INFORMATION SYSTEM AS TECHNICAL SUPPORT FOR THE MANAGEMENT OF NUCLEAR EMERGENCIES

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ABSTRACT

Following to the Chernobyl accident, that affected large europen areas, many countries have improved their organisations for the management of radiological emergencies, in order to make them suitable to face situations with a large territorial impact in terms of contamination.

In case of accidents with a deep radiological impact, the national competent authority has the role to make decisions about countermeasures to be adopted in order to minimize the consequences of the contamination to population and to the environment. Such countermeasures get adopted on the basis of measured contamination as well as on the basis of the forecast evolution of the radioactive plume.

In order to accomplish this role, it is necessary to have, in real time, the availability of all the relevant information required to assess and to continuously update the accidental scenario as well as the possibility to perform forecast about the evolution of the situation.

To this purpose ANPA Emergency Centre has designed and implemented an Information System in Support to Nuclear Emergencies Management (SISGEN) which is rapid and reliable in the acquisition and elaboration of huge quantities of data.

This paper presents data elaborated by the information system as well as objectives, functions and architecture of the system.

INTRODUCTION

A nuclear emergency is a very particular situation which get started whenever there is a risk of contamination and irradiation to the environment and to population due to accidental releases of radioactive material (i.e. accident to a nuclear power plant).

In Italy, during an emergency a committee of expertise's, named CEVaD, is activated to follow and estimate the evolution of the accident and its radiological impact and to make decisions based on the radiological scenario about eventual countermeasures (evacuation, sheltering, etc.) depending on the accident, in order to limitate damages to population and to the environment (Di marco G."et al." 1994).

This committee is under the Department of Civil Protection and the technical support is supplied by the Emergency Center of the National Agency for Environmental Protection (ANPA).

According to this role, the Emergency Center has developed an information system (SISGEN) that acquires, elaborates and supplies in real time to the expertises all the information needed to manage properly and quickly an emergency (ARA/CEM 1991).

The main objective of the system, that acts as a technical support in case of emergencies, is to supply:
- a correct evaluation of the radiological impact following a nuclear accident to population and environment;
- a forecast about the evolution of contamination and sanitary impact,

in order to take proper countermeasures for the protection of population and environment following a nuclear accident with a deep radiological impact on national territory (Ursino S."et al" 1993).

The estimates and forecast are based on data described in chapter Data managed by system of the present paper.

Data collected in real time during an emergency are stored into databases and made available, together with previously acquired data, to CEVaD for consulting and elaboration by means of interactive and automatic functions described in chapter Functions of the system.

SISGEN is a modular distributed system having various functions loaded on different dedicated and properly configured hubs of a local network, and various data stored on different databases which are reachable from all interested hubs. The system integrates different operative systems (VMS, DOS and UNIX) and employs a GIS (ARC/INFO) and a X-Window user interface whose architecture is described in chapter Architecture.

Chapter Conclusion, describes advantages and future development of the system that have been pointed out during operative tests of the system.

DATA MANAGED BY THE SYSTEM

Data managed by the system may be grouped into the following four categories:

- notification data collected in real time from national and international authorities;
- radiometric data measured in real time by laboratories spread all over national territory;
- meteorological data, both measured and forecast, supplied by National Meteorological Office;
- territorial data, already available at Emergency Center, which remain unchanged during emergency.

Notification data are information about the accident that are contained in the notification messages, and concern location of the release, date and time of release and other relevant information about the accidental scenario which are available when the notification message is sent.

These data come from the plant where the accident took place and, usually they arrive by telephone or by fax in plain language. Anyway, according to conventions with IAEA and CEC the member State where the accident happened must inform IAEA and/or CEC and send them all the information available in a coded form by means of telex or the GTS (Global Telecommunication System, that is the W.M.O. world wide network) for dissemination to all the other member States. This information are the first to be available and play a key role for the activation of emergency.

Radiometric data are information about radioactive measurements performed by laboratories (or mobile units) spread all over national territory according to five different kind of measurements: irradiation, air concentration, ground concentration, wet and dry deposition (fall out), concentration of nuclides in foodstuff.

Measurement data are contained in predefined forms filled by laboratories and sent in real time to the Emergency Center by fax. The measurements give the concentration on main radionuclides (I131, Cs137, etc.) in air, on the ground and in the main foods. All the measurements are connected to other data like date, hour of sampling and location of sampling. These data allow to report in real time the radiological scenario and to provide data required to perform estimates of doses to population.

Meteorological data are collected and sent through the GTS by national and international meteorological stations. These data are available at the Emergency Center by a direct link with the National Meteorological Office, that is a hub of GTS. The most relevant information are: wind speed and direction, precipitation and cloud coverage, and forecast field data issued by the European Center for Medium Range Weather Forecast.

These data allow to assess in real time the meteorological scenario above the area involved or to forecast by means of dispersion models the trajectory of the radioactive plume in the atmosphere and the locations where deposition is most likely to take place. This is relevant in order to make decisions about the areas where proper countermeasures must be adopted.

Territorial data are already available at the Emergency Center and remain unchanged during a nuclear emergency. These data are relevant in order to locate exactly the accidental scenario and its evolution in order to decide the proper countermeasures to protect population (evacuation, sheltering, iodine tablets distribution, etc.).

In the last years ANPA has collected a lot of territorial data about all national territory. In particular, databases have been developed containing most relevant data for emergencies management as:

- communications (railways, roads, etc.) to be prepared to face eventual evacuation;

- land use, to take eventual countermeasures involving foods (vegetables, fruits, meat, milk);
- hydrography (Guarracino M. and Seart s.p.a. 1990), to study the evolution of contamination in water bodies;
- orography (Ursino S. 1991), to make accurate dispersion forecasts and for a morphological knowledge of the area ;
- administrative boundaries (national, regional, provincial and municipal) in order to connect data to location of reference;
- demographic data (number of inhabitants, age classes, etc.) relevant in order to give information about the number of people living inside contaminated areas;
- location of measurement laboratories with all related information (address, telephone, kind of available measurement devices, etc.).

Most of these data have been retreived from Army Geographical Institute cartography (scale 1:250.000). Great efforts are being devoted to obtain more detailed information (scale 1:25.000) as far as municipalities data are concerned.

Furthermore, ANPA Emergency Center has the availability of cartographic data all over Europe at scale 1:1.000.000 about most relevant information with particulate attention to location of meteorological stations and nuclear power plants.

The effectiveness in supporting decision makers depends on the ability of the system to acquire in real time data which may change during an emergency (radiometric and meteorological), to elaborate and integrate them with territorial data and to give the experts a continuous monitoring of the situation at national and local scale.

FUNCTIONS OF THE SYSTEM

During an emergency data collected in real-time are stored into databases, and made available, together with previously acquired data, to CEVaD for consulting and elaboration by means of interactive and automatic functions. All these functions have been grouped, during the designing of the System, into five classes: Acquisition, Automatic elaboration, Interactive elaboration, Consulting and Management.

Acquisition consists of hardware and software resources for acquisition, validation and storage of notification, radiometric and meteorological data collected in real time.

In particular, meteorological and coded notification data are acquired automatically by the computer, while radiometric data and non coded notification data must be inserted manually into the computer. Radiometric data are stored according to computer procedures that direct and validate the inserting data process (Di Marco G. "et al."1992).

Automatic elaboration consists of batch procedures performing calculations and reports to summarize the radiometric scenario and its sanitary impact on population (Di Marco G. "et al."1992).

The radiometric scenario is presented by means of following procedures:
- daily production of tables where, for each region, statistics about contamination on environmental matrixes and foodstuffs is reported (list of measurements, average value, minimum, maximum, standard deviation);
- continuous displaying of irradiation measurements updated for each italian municipality (more than 8.000 italian municipalities);
- displaying of average values, for each region and for eventual areas of interest, of air and ground concentration for two selected nuclides.

The sanitary impact on population is presented by means of daily production of tables, where, for each region, doses to population are reported. Contribution of each nuclide to daily dose as well as total dose are calculated from radiometric measurements data, averaged for each region, and employing dose factors that take under consideration, for each nuclide, different age classes and different pathway of exposure. Furthermore, cumulated doses over a given number of days of exposure are calculated.

Total doses are relevant to make decisions about countermeasures like evacuation and/or sheltering, partial contribution to total dose are relevant to make decisions about specific countermeasures like iodioprophilaxis or foodstuff banning.

All these data are stored into a database of the system and are available for further consulting options.

Interactive elaboration consists of software models and procedures that allow the user, on request, to perform further elaboration on acquired data.

The user may ask for calculation of averages or doses for particular days, areas of interest, nuclides and matrixes.

Results are displayed and printed but they are not stored in the system.

Furthermore, the user has the availability of tools to evaluate in real time the meteorological scenario above the area involved (METEODATA) (Picodata s.r.l. 1991) and to forecast the trajectory of the radioactive plume in the atmosphere as well as the location where deposition is most likely to take place (ARIES) (Desiato F. "et al." 1993). Finally, a model for the estimate of long term contamination in foodstuffs and projected doses to population due to different pathways of exposure, is also available (EURALERT) (Muller H. "et al." 1989). This model takes under consideration the evolution of contamination in the environment, the radioactive decay and population diet.

Consulting consists of software procedures for retreiving, correlating, and reporting acquired and elaborated data stored in the system.

The retrieving and reporting actions are performed by computer procedures directing the user to specify data required both acquired (notification, radiometric, meteorological) and elaborated (statistics on contamination, doses, plume trajectories and meteorological fields).

The correlation and reporting actions are performed by means of Geographical Information System (GIS) (Ursino S. "et al." 1992) allowing production of thematic maps. In particular procedures have been developed to allow:

- making an interactive inquiry of radiometric, demographic, meteorological, territorial data of a particular area or location;
- supplying a graphic output of dispersion models as far as the trajectory of the radioactive plume over the territory is concerned;
- supplying a graphic output of meteorological data;
- reporting information about national laboratories, national and european meteorological stations, and european nuclear power plants.

Management consists of additional functions, allowing the user to set proper parameters into the system to take under consideration the evolution of the situation. The user may define regions, areas, radionuclides, foodstuffs, diets and age classes for the automatic elaboration previously described. Furthermore, the user ask for plots of time evolution of the contamination for each region.

In addition, the system is comprehensive of procedures to update dose factors and to customize meteorological data acquisition scheduled queries.

Finally, by means of GIS is has been possible to develop procedures to select interactively new areas of interest in addition to regions, to produce geographic maps for items of interest in order to properly locate notification, meteorological, radiometric and dose data as well as trajectory of the radioactive plume.

ARCHITECTURE

SISGEN design has been started in the beginning of 1991, following to the design of a radiometric data management system, and with the aim of integrating data managed by this system with other data managed by software products already available. The implementation of the system required a GIS (ARC/INFO) for the development of procedures for the correlation of radiometric, notification and meteorological data with territorial data.

The implementation of the radiometric data management system was carried out at the beginning of 1992 and this system became operative at the beginning of 1993, after one year of tests and drills.

Up to now SISGEN is comprehensive of: a system that collects all the functions for radiometric data management (SIGEDRA), a system for notification data management (SIPRON), a system for radioactive plume trajectory forecast (ARIES), a system for projected doses evaluation (EURALERT), a system for meteorological data management (METEODATA) and a system for territorial data management (GIS). Fig.1 shows the Data Flow Diagram for this situation and underlines the flows of data from sources to users.

Most of the functions and data of the system are managed by a computerised distributed system constituted by a local network (ETHERNET) connecting two computers (VAX 6000- Digital) in cluster, a Workstation (DEC Station 5000/240), a PC (DEC Station 325) and an interface for remote connections apart from a lot of peripherals for inserting, printing and displaying data.

Hardware and software architecture of the system has been realized in such a way that all network hubs are organized as a specialized work station in order to accomplish specific functions and able to have access to all the data stored in the system.

The software products are modular and run on different operative systems (VMS, DOS and UNIX); they employ ARC/INFO procedures for territorial data management and X-Window as user interface.

SIGEDRA run on VAX in VMS environment and its software is constituted by FORTRAN programs and/or DCL commands, radiometric and dose data are stored into relational databases (RDB); SQL embedded language has been employed as Data Management System.

The peculiarity of this system is the ability to insert, validate and store a huge quantity of data, by means of masks directing and validating manual inserting procedure and by means of the development of two relational databases.

SIPRON runs on PC in DOS environment, the software is constituted by a package for coding and decoding notification messages and has been distributed by IAEA and CEC to all member states, on request. This product has the ability of catching coded notification messages sent by telex and/or GTS; this capability has been realized by means of a telex and a GTS interfaces which are able to recognize messages from a keyword identifying this kind of messages.

ARIES runs on VAX computers in VMS environment and is constituted by FORTRAN programs and DCL commands. The system contains modules which are able to forecast the trajectory of a radioactive plume on the basis of physical models from data about the accident and meteorological data.

METEODATA runs on VAX computers in VMS environment and contains FORTRAN programs and DCL commands. This system is able to acquire and store in real time data collected from meteorological stations all over the world and disseminated by GTS. This has been realized by means of a dedicated connection with the Meteorological Service and by procedures for acquisition and storage of data.

GIS runs on Workstation in UNIX environment; the software is constituted by ARC/INFO commands and AML procedures. This system has the ability of managing many different territorial items by means of ARC/INFO peculiarities and by means of several databases collecting territorial data that may be relevant for the management of a nuclear emergency.

CONCLUSIONS

The present paper has briefly described the organization that has been predisposed in Italy for the management of nuclear emergencies and the role of ANPA Emergency Center in this contest. Furthermore, the information system developed to provide required technical support to decision makers has been presented.

In particular, functional and operational characteristics of the system have been presented underlying performances and goals like , for example, the ability of the system to manage in real time all the information needed during an emergency and the employment of a GIS to correlate and georeference of data stored in the system.

Tests and drills demonstrated that SYSGEN allows the user to have detailed and standardized information in a users friendly way in order to get in real time an ergonomic estimate of the accidental scenario on the territory.

As far as further development is concern, it has been planned to implement a computerized system for automatic acquisition and storage of radiometric measurements performed by laboratories spread all over national territory; and to load Client-Server network protocols that will improve the abililty of the system to exchange data among the different work stations. With a longer period of time it has been planned to load SIGEDRA, ARIES, METEODATA and another GIS on two different Workstations (Alpha-Digital) in OPEN-VMS environment resulting in a great improvement of computer time consuming.

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FIG 1

DATA FLOW DIAGRAM OF SISGEN