RISK ASSESSMENT MODELLING AND VISUALISATION

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ABSTRACT

The MEMbrain toolkit provides methodological and computer based support for personnel responsible for the management of emergencies. It links geographical information system (GIS) technology to environmental monitoring, emergency preparedness planning, accident simulation, and crisis time communication.
Tools were developed for municipal fire and rescue operations in the Finnish subproject of MEMbrain. The users were given easy access to basic registers of population, building, tenement and property information, and state-of-the-art tools for risk assessment were integrated to the GIS framework.
Chemical accidents can occur in varying conditions and they can evolve in numerous ways. The quantitative models incorporated in the RISKWIT consequence modelling software package cover the variations well and make the reliable quantitative assessment of accident consequences possible.

1. INTRODUCTION

A decision support system was developed for emergency managers in the Eureka project MEMbrain (EU904). The MEMbrain toolkit provides methodological and computer based support for the activities that are carried out in the stages directly following the onslaught of a major emergency, in order to deal with the effects on the environment, human life, and economy. In this paper, the results of the Finnish subproject of MEMbrain are discussed.
MEMbrain links geographical information system (GIS) technology to environmental monitoring, emergency preparedness planning, accident simulation, and crisis time communication. The starting points for the MEMbrain work carried out in Finland were the GIS software for municipalities developed by Oy Siemens-Nixdorf Informaatiojärjestelmät Ab, and the RISKWIT consequence modelling software developed by VTT. These two partners joined their efforts to develop a decision support system for municipal fire and rescue operations.

2. RISK ASSESSMENT STUDIES AS PART OF EMERGENCY MANAGEMENT, PLANNING AND TRAINING

In connection with territorial management activities, potential risks to the population and risks for costly material damages need to be assessed. This forms the basis for emergency preparedness planning, and the knowledge gained is also used for steering other planning activities, such as planning of land use.
Risk assessments are also sometimes carried out as part of the design of new facilities. An example of this is the construction of a new industrial site which always requires a permission from the authorities. A study of the potential hazards associated with the planned industrial activities is part of the authorities' requirements.

Various types of risk assessment studies may be carried out in connection with territorial management. A list of the types of risk assessment studies considered in the MEMbrain project is given below:

- nuclear radiation protection (dispersion of radioactivity, radiological impact)
- releases of toxic and flammable chemicals at industrial sites or during transport
- flood prediction
- landslide and avalanche prediction
- earthquake damage prediction.

In principle, the information produced in the risk assessment studies can be used for decision support in real time during an emergency. However, it is often more practical to pay greater attention to the effective use of the information during emergency preparedness planning and during the training of emergency management personnel.

An emergency management information system should, ideally, cover both the needs of real time emergency management and the needs of planning and training activities. If possible, the appearance of the information system should be the same regardless of the task supported.

In the MEMbrain project, it was necessary to pay attention to the wide applicability of the software to be developed. The architecture of the module supporting the real time use of risk assessment information is presented in Fig. 1.

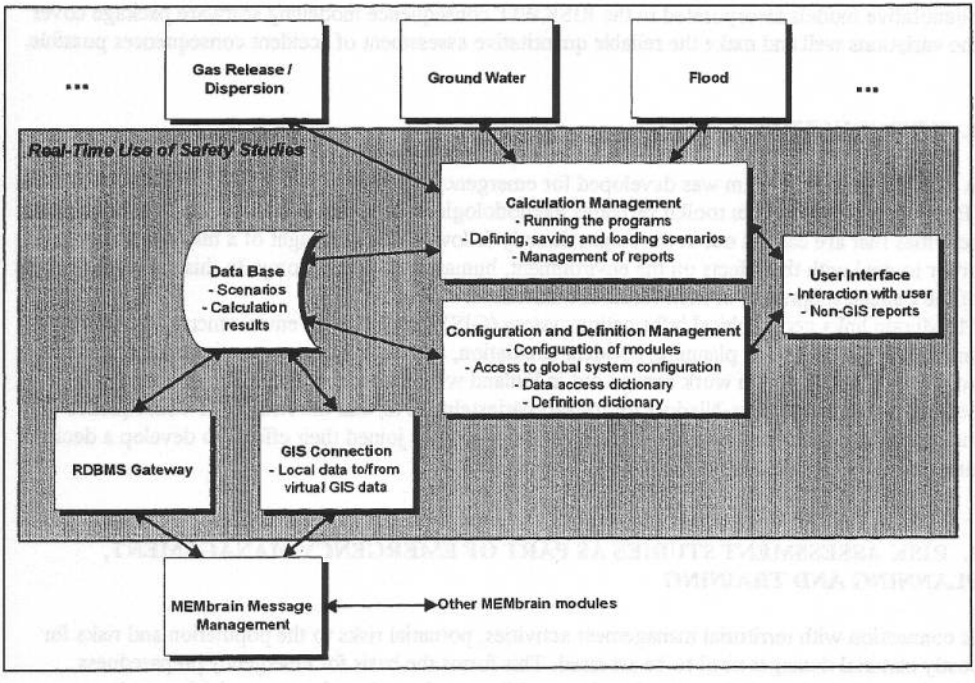

Fig. 1. Architecture of real time risk assessment information system.

The calculations (gas release/dispersion, ground water contamination, flood prediction etc.) can either be carried out in real time or stored as scenarios in advance for later real time use. RDBMS

gateway and GIS connection features are provided in order to make the system compatible with different RDBMS and GIS systems.

3. ROLE OF GEOGRAPHICAL INFORMATION SYSTEMS IN EMERGENCY MANAGEMENT

Geographical information systems (GIS) are nowadays widely used by authorities at regional and municipal levels. When such systems are taken into full use, basic registers are connected to GIS and thereby all population, building, tenement and property information can be managed directly from the map.
In the MEMbrain pilot application for municipal authorities (Ilmavirta 1994), the local fire and rescue personnel were given access to GIS with a connection to all the basic registers. This was already a step forward because the fire and rescue personnel could now easily examine the information associated with different buildings within the area of their responsibility.
However, the objective was to develop the municipal information systems further to cover a set of important activities in the area of fire and rescue, as well as in the area of environment protection. In addition to accident training, simulation of catastrophes and management of real catastrophes, daily routines of the fire and rescue personnel were examined closely.
The daily routines which need to be supported by the extended system include:

- Inspections control
- Preparedness planning
- Message management
- Chemical data retrieval
- Incident reporting

Management of fire and rescue resources.
In many cases, the basic registers give an excellent starting point for the development of specialised services related to the above mentioned routines. An extensive discussion of the optimal use of GIS by municipal authorities in the areas of fire and rescue and environmental protection is given by Lappalainen (1994).
In the area of emergency management, planning and training, risk assessment calculations form the basis for decision making. When the calculations are linked to geographical information, it is much easier for the fire and rescue personnel to consider the risks in concrete terms. Fig. 2 presents a visualisation of the risk associated with the release of a flammable gas from a rail tank due to a rail accident.
The calculations were made using the RISKWIT consequence modelling software which is discussed in more detail in chapter 5.

The results of another European research project were used to complement the GIS services made available to the fire and rescue personnel. A quick decision software package was produced in the TOXFIRE (Guidelines for Management of Fires in Chemical Warehouses) project which was part of the EC ENVIRONMENT research programme. This software package (Virtanen and Kakko 1996) was integrated with the GIS in order to provide the following additional services:

- Decision tree for fire extinction
- Reaction matrix
- Chemical properties database
- Target card database
- Target card drawing tool.

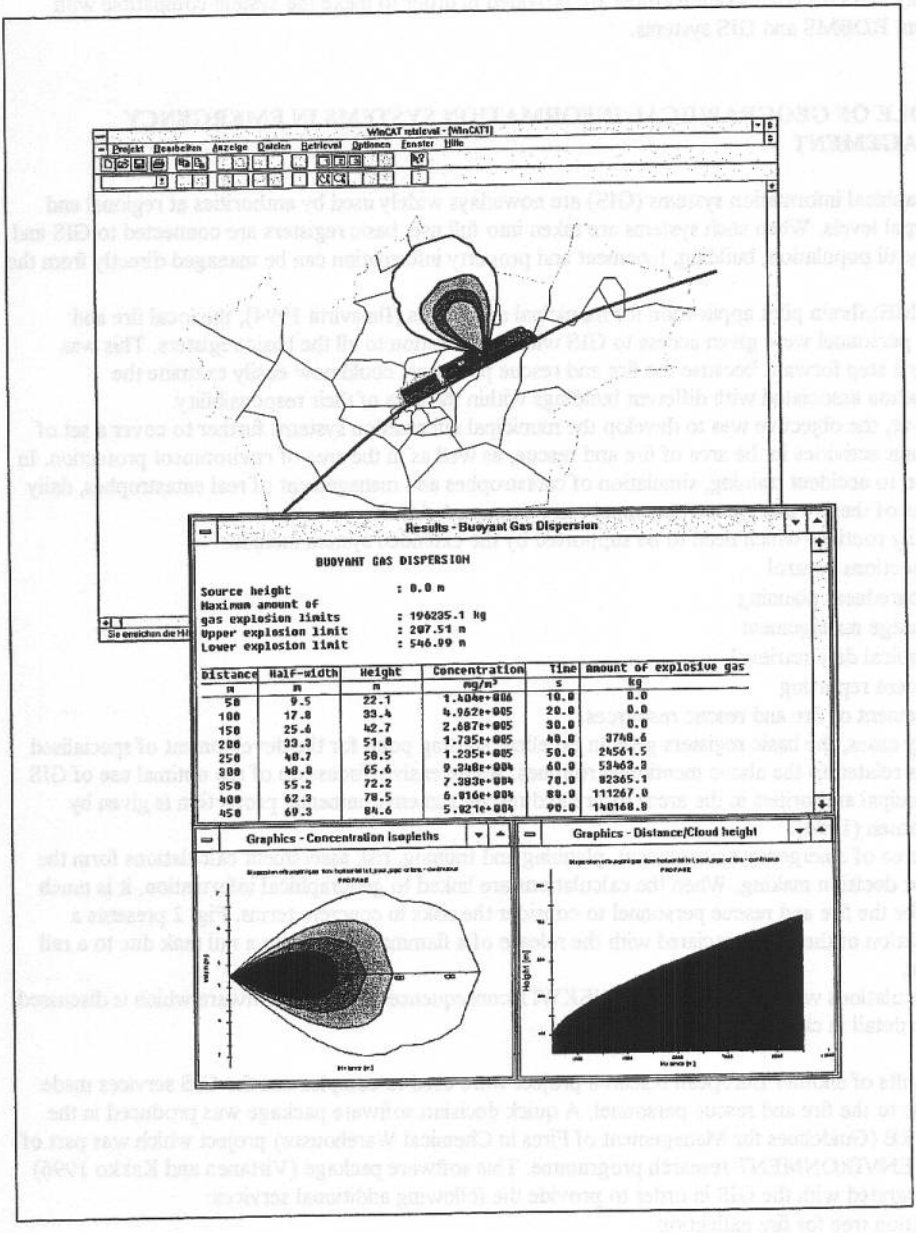

Fig. 2. An example of visualisation of a dispersion case of a flammable chemical.

4. CHARACTERISTICS OF CHEMICAL ACCIDENTS

Industrial production of goods sometimes means that harmful chemicals need to be processed, stored and transported. This leads to toxicity risks, in the case of toxic chemicals, and to fire and explosion risks, in the case of flammable chemicals. Permanent storage and processing of harmful chemicals usually takes place in a very controlled environment far from population centres. Therefore, many authorities are mainly concerned with the transportation of harmful chemicals through populated or environmentally sensitive areas.

When a chemical accident occurs, there are normally only a few minutes available for the necessary protective actions. Adequate training with access to realistic predictive information is therefore extremely important. Thorough preparedness planning for chemical accidents is, naturally, a vital prerequisite.

Depending on the chemical and weather conditions, the chemical accident can evolve in numerous different ways. The model of the initiating phase of a chemical accident in Fig. 3 illustrates the complexity of the associated phenomena.

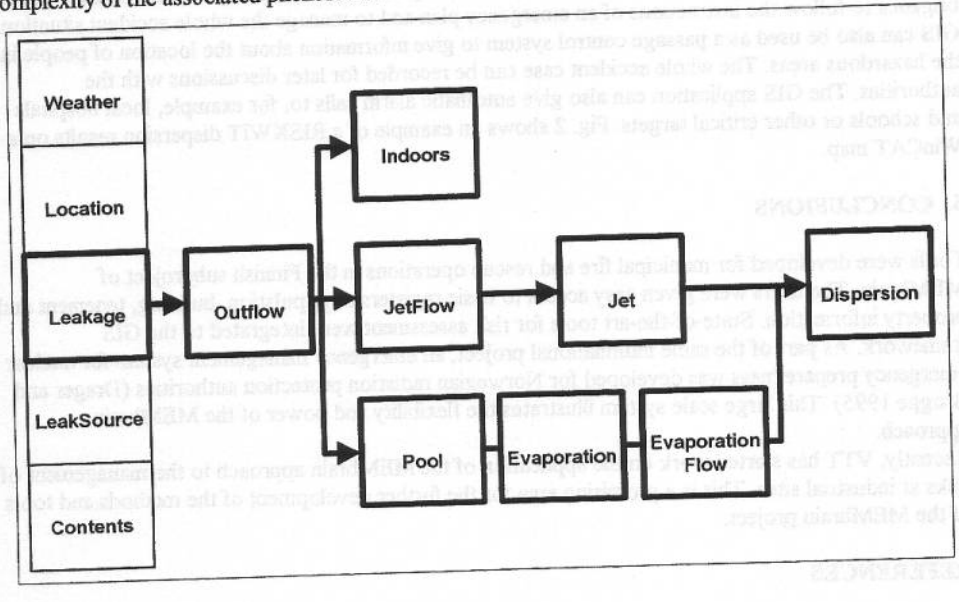

Fig. 3. Model of the initiating phase of a chemical accident.

5. QUANTITATIVE MODELS FOR RISK ASSESSMENT

RISKWIT software was designed to improve process safety and reduce environmental risks. For design and operational applications, RISKWIT is an effective tool for preventing hazardous events. In emergency situations, it can help staff respond quickly and appropriately, minimising the consequences of accidental releases. In industry, the applications range from plant layout design and inventory planning to safety management, emergency planning and transport safety. For government agencies and other authorities, RISKWIT provides a useful tool for monitoring the environmental

performance of industrial plants. Education, particularly environmental education, and research are also potential application areas.
RISKWIT software can be used to establish the parameters of 12 different release scenarios - including instantaneous and continuous releases from tanks and pipelines, indoor releases, evaporation from a confined and unconfined pool, buoyant and dense gas dispersion, dispersion through a building, fires and explosions, and the risks/consequences of toxic and/or flammable releases. A thorough discussion of the underlying calculation models can be found in Kakko (1991). The user selects the chemical involved in the potential release and the typical meteorological conditions. A calculation model is then selected from a menu or a model bar. The results are given in a variety of easy to read graphs, ellipses and tables. The calculation results of RISKWIT are easy to export to site dependent GIS applications for display on overlay maps. An interface for showing dispersion, heat radiation and overpressure isoplehts over WinCAT and MapInfo GIS systems are also available.
In a tailored real time system of a site/site area, the calculation modes of RISKWIT can also be part of a GIS application. In real accidents, it can provide important assistance to the rescue teams or fire brigades to follow the instructions of an emergency plan and to manage the whole accident situation. GIS can also be used as a passage control system to give information about the location of people in the hazardous areas. The whole accident case can be recorded for later discussions with the authorities. The GIS application can also give automatic alarm calls to, for example, local hospitals and schools or other critical targets. Fig. 2 shows an example of a RISKWIT dispersion results on a WinCAT map.

6. CONCLUSIONS

Tools were developed for municipal fire and rescue operations in the Finnish subproject of MEMbrain. The users were given easy access to basic registers of population, building, tenement and property information. State-of-the-art tools for risk assessment were integrated to the GIS framework. As part of the same multinational project, an emergency management system for nuclear emergency preparedness was developed for Norwegian radiation protection authorities (Drager and Brogge 1995). This large scale system illustrates the flexibility and power of the MEMbrain approach.
Recently, VTT has started work on the application of the MEMbrain approach to the management of risks at industrial sites. This is a promising area for the further development of the methods and tools of the MEMbrain project.

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