MEMBRAIN
A MODULAR EMERGENCY MANAGEMENT SYSTEM

by

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ABSTRACT

MEMbrain is a technology developed in an EUREKA project.

MEMbrain is a total emergency management concept which may comprise one or more of the following items:

- A risk assessment approach in order to define the functional requirements for the clients emergency management needs.
- A MEMbrain software system comprising the necessary modules fullfilling the clients needs for decision support in an emergency.
- Instrumentation, computer hardware and communication equipment necessary for equipping an emergency management center.
- System installation and client user training and support

The MEMbrain technology is modular and can meet different customers needs, for different applications.

A set of software modules are available as stand-alone software tools or integrated to a total integrated MEMbrain system, tailor-made to the clients needs.

The MEMbrain technology is state of the art technology for emergency managemtn and is based on commercial available development software tools. This assures that MEMbrain is a live system, always abreast with the newest technology in the hardware and software field.

MEMbrain provides a methodical support for the rescue and relief activities carried out by the emergency staff after a natural or man-made disaster, in order to minimise the negative effects on the environment, human life and economy.

The MEMbrain concept includes a mobile Emergency Response Field Station, which is fully equipped with instrumentation and communication equipment as well as a replica MEMbrain system for communication with the central emergency management center from the disaster site.

BACKGROUND

The nuclear disaster at Chernobyl in Ukraine, the toxic gas tragedy at Bhopal in India, the toxic gas accident at Seveso in Italy, the unconfined gas cloud explosion in Flixborough in the UK and the crash of a road tanker with gas in San Carlos de la Rapita in Spain, have all shown the vulnerability of the modern society to industrial accidents.

In addition comes natural catastrophes like drought in African countries, hurricanes, earthquakes, forest fires in the USA, floods in China and Bangladesh, etc.

These examples illustrate that both industrial accidents and natural catastrophes happen all over the world, and represent a continuous threat to the world society.

The consequences may be of enormous scale. This has focused the world public opinion on industrial accidents aimed at avoiding them to happen. Stricter legislation and open international communication on problems have so far been the result of this. However, the potential for similar disasters to happen is still high. Even if a lot of effort is put into reducing the probability that such accidents should happen, the modern society has to be prepared for both industrial disasters and natural catastrophes in order to reduce the consequences and sufferings caused.

MEMbrain (Major Emergency Management) is an international EUREKA project having developed a modular computerized decision support system for handling of natural and other major crisis. The technology is based on an internationally acknowledged, state-of-the-art technology.

The basic concept of MEMbrain is to reduce human, environmental and economical losses, and ensure that decision makers in industry and authorities have the necessary foundation for informed decisions in emergency situations.

THE EUREKA PROJECT EU904 MEMBRAIN

MEMbrain is the name of the EUREKA project EU904. MEM is an abbreviation for Major Emergency Management and brain refers to computer technology.

The EUREKA project MEMbrain has as its goal:

> *"Provide methodical 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."*

The strategy for the project has been to develop a dynamic decision support tool based on:

- Information
- Prediction
- Communication
- On-line training.

- Through continuos monitoring to be immediately informed about an accident and be able to measure the development continuously.

- Through simulation models quickly predict the on-coming development.
- Through on-line communication with rescue personnel, etc., efficiently reduce the consequences and be able to give necessary rescue support.
- Through on-line training see to it that the emergency management organization is familiar with their tasks and equipment and has the right skills.

MEMbrain has been specified as to significantly improve the quality of available support in an emergency situation. MEMbrain's tools and services has been developed on the basis of a formalization of hands-on expertise in major emergency management (MEM) and related fields, while development work has concentrated on providing support for collaborative work involving heterogeneous MEM actors and tools.

The project has resulted in a set of knowledge-based software tools supporting MEM activities e.g., public protection management, man to man communication management, environment information management, resource management, as well as an implementation of an architecture to integrate such tools.

MEMbrain has been a strategic European project - the consortium includes partners from six countries, covering the European continent from North to South (Finland, Norway, Denmark, France, Portugal and Greece).

THE MEMBRAIN SYSTEM ARCHITECTURE

The MEMbrain system architecture is modular, consisting of a set of modules which can operate as stand-alone modules or be linked together by the Integration Platform (IP) into an integrated MEMbrain system.

The following software modules are at present available as MEMbrain software modules:

- IP - Integration Platform
- MM - Main Menu
- SATI - Static Administrative and Technical Information
- MMS - Message Management System
- ENVIS - Environmental Information System
- PPS - Public Protection System
- CARIS - Chemical and Radioactive Information System
- TS - Training System
- ERFSC - Emergency Response Field Station Communication
- GIS - Geographical Information System
- MESA - Models for Emergency Scenario Assessment

The system architecture is shown in the following figure:

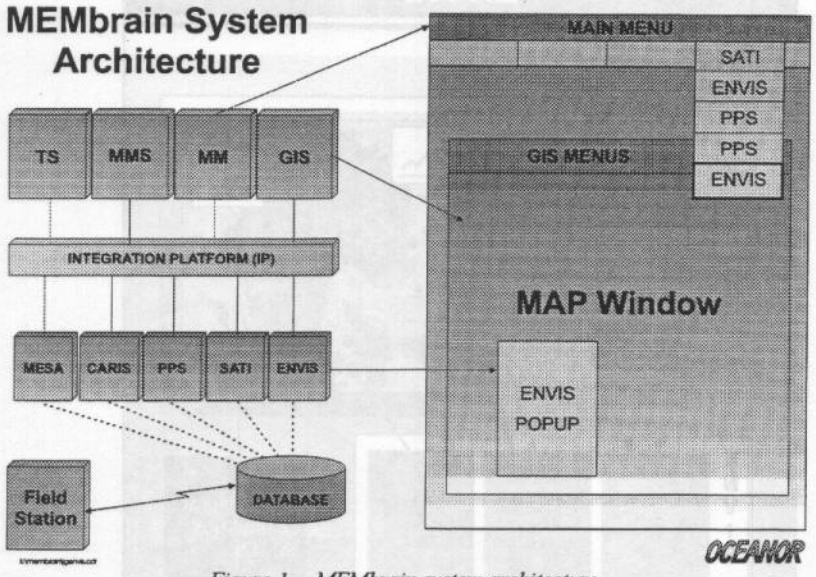


Figure 1 MEMbrain system architecture

MEMBRAIN MODULE DESCRIPTION

The MEMbrain software concept is briefly described in the following.

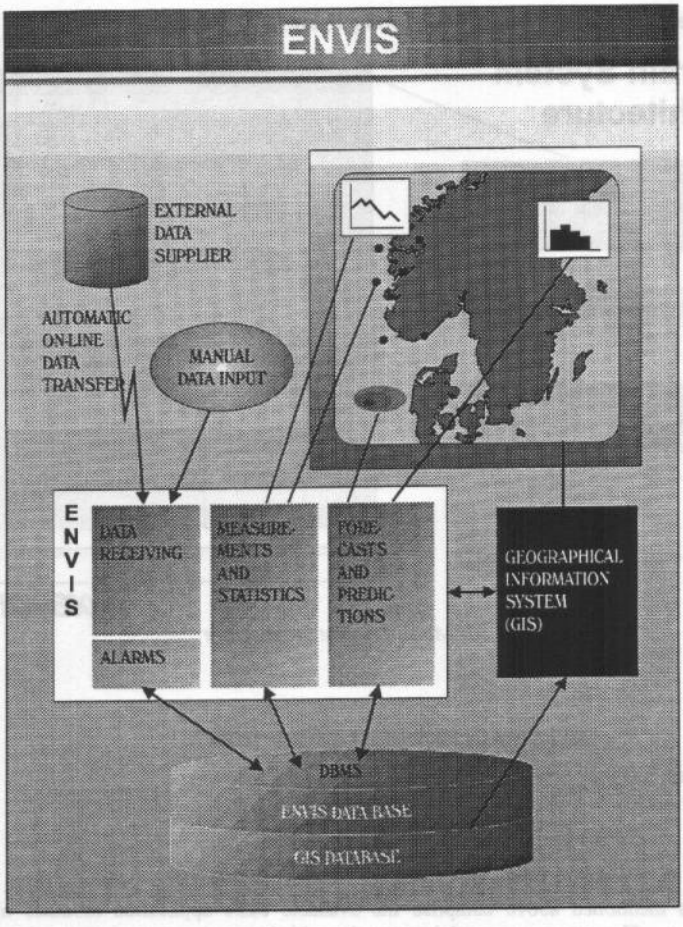
The modularity of MEMbrain

The modules mentioned above comprise the available basic application modules of a MEMbrain system. However, new modules may be added at a later stage depending on customer needs and actual emergency situations to handle.

Most of the modules are also available as stand alone modules, besides being part of an integrated MEMbrain system.

Whenever putting together a MEMbrain for a specific region or customer, the risk evaluation of the emergency region/customer property in question, will conclude the functional requirements of the system. The MEMbrain system will thus be built up by relevant modules from the basic application modules, new ones to be developed will be identified, and the whole system will be tailored according to the customers/emergency regions needs.

In the following three of the modules are described in more detail.



Environmental information system (ENVIS)

The objective of the ENVIS module is to give information about the environment: Its previous, present and future state. ENVIS is able to synthesise environmental data of many different kinds and from many sources. ENVIS is working together with a Database Management System (DBMS) and a Geographical Information System (GIS).

ENVIS is able to receive data from a number of external sources. Data are updated on-line by use of computer networks. Standardized data formats are defined for environmental measurements as well as for results from numerical simulations (forecasts). The user of ENVIS may establish automatic data transfer from any external data supplier provided the supplier makes his data available in one of the pre-defined data formats. Automatic alarm functions may be defined for user selected parameters.

The measurements may be presented graphically, e.g. as time series plots. The different measuring sites and stations may be shown on the map. The user may select a station for data investigation by selecting from tables or by clicking on the station in the map.

Results from numerical models are presented as concentration fields (iso-lines) on the map. The iso-lines represent predictions of transport and dispersion of contaminated air or water. In addition, weather forecasts may be presented. Numerical models may be directly integrated into ENVIS and run by the operator, or they may be run at other institutions located elsewhere.

Public protection system (PPS)

The PPS is a decision support system as to public protection in emergency situations with hazardous materials. The system is designed to be used for an ongoing incident with release of a radioactive or toxic material. Based on consequence/dose models and prognoses of the incident, the PPS can estimate the consequences for the population in the affected area. The PPS predicts doses to the population, assesses risks and evaluates the effects of possible consequences and countermeasures. The system also gives support in administrating an emergency.

The PPS can be used for simulation of scenarios. For example evacuation simulations can be performed upon which evacuation strategies can be planned. The PPS can also be used for training the emergency experts for an emergency situation.

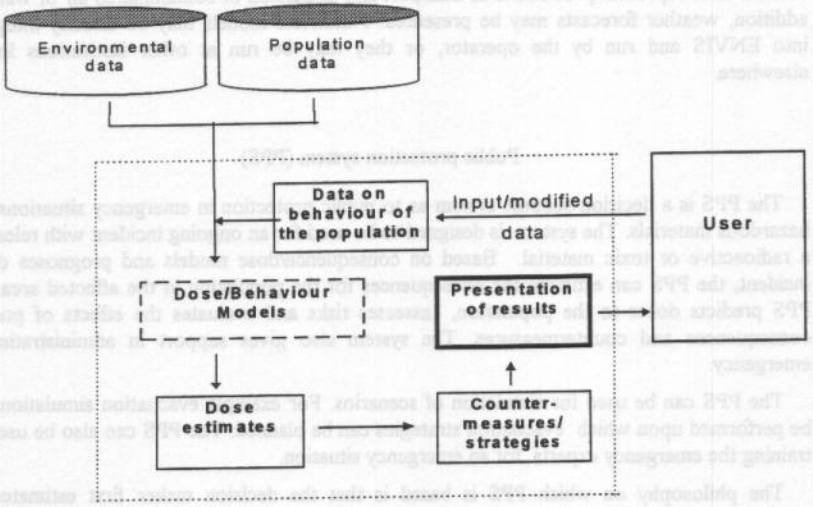
The philosophy on which PPS is based is that the decision maker first estimates the consequences, then evaluates the effects and costs of the possible countermeasures, and then the user can take the decision on what to do. The decisions are to be taken by the user; the PPS gives input for such decision.

Different kinds of data is necessary for the risk assessments and for the evaluation of countermeasures, such as for example evacuation of people. The PPS is able to retrieve data from a variety of sources and synthesize the information for performing the task. Environmental- and population data are retrieved from different modules elsewhere in the MEMbrain system. The user has the possibility of entering data manually. The user can define which area he wants to perform evaluations for and the time schedules for the estimates. He can select the population groups to calculate doses for. The user can set parameters for dose models and/or he can modify other data for the estimates. This possibility to enter and modify data is of special importance for the user in order to be able to simulate different scenarios, and to evaluate the consequences. In this way, for example "worst case" situations can be simulated and looked upon.

The results of the assessments and the evaluations are mainly presented as map overlays. The results can also be presented as tables. The user can himself define the geographical evaluation area which is of relevance.

The PPS includes different kinds of behaviour and dose models, procedures and algorithms.

The models to be used and countermeasures and strategies to be selected will depend on the type of accident and emergency situation in question. The MEMbrain models used by the PPS can be modified according to the situation of concern. In that way is it possible for users to implement and use their own preferable models. The user can prescribe protective actions and make assumptions about their efficiency.



Emergency response field station communication (ERFSC)

An emergency response field station (ERFS) is also available as a MEMbrain system part. The ERFS is a movable container fully equipped with sensors and instruments and a computer system with full software capabilities. The ERFS can be used as a central emergency response field station, close to the accident site, connected on-line to a central system. The software module connecting the ERFS to the central system is named ERFSC.

The sensor and instrumentation to be equipped on the container will be agreed with the client dependent on the emergency situation to be handled.

MEMBRAIN PROJECT APPLICATIONS

The MEMbrain project work-program was based on an extensive initial phase in which the requirements and specifications of the *generic MEM platform* were defined through the development of MEM systems tailored to the needs of specific applications.

Pilot applications have been selected with national authorities in order to cover a range of typical major emergencies e.g., nuclear accidents, environmental accidents, natural catastrophes, etc. This guarantees that the project's results will, in fact, be of immediate use to potential users.

The specific applications planned were:

- France : Environmental Emergency Management
- Finland : Emergency Management of Transport of Dangerous Goods
- Norway : National Nuclear Emergency Management
- Greece : Industrial Emergency Management
- Portugal : Earthquake Emergency Management
- Denmark : Hospital Emergency Management

The two last ones in Greece and Portugal have not been initiated due to financial constraints of EUREKA project funds in these countries. However, the three first ones are well underway, and have given the project valuable feedback in order to arrive at the final commercial design of a MEM system.

A Decision Support System for Norwegian Nuclear Emergency Preparedness

The Norwegian application, a decision support system for the Norwegian Radiation Protection Authority (NRPA) has been successfully completed and a MEMbrain version 1.0 was delivered to NRPA primo 1996. A brief description of this application is given in the following.

The central emergency organization for nuclear accidents, the Crisis Committee and the Advisory Committee, are responsible for management of nuclear accident threatening or having consequences in Norway. The Crisis Committee has been given extensive authority to decide and order remedial actions in order to prevent or reduce radiological and economical consequences in the Norwegian society.

The 18 organizations in the central emergency organization have information, data and operating responsibility for various measuring systems and equipment in order to evaluate an emergency situation. All these data and information must be available to the central emergency organization at their operation centre at NRPA. In addition these organizations have specific areas of responsibility during an emergency situation, all of which must be coordinated.

The daily maintenance and support of the emergency preparedness is carried out by the secretariat at NRPA. The secretariat is responsible for maintaining a high level of readiness and availability of information required in accident situations. This implies that it must be a continuos activity to survey and monitor releases and the current radiation levels in Norway and in the neighbouring countries.

Considering the vast amount of information and data needed to keep an updated overview of a situation both during the daily surveillance work and during accident situations the need for an efficient information and retrieval system is evident. Accordingly, it has been decided to install a computerized system for continuos monitoring and decision support in accident situation.

The main objectives of this system were:

- Assess consequences of nuclear accidents,
- Establish a basis for right decisions on countermeasures in order to reduce health effects and economical consequences.

The health effects considered are increased cancer risk for individuals and increased frequency of cancer in population groups or the whole population. Only in special situation acute radiation effects must be considered.

To fulfil the main objectives, the system had to include functionalities covering the following areas of application:

- Contain tools for assessing the impact of real accidents to provide guidance and decision support for the emergency organization in accident situations.
- Contain tools for assessing hypothetical accidents to provide guidance and support for the emergency preparedness.
- Provide data and presentations necessary to support a continuos and updated public information and press service in an emergency situation.
- Function as an information collection and retrieval system for the NRPA, supporting the staff in maintaining an overview of the radiological situation in Norway and its environment, including the marine environment in the Arctic regions.
- Contain the means required to run in a training mode for use in preparedness exercises and in training of staff within the emergency organization.

The time phases of a nuclear accident are often divided into the early phase, the intermediate phase and the late phase. The decision support system had to be available and give support to the emergency organization in the various phases.

In the following is described the system functions as administrative functions or technical functions.

Administrative Functions

The functions described as administrative are those usually found in an emergency handbook, and includes:

- Description of the various parts of the emergency organization, its members and their responsibility within the organization.
- Description of procedures for alarming and mobilization of all parts of the emergency organization.
- Contact points within the Ministries and other relevant organizations in Norway.
- Descriptions of other Nordic emergency organizations with contact points and information on communication systems.
- Descriptions of international organizations to be contacted and how.
- Descriptions of bilateral and international agreements and the requirements and procedures to fulfil these agreements.
- Descriptions of all resources available to the emergency organization, described as what, where, how many, responsible person and contact point.
- Means for receiving, logging, management and storage of all messages received or transmitted.

Technical functions

As a part of the basis for management of a nuclear accident the following have to be available:

- Information on fixed installations containing radioactive sources and examples of expected source terms in case of accidents. This information shall include knowledge of incidents and accidents for these sources. These sources are nuclear power plants and other reactors, reprocessing plants, stocks and dumping areas of radioactive waste, nuclear weapon test sites and concentrations of atomic weapons if possible.
- Information on movable installations containing radioactive sources. This includes reactor powered military vessels i.e. surface vessels and submarines, the fleet of Russian icebreakers and nuclear powered satellites.
- Data on the present levels of contamination in the air, at the ground, in water, in the environment (vegetation, animals), in the food chains and in foodstuffs. These data can be used during the regular work on radiation protection at the Norwegian Radiation Protection Authority and in cooperation with other institutions, but must also be available in order to assess the consequences of a new accident.

- Data on the external exposure rates from natural sources and from the present contamination at the ground and in the environment.

In the acute phase of a nuclear accident the following had to be available:

- Meteorological data and models for predicting transport of radioactive materials from a given source term in air and in water.
- Models for predicting air, ground and water contamination levels given the source term, meteorological conditions and aquatic conditions.
- Models of predicting the radiological impact of radioactive substances and their migration in the environment and the food chains.

These models are tools for predicting consequences and make decisions on countermeasures in the early and intermediate phases of a nuclear accident when little is known about the situation and how it will evolve.

In the intermediate and late phases of a nuclear accident the following had to be available:

- Information and data from all kinds of measurements made during and after an accident shall be available. This includes data on dose rates and contamination levels in air, at the ground, in water, vegetation, animals, the food chains and in foodstuffs. All considerations of consequences must be based on this total amount of information. It must therefore be possible to register and store a vast amount of data in a systematic way in the system.
- Necessary functions for handling, synthesizing and displaying information and data on digital maps in graphs and charts. Presentation of information and data in a comprehensive way either as predictions from model calculations or from measurements must be possible for assessing the evolvement of the situation all the time.
- Models and algorithms for estimation of doses to individuals and population groups either from predictions of contamination levels or from measurements of dose rates and contamination levels. Radiation doses to individuals and population groups must be known in order to assess the health effects and also as a basis for introducing countermeasures.
- Models and algorithms for calculating short term and long term consequences from predicted contamination levels or from measurements.
- Models and algorithms for calculating the cost-effectiveness, optimization and adverted doses for countermeasures. The main rule in radiation protection is that countermeasures shall be justified by producing a net benefit for individuals and the society. The reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and costs, including social costs, of the countermeasure. In addition countermeasures shall be optimized in form, scale and duration.

- Means of assessing long term impact taking into account all countermeasures and consequences on the Norwegian territory and for the Norwegian population. Consequences are increased frequency of cancer and economical and social costs.

CONCLUSIONS

The functional requirements for the Norwegian nuclear emergency preparedness decision support system have been decisive in the design of the MEMbrain technology. This application drive from users combined with information technology expertise have guaranteed development of a useful emergency management system.

The time constraint under which the development has taken place, and a demanding customer have also contributed to a market driven development. Thus the MEMbrain technology should contribute to an improvement of emergency management.

MEMbrain's approach together with the active participation of MEM authorities in participating countries have helped promoting the project's results as an emerging European standard for MEM decision support systems.

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