideal tool for educating emergency department staff. Most emergencies that are addressed in the field of crisis management are the leakage of hazardous substances. Terex is an ideal tool for simulating release of hazardous substances and estimate the consequences of this incident [2].

B. Symos´97 Software

The System modeling methodology stationary sources (with acronym SYMOS'97) is designed to monitor and prediction the amount of harmful substances in the air. The program was created as a software-in- support methodology for calculating the dispersion of hazardous substances in air, which is a nationwide recommended by the Ministry of the Environment. The methodology is intended for the development of dispersion studies for the assessment of air quality. The methodology in SYMOS'97 program allows you to [2]:

- calculation of air pollution gaseous substances and dust from point, line and area sources;
- calculation of the contamination from a number of sources;
- to identify the characteristics of pollution in dense geometrical network of reference points;
- to consider the statistical distribution of wind speed and direction relative to the stability classes layers of the atmosphere.

Symos´97 is the software simulation tool for quick forecasting of consequences and impacts of chemical materials leaks on the environment. Thanks to this program, it is possible to calculate, predict and visualize the emission leaks and to model the consequences that resulted from contamination of the environment. The model includes connectivity to geographic information system for direct results display in the map. This software is easy to use members of crisis management. They can create simulations and estimates of emissions in populated areas and forecasts the size of the concentration in the monitored area.

Input data needed to calculate air pollution can be divided into the following categories:

- details of the sources;
- meteorological and climatic bases;
- the data on the topographical distribution of data points in which the calculation is performed, information on the height and location of buildings in the area of interest;
- the data on air pollution limits and allowable concentrations of pollutants.

The required input data for simulation are further varied by source of danger type (point, area, road, cooling towers, etc.) and conditions in the atmosphere modeled calculation (calculation under normal conditions or still air). The most commonly used coordinate system used to describe the location of a resource or reference nodes, the rectangular system, the X axis pointing to the east, the Y axis pointing to the north and the Z axis pointing to the zenith and represents the altitude or height of buildings.

C. Program WAVE

Simulation program WAVE is the software to calculate and visualize the flood breakthrough water wave and to model the consequences that resulted from the water dam destruction [11]. The program can be easily used by every people. Thanks to this program it is possible to anticipate the flood effect after destructed water dam with sufficient probability and make necessary steps for civil- and army protection in time [8].

The core consists of the mathematic model designed at our university. It can quantify the height of the breakthrough water wave depending on the distance from destructed water dam and

on the character of the terrain where the wave proceeds ahead. The calculation of the failure wave depends on these parameters (se Fig. 4):

- water tank volume;
- width of the dam;
- dam depth in front of the dam;
- dam depth below the dam;
- bed slope of the river in the lap between profiles;
- valley shape and its character.

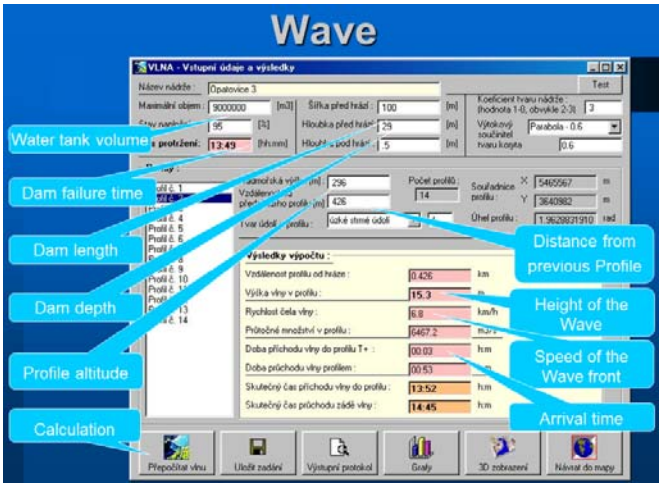

Fig. 4 The parameters of wave calculation

According with the map it is the river separate into sections with approximately congruous bed slope, valley shape and forested character. After that it is defined the cross profile for every section. Stream cross-section it is necessary to determine also in places where bold change flow direction is. The parameters of failure wave are set in particular cross profile for calculation.

Calculation of the failure wave characteristic consists of these steps.

- definition and location of profiles;
- determination of fall of the river;
- calculation of the wave speed and coming of the wave into the profile;
- calculation of the wave high in the profile;
- calculation of the wave passing time in the profile.

The input data are presented in the Fig. 4.

After visualization of the flooded wave, which can be seen in Fig. 5, it is possible to estimate effect area and make a basis analysis of extraordinary event using geographic information system:

- flooded area range;
- probably flooded municipal territory;
- high of the flooded wave;
- number of the evacuated population;
- farmland affected by flooded wave.

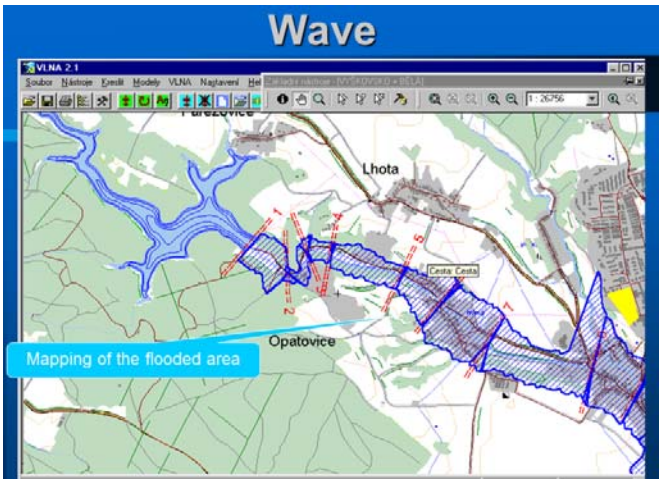

Fig. 5 The output of the simulation - flooded area

In geographic information system is possible do display 3 D view of affected area and both the profile of the terrain along the river and across the valley of the river. In longitudinal profile it is possible to mark the points with known height of flood breakthrough water wave from previous calculations and to finish calculation in other points by approximation. In 3 D view it is then possible to represent the water level formed by flood wave in particular reach of the river by the curved area consisting of basic model elements. The area obtained this way is possible to display subsequently into two-dimensional map of geographic information system.

IV. Conclusion

Information on the extent and impact of emergencies and crisis situations gives the basic framework of information for members of the emergency department. On the basis of this information may be precautions, prevention and then deal with the crisis too.

The research project uses existing structures and communication systems for implementation simulation outputs to decision making processes of crisis management members. The key idea is to connect existing heterogeneous information systems and other relevant organizations in the area of crisis management. These individual management entities will be able to exchange information and experiences of dealing with emergencies. They can use selected simulation programs (such as TerEx) and information systems of other entities connected to the network.

The same information on the extent of the emergency are important for critical infrastructure entities to ensure the security of critical infrastructure elements and their preparedness of employees to manage and minimize damage of communication and information systems. It ensures better training of critical infrastructure emergency staffs. Good practical preparedness and quickly management of emergency or crisis situation will have a positive effect of the course event solutions and it will minimize the impact of negative effects on the environment.

Finally, it is necessary to say that all software products

represent the function of crisis manager helper in his decision making. All computer programs are only "lifeless" products. The crisis manager is featured, especially his knowledge, abilities and acquirements, and many times also his extemporization.

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