Improvements in Off-site Emergency Management after Nuclear and Radiological Accidents

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Introduction

The Chernobyl accident had a profound effect on emergency preparedness and post-accident management worldwide and, in particular, in Europe. Deficiencies in arrangements dealing with an accident of this magnitude, at both national and international levels (e.g., in world food trade), led to many problems of a practical and political nature. Many lessons have been learnt, and considerable resources have since been committed to improve emergency preparedness and post-accident management in order to avoid similar problems in future. Improvements have been made at national, regional and international levels and have been diverse in nature. However, more needs to be done to ensure a timely and effective response to any future accident.

Emergency management more generally has received increased attention following the tragic events in the U.S. in September 2001. Attacks with radiological dispersal devices (RDD), which spread radioactive material by aerosolizing or dissolution in water reservoirs, are currently under intense discussion.

A number of requirements emerge from these considerations; they include

- the need for a more coherent and harmonized response in Europe and during different stages of an accident (in particular, to limit the loss of public confidence in the measures taken by the authorities for their protection);
- exchanges of information and data in an emergency so as to enable neighboring countries to take more timely and effective action; and
- the need to make better use of limited technical resources and avoid duplication.

The RODOS project was established to respond to these needs. It was launched in 1989 and increased in size through the European Commission's 3rd, 4th and 5th Framework Programs. Significant additional funds have been provided by many national R&D programs, research institutions and industrial collaborators. In particular, the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) contributed to the project financially with a special focus on early emergency response. Up to 40 institutes from some 20 countries in the EU, CEE, and FSU were actively involved in the project [1] (http://www.rodos.fzk.de).

The RODOS Project: Strategic Achievements

As a result of these collaborative actions, a comprehensive decision support system (RODOS) has been developed which can be applied generally within and across Europe [2, 3]. It can be used in national or regional nuclear emergency centers, providing coherent support at all stages of an accident (i.e., before, during and after a release), including the long-term management and restoration of contaminated areas. The system is able to support decisions about the introduction of a wide range of potentially useful countermeasures (e.g., sheltering and evacuation of people, distribution of iodine tablets, food restrictions, agricultural countermeasures, relocation, decontamination, restoration, etc.) mitigating the consequences of an accident with respect to health, the environment, and the economy. It can be applied to accidental releases into the atmosphere and into various aquatic environments. Appropriate interfaces exist with local and national radiological monitoring data, meteorological measurements and forecasts, and for adaptation to local, regional and national conditions in Europe.

The current version of the system (RODOS version PV 6.0) has been, or is being, installed in national emergency centers in several European countries for (pre-operational) use (Germany, Finland, Spain, Portugal, Austria, the Netherlands, Poland, Hungary, Slovakia, Ukraine, Slovenia, and the Czech Republic). Installation is foreseen or under consideration in Switzerland, Greece, Romania, Bulgaria, and Russia within the next few years. Installation in the CEE and FSU has been achieved with support from the European Commission's ECHO, PHARE and TACIS programs, respectively.

Installation is most advanced in Germany [4] (see Fig. 1). A RO-

DOS Center has been established at BfS/ZdB, Neuherberg, and has been coupled to the nuclear reactor remote monitoring systems (KFÜ), the German Integrated Measurement and Information System (IMIS), and the German Weather Service (DWD). In the current configuration, ten main users actively access the RODOS Center as A- and B-users; seven of these are responsible for emergency management in their respective federal states, and three of them act at a national level. Five federal states are passive C-users.

Installation of the system for (pre-operational) use in many national emergency centers is indicative of the success of the system and its potential for achieving more coherent and effective responses to future accidents which may affect Europe.

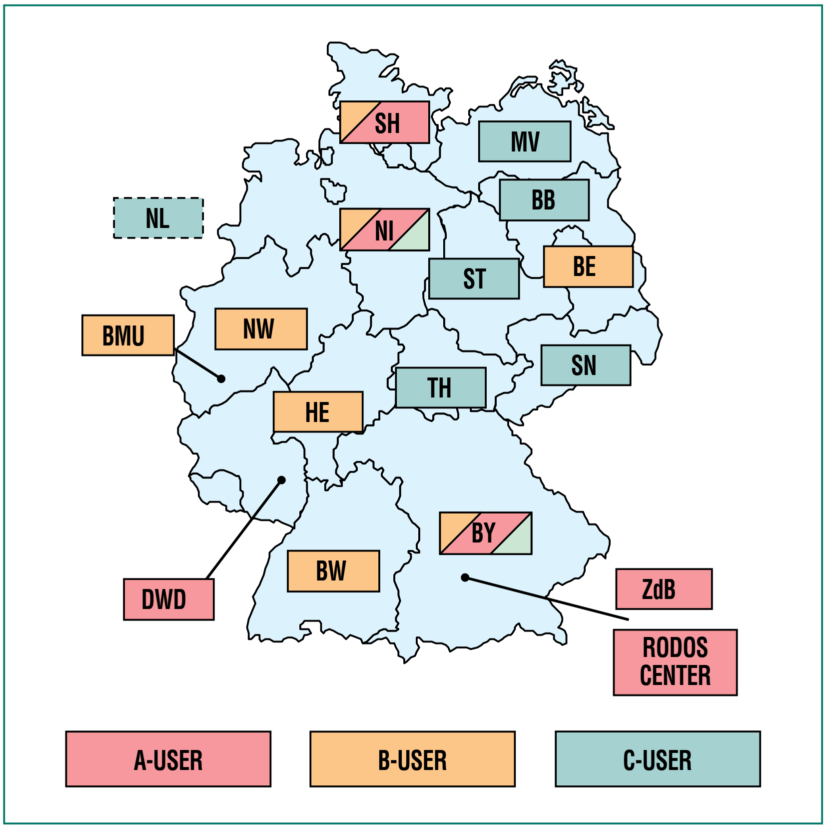

Fig. 1: RODOS users in Germany.

The RODOS System: Technical Performance

The RODOS Concept of Decision Support, Data Assimilation, and Uncertainty Handling

The RODOS system provides coherent decision support at all levels, ranging from largely descriptive reports, such as maps of the predicted, possible and, later, actual contamination patterns and dose distributions, to a detailed evaluation of the benefits and disadvantages of various countermeasure strategies and their ranking according to the societal preferences as perceived by the decisionmakers (see Fig. 2).

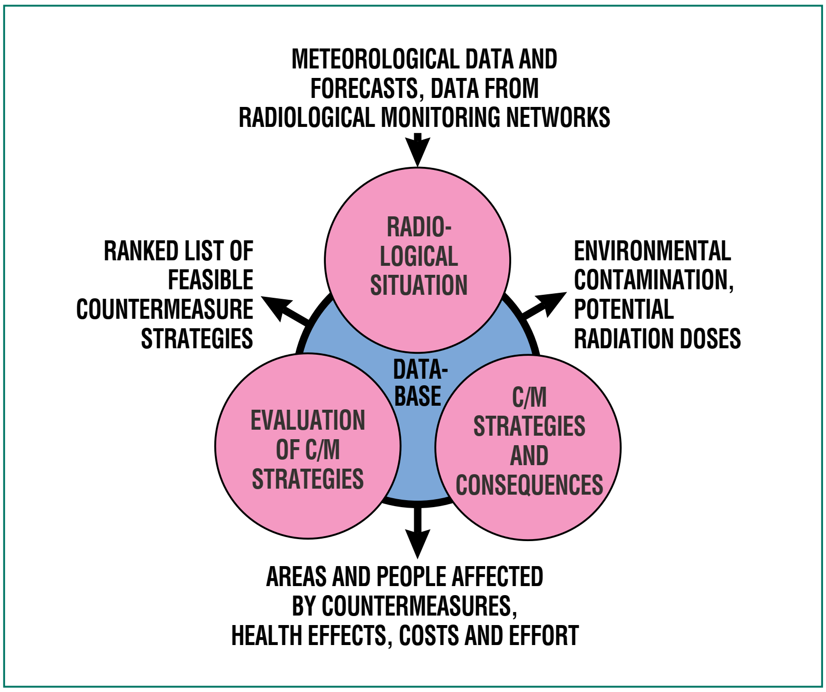

Fig. 2: Information processing in RODOS.

It is also able to perform 'what-if' calculations, allowing investigations of how a situation could develop in different scenarios. Its modern decision analysis techniques (MAV/UT – multi-attribute value and utility models) support emergency managers in evaluating the overall efficacy of possible countermeasure strategies. Data assimilation techniques combine model predictions and monitoring data for smooth transition from pure model predictions (in the pre-release phase) to a real situation (in the post-release phases). The Bayes decision analysis approach addresses all issues of uncertainty and data assimilation in a manner coherent with the decision analysis techniques used in evaluation. No decision support system on this scale has ever achieved this broad functionality in other contexts, much less so in an area as demanding as a nuclear emergency.

Interfaces with Plant Safety and Environmental Monitoring

The RODOS system provides appropriate interfaces to meteorological and radiological monitoring data and numerical weather prognoses from national weather services broadly used in Europe (see Fig 3). Customization guidelines help users adapt the system to regional and national conditions.

Prototype software tools have been developed within the STEPS/ASTRID and STERPS projects [1] which, in the event of an emergency situation in a light water reactor, allow monitoring of the progression of an accident from the moment it is detected to forecasting the future behavior of the reactor and estimating ongoing and potential releases as a function of time. The source term, thus evaluated faster than in real time, can be used to predict and/or assess the potential and/or real radiological consequences. A uniform interface exists which allows direct transfer of source term data to the RODOS system. On the basis of the results of its prognostic calculations, decisions about precautionary emergency action can be initiated in a timely manner.

User Interfaces

Three user interfaces are adapted to the needs of different users. The first one is based on X-Windows for UNIX and is intended for qualified operators and systems developers (User Category A). This interface offers full access to all systems functions, model parameters and

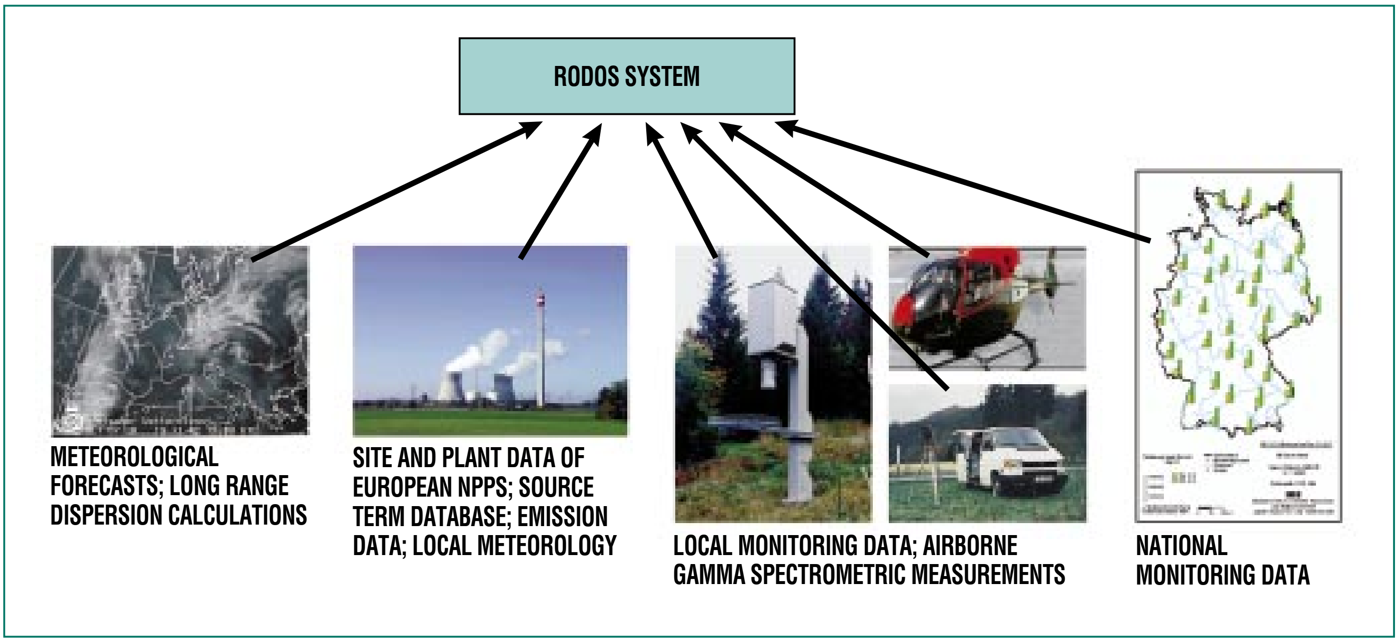

Fig. 3: Coupling RODOS to meteorological and radiological monitoring data.

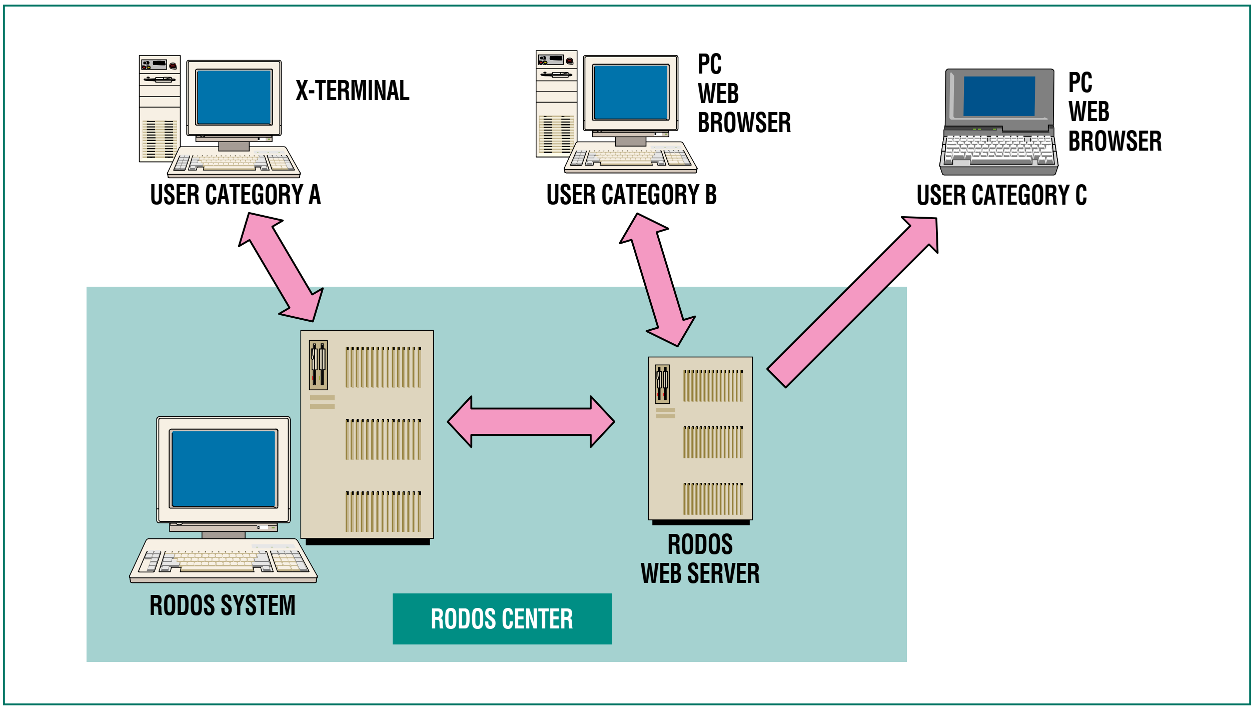

Fig. 4: User categories of the RODOS system.

stored data. The second interface (User Category B) is based on the design of Internet sites using well-established WWW technology. It is intended for users (User Category B) not needing permanent access to the system (e.g., only during an emergency or in drills), such as radiological advisers, decisionmakers, etc. The third user interface for User Category C is identical with Category B, but is limited to receiving results of RODOS calculations only (see Fig. 4).

With increasing power of personal computers and the extended functions of their operating systems it is now possible to migrate the RODOS system to one of the most advanced operating systems running on personal computers, the LINUX operating system. The possibility to use powerful PCs and LINUX servers will greatly reduce installation and maintenance costs. In that way, dependence on one hardware provider (Hewlett Packard) will cease to exist, and platform-independent installations of RODOS will become possible. The first LINUX-based RODOS version will be available in summer 2005.

Data Exchange Between Neighboring Countries

As past experience clearly demonstrates, the consequences of nuclear emergencies do not stop at national borders. It is essential in good emergency management that dose assessments and decisions be co-ordinated and harmonized among the countries affected. Countermeasures, recommendations, and information of the public and the media must be consistent. Discrepancies in assessments by different emergency centers and decisionmakers in different countries must be avoided or, at least, must be well understood. Consequently, there is great need for thorough, rapid, reliable exchanges of all kinds of information.

Given the fact that computer-based decision support systems for nuclear emergencies have become a reality in Europe, the most effective way of achieving this goal is by ensuring timely and direct data and information exchanges among those systems. Accomplishing this objective will guarantee that, regardless of the operating system and hardware platform, decision support systems will be able not only to run and serve their purpose, but also to communicate with each other and share all necessary information and data associated with an accidental release of radioactivity, thus ensuring prompt and adequate emergency management.

With the MODEM Project [1, 5], a Web server technology based data exchange tool using the XML format has been developed which allows for direct communication among decision support systems, such as RODOS (push-pull concept). The tools have already been tested successfully in a number of European-wide emergency drills. Their application in international data exchange between the U.S. and Japan is currently under investigation.

The EURANOS Project

Despite the considerable resources devoted to improving the management of consequences of nuclear emergencies and, in particular, the progress achieved in the RODOS project, the situation in Europe continues to be characterized by national solutions in the technical as well as the administrative/political areas. The EURANOS Project, which integrates 17 national emergency management organizations with 33 research institutions, combines best practice, knowledge and technology to further preparedness for Europe's response to any nuclear or radiological emergency (see Fig. 5). The five-year multinational project, which started in April 2004, combines all EC-funded activities in nuclear and radiological emergency management and rehabilitation strategies in one integrated project (http://www.euranos.fzk.de).

Nature and Scope of the Project

European countries are prepared to respond to radiation emergencies to various degrees. Emergencies of this kind can occur within a country or outside its borders, as a result of an accident or of a deliberate terrorist attack, at a site for which emergency plans exist, or at an unexpected location. Whatever the cause, an emergency in one country in Europe to some extent will affect all others. By sharing expertise, data and technology among member states, Europe is

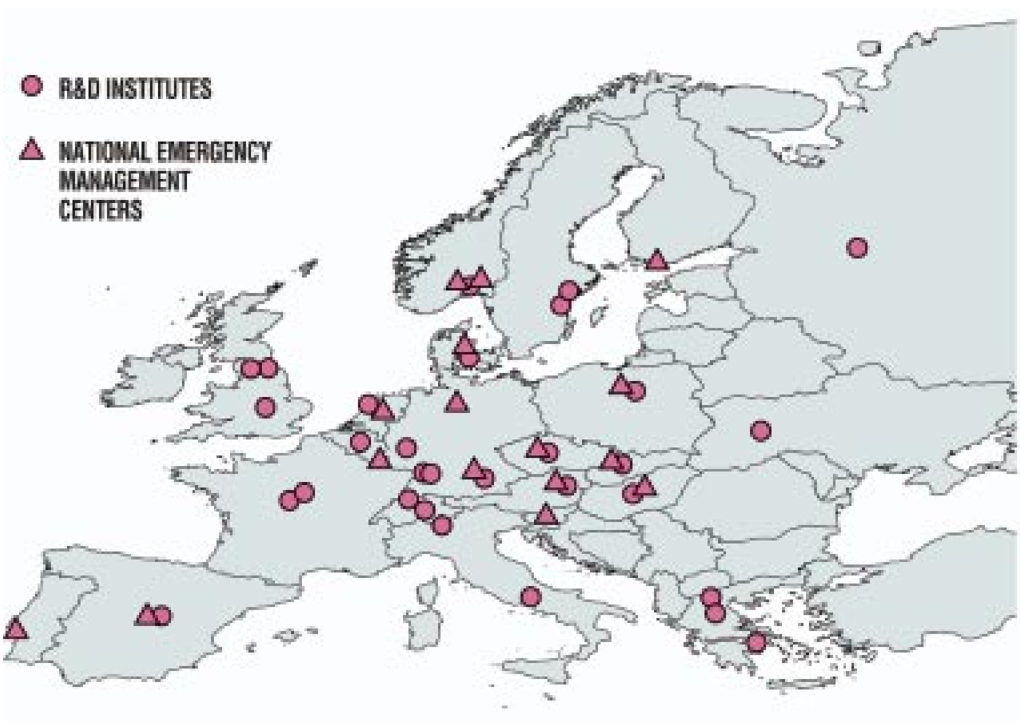

Fig. 5: European extension of the EURANOS project.

getting ready to respond to a radiation emergency appropriately and effectively.

Here are the main objectives of the project:

- Collate information about the likely effectiveness and the consequences of a wide range of countermeasures.
- Provide guidance to emergency management organizations and decisionmakers in establishing an appropriate response strategy.
- Further enhance advanced decision support systems, in particular RODOS, through feedback from their use in the field.
- Create regional initiatives to achieve information exchanges based on state-of-the-art information technologies.
- Develop guidance to assist member states in developing a framework for the sustainable restoration of living conditions in contaminated areas.
- Maintain and enhance knowledge and competence through emergency drills, training and education, thus fostering best practice in emergency response.

Activities and Impact

The project is divided into three R&D 'Categories' and a set of 'Demonstration' activities. The project is subdivided into a first and a second phase lasting two and three years, respectively.

The R&D 'Categories' address specific issues previously identified by users or by earlier research in the area. They are focused on

- emergency actions and countermeasures,
- enhancement of decision support systems for field use,
- rehabilitation strategies and guidance.

Demonstrations practice the methods and tools developed in their real field environments. In Phase 1, they will focus on methods and IT tools developed within previous EC Framework Programs. In parallel, the R&D activities requested by end users will be performed. The results of these R&D activities will be demonstrated in Phase 2. Throughout the work program, training activities are planned to ensure broad dissemination of the project results.

At the end of Phase 1, the project will be reviewed on the basis of feedback from demonstrations and training activities, R&D results, and recommendations from users. As a result of that evaluation, the strategic orientation and the key elements of the work program for the remaining three years will be defined.

Integration in one common project of R&D institutions with agencies responsible for radiation emergency management and rehabilitation allows project resources to be focused on the practical needs of decisionmakers. This collaborative iteration process ultimately will lead to a shared and integrated technical, methodological, and strategic approach in national and cross-border emergency management and rehabilitation in Europe. A well-conceived approach like this can progressively lead to the development of a European policy of emergency management and rehabilitation strategies.

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The Accident Consequence Group of the Institute for Nuclear and Energy Technologies at the Karlsruhe Research Center bears the main responsibility for developing and installing the RODOS system, has acted as principal co-ordinator of the RODOS activities for the past fifteen years, and is now co-ordinator of the EURANOS project. All current Group members have contributed to the work described in this publication: G. Benz, F. Fischer, E. Munz, C. Haller, I. Hasemann, C. Landman, A. Müller, J. Päsler-Sauer, M. Rafat, W. Raskob, T. Schichtel, A. Weis.

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