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RODOS Users' Group:

Final project report

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ABSTRACT

Prior to 1998, the development of RODOS, a decision support system designed for the management of nuclear emergencies, had been carried out almost entirely by research scientists and engineers. The end-users/operators had little or no input into this development. To redress this situation, the RODOS Users Group (RUG) was established in 1998 under a Concerted Action Contract between the European Commission and STUK. The main objectives of this group were to encourage the emergency management community to use such a system, to provide a forum for end-users to share their experience in the use of such systems and to provide feedback from the end-users to the model and system developers in regard to operational problems and required improvements. The contract, which commenced on 1st September 1998, was for a period of two years. During this period, RUG established a WWW homepage, planned and performed two nuclear accident exercises and held four meetings.

Technically the Web page operated very well. State-of-the-art Internet technology provided an efficient communication channel at low cost. The membership of the RUG was, however, too low to maintain a lively and ongoing discussion in parallel with the RODOS project Web page. This experience would suggest that it might have been better to have operated a Web page for RUG on the RODOS project Web-site rather than an independent RUG Web-site.

Exercises based on fixed accident scenarios proved to be an appropriate means of highlighting issues that needed to be discussed between users and developers and to stimulate and motivate the end-users to maintain and

further develop the system. Such exercises also promoted further activity in the field of emergency management.

The organisation and administration of realistic exercises are time consuming, laborious and expensive. It is therefore very important that the maximum benefit is achieved from such exercises. The use of analytical evaluation methods could be better employed for assessing an exercise and analysing the results. It would be useful in this context to formulate a framework that could provide scientific levels of merits and guarantee the full documentation of the work and effort invested. The workload in designing future exercises for RODOS could be reduced by taking all opportunities to use RODOS in international exercises.

Users with expertise and a responsibility in the field of emergency management have to be familiar with the relevant models used in the decision support system (DSS). They have also to be aware of the level of reliability of the calculated results and the limits and conditions applying to the model predictions. It is therefore essential that good co-operation exists between end-users and the R&D community developing the system. The RUG provided a forum for the end-users through which they could communicate their requirements to the developers, receive advice and demonstrations of the latest additional features to the system. It is seen essential that the end-user can contribute to the development of models used in RODOS and other DSSs, and perhaps in the future, become more involved in the R&D aspects of these systems.

CONTENTS

1 INTRODUCTION

The varied emergency response to the Chernobyl nuclear accident demonstrated the need for internationally accepted procedures and methods to ensure an integrated and coherent response to possible future accidents. There was also a need to have a comprehensive and seamless set of models to assess radiation exposure from different pathways, over different time spans and at all distances, both near and far from the accident site. To provide such models, the European Commission endorsed and funded a project for the development of RODOS, a Real-time On-line Decision Support system (Ehrhardt and Weis, 2000).

RODOS has been developed to provide consistent and comprehensive support for off-site nuclear emergency management. Comprehensive support implies that RODOS must be able to support a wide variety of experts and decisions-makers during the various phases of an accident. RODOS can be linked to radiation monitoring systems and uses a geographical information system to present radiological data in combination with geographic and demographic information. Based upon real time monitoring and meteorological data and using various models it analyses the current and predicts the future radiological situation (i.e., the distribution in space and time of the released radioactive material). It simulates the impact of taking protective actions, such as sheltering, evacuation, relocation, iodine prophylaxis and food bans. It determines their feasibility and quantifies their benefits and disadvantages. It is planned that the system will provide support to all parties involved in emergency management and decision-making, helping them to explore and develop their judgements and evaluations on countermeasures.

Decision support systems (DSS) for the management of nuclear emergencies have been designed and developed almost entirely by an R&D community of scientists and engineers. There has been little involvement of real end-users. There was a need to stimulate the use of such systems by operators within the emergency management community and to reinforce communication and feedback between these users and the model and system developers in order to develop a system that better fits the needs of these end-users. It was also thought that a forum where the end-users could share their experience in the use of decision support systems was necessary. In 1998 a Concerted Action

Contract was signed between the European Commission and STUK on the RODOS Users Group (RUG). The contract started on 1st September and covered two years. Membership of the RUG consisted of representatives from those institutes that were responsible for installing, customising and operating the RODOS system or that had expressed an interest in using the system within their countries in the near future. Around ten European countries have participated in the Group.

RUG's activities focused on the application of the RODOS system in emergency management arrangements. The group organised biannual meetings during which not only users met other users and shared their experience in the use of RODOS but also developers were present to listen to the users and discuss their problems. RUG established a Web site service to offer an open and fast communication forum for frequently asked questions and to efficiently distribute information amongst users and also between users and the development teams. Two exercises were organised to compare the consequence assessments from RODOS for a hypothetical nuclear accident and to compare the procedures of emergency management in the participants' countries. A fixed release scenario was used in both of the exercises. The focus in the first exercise was on early phase and near site issues, e.g., near-range dispersion and early countermeasures. The second exercise dealt with later phase issues like contamination of the food chain and appropriate countermeasures. The sharing of experience and know-how in the installation and use of the RODOS system was an integral part of RUG. It was also important to look at national emergency arrangements and decision-making procedures to determine how RODOS fits into this framework and how it could support the decision-making in each country. Major attention was given to the type of information that is provided/should be provided to the decision-makers to enable them to make informed decisions on protective actions.

The secretariat of the RUG was organised and managed by STUK - Radiation and Nuclear Safety Authority, Finland. The tasks of the secretariat were to organise and maintain the Web page, to co-ordinate and prepare technical reports and to provide administrative support during meetings.

2 OBJECTIVES

The development of the RODOS system within the European Commission's Nuclear Fission Safety Programme has stimulated a large-scale collaboration on nuclear emergency preparedness between organisations in EU-member states and a number of research institutes in countries of the former Soviet Union and Central and Eastern Europe. While some organisations from the emergency management community were directly involved in the development work, it was seen of paramount importance to broaden the user group, to promote the operation of the system in emergency centres and to enhance the system's applicability for nuclear emergency management.

Since the RODOS system was being developed for use in emergency management centres, and not just as a research or training tool, it was important that the emergency management community could have an influence on the development of the system. RUG was established to enhance the communication between the end users and, also, between the end users and the model and system developers. The objective was to share technical know-how and other experiences gained during the implementation, customisation and operation of the RODOS system. In particular attention was focused on issues arising from the operation of RODOS in emergency centres and in establishing links with radiation monitoring and meteorological networks. The sharing of knowledge on how best to integrate RODOS into national emergency management arrangements was also considered important.

The main objectives of the RUG were:

- to stimulate the communication between model and system developers and the end users;

- to share technical know-how, software developments and the experience gained during the implementation, customisation and operation of the RODOS system, in particular, its remote operation, via networking, at local/regional/national emergency centres and with remote users, and in establishing on-line links with radiation monitoring and meteorological networks;

- to share experiences encountered in integrating RODOS in the national emergency management arrangements and development of improved strategies and structures;

- to identify faults and limitations of the RODOS system during its commissioning and operation, and to provide feedback to the development teams;

- to promote the system as a training tool for emergency management, and its use in nuclear emergencies and exercises;

- to identify where further R&D may be needed to improve the operational efficacy of the RODOS system;

- to enhance communication and exchange of experiences between the users of RODOS and the users of other decision support systems for off-site nuclear emergency management.

3 PROGRESS AND RESULTS

In response to the objectives set out in section 2, RUG organised and hosted biannual meetings of users and potential users to discuss and share information on different tasks (Minutes 1999A, 1999B, 2000 and 2001). In the four meetings that were held the discussions concentrated mainly on system implementation and the application of decision support systems in emergency management. RODOS developers were invited to attend the meetings to share their technical knowledge and guidance in the use of RODOS. RUG established a World Wide Web page to offer an open and fast communication forum for frequently asked questions and for the distribution of information, technical reports and RODOS outputs. This Web site was also open to institutes interested in the operation of RODOS. RUG co-ordinated, prepared and distributed various kinds of reports, including proceedings of the meetings and notes concerning the operation of RODOS. It provided support in organising, performing and attending regional, national and international emergency exercises, training courses and elicitation exercises. In addition, RUG provided an interface with other institutes/emergency centres that are developing or operating other decision support systems for off-site nuclear emergency management, e.g. ARGOS NT.

3.1 RUG homepage

In order to enhance communication within both the RUG and RODOS projects STUK established a Web site service. This offered an open and fast method for the distribution of information, technical reports and RODOS outputs not only within the users community but also amongst users and development teams. It also provided a site for sharing questions and problems relating to RODOS. The objective was to have a Web site that provided an integrated platform for sharing different types of information and at the same time was easy-to-maintain and user-friendly. Conceptually, it consisted of a *discussion forum* and a *document archive*. Announcements on the top page drew the attention to news and changes to the archive. The graphical user interface of the site followed HTML-standards.

The *discussion forum* provided a place where visitors could leave questions, remarks, opinions, discussion openings etc. The discussion could be divided into different topics and contributions were easily made using Web forms where the user simply wrote the subject for the message and the message body text and chose the proper discussion group. Anyone with access to the site could follow the ongoing discussion and was able reply to previous messages.

From the *document archive* the participants could download files and documents. Uploading files was easily done with Web forms and files could be stored in any format. The user simply provided a file name and the path to the hard-disk where the file was stored, gave the file a descriptive title and submitted it to the server. Uploaded files were downloadable at once for all other users. The person who had uploaded the file had the privilege to remove it from the site. This made it easy to keep the site up-to-date.

Because the RODOS software was still under development it was decided to restrict access to institutes interested in the operation of RODOS. Hence the site was protected with user-id and password. There were three levels of access rights: (1) read and download, (2) read, download and upload and (3) administrator

3.2 Benchmark exercises

To enhance discussion and to clarify issues of common interest within RUG it was agreed to analyse and compare the consequence assessments of hypothetical nuclear accidents using a common release scenario. The main purpose of this exercise was to stimulate the use of the RODOS system in participating institutes and to share experience on its installation and use in emergency centres. Furthermore, it has been recognised that national emergency arrangements and the decision-making process in different countries needed to be scrutinised in order to see how the RODOS system could best support the decision-making.

Two exercises were prepared and conducted. These tabletop exercises provided a common accident scenario to be run on RODOS by the end users, and served as a means of highlighting operational problems. The issue of what data should be presented to the decision-makers was also to be considered. The accident scenarios were prepared only for use within the RUG. The exercises were neither planned to be national command post exercises nor to include decision-makers or higher level advisors. However, where seen appropriate, participants were free to interview relevant competent national safety authorities.

Questions addressed included: at what point in time would the RODOS system be operated and by whom? Is appropriate input data available, if not, what do you do? How do you deal with uncertainties? What information is needed by decision-makers and in which form should this information be presented to them? What information is needed and requested by parties involved in emergency management (experts, advisors)? How would RODOS be used to provide this support?

The objectives of the exercises can be summarised as:

- to train and improve the skills of users in performing interactive scenario calculations with the RODOS system; in particular to get familiar with the input/output interfaces and with the models available within the RODOS system;

- to study what information is available from the RODOS system and what subset thereof should be given to the decision-makers and other parties involved, and to identify possible requests from crisis teams that are not available in the present RODOS calculations;

- to enhance and deepen discussion within the RODOS users' community; in particular on what information is useful in an accident and in what format should it be exchanged;

- to clarify the role of the RODOS system in emergency management, e.g. the advantage of having support in areas that are not so coherently supported by other tools; and to identify the demands on personnel, infrastructure and other resources.

The role of the participants in the comparison exercises was to support the crisis team (experts, decision-makers), i.e. to assess the radiological situation and provide the crisis team with information concerning protective actions. The crisis team was assumed to be responsible for preparing recommendations on protective actions, but not deciding on nor implementing them. The focus was on the actions that are most efficient in reducing doses e.g. iodine prophylaxis, sheltering, evacuation and food restrictions.

First joint exercise

A modified version of the INEX 1 (OECD 1995) international emergency exercise scenario was used in the first joint comparison exercise. This particular scenario was chosen because new RUG members had not completed their collection of national data at the time of the exercise. Also, the RODOS software was distributed with a complete data set for this scenario (Steinhauer 1996A and 1996B, Rojas-Palma, 1999). The exercise focused on early phase issues and the calculation area was limited to the near-range, i.e. the computation area covered 40 by 40 square kilometres (Ammann et al., 1999). Most participants used the near-range atmospheric dispersion and deposition module RODOS/QUICKPRO and the early countermeasure simulation module RODOS/EMERSIM to assess the potential consequences and to perform 'what-if' analysis.

The accident scenario, which included the timetable of events, was supplied to the crisis team. The exercise stopped twelve hours after SCRAM. It was not prescribed when or how the crisis team entered the scene, nor how the emergency situation should be managed. It was proposed that all participating teams should follow their own national procedures.

According to the scenario description the accident started with a fire in a switchboard at midnight, leading to the shutdown of the reactor. At 04:00 in the morning the utility informed authorities that in the worst case fuel uncovering could happen in about 5 hours, i.e., 09:00. There was a significant risk (about 50%) of a large release from the plant but again it was estimated that the release would not occur before 09:00. The assessment provided was conservative, i.e., the actual release, if it happened, would not be greater than the given source term. Real-time weather data was available supposedly on-line from site instrumentation. It was assumed that the most recently recorded weather situation would prevail for the following hours.

Given this sparse information first 'what-if' consequence assessments were made with the RODOS system. Some participants started with the identification of the potentially threatened area and an assessment of whether protective actions may have to be taken to prevent deterministic health effects. The effective dose in normal living conditions, summed over all pathways for the duration of the plume, was used to estimate the deterministic health effects and the risks of large-scale stochastic effects. To assess the need for iodine prophylaxis some crisis teams requested either the thyroid dose for children in normal living conditions or the estimated number of thyroid cancer occurring in children. By applying dose criteria, potential intervention areas were defined where measures like evacuation, sheltering and iodine prophylaxis should be taken. RODOS provided this information in the form of thematic maps, which together with other information (plant status, weather) were used to make recommendations regarding countermeasures in specific areas.

Decision making on protective actions prior to a release is rather difficult. In the threat phase or in the early release phase decisions on protective actions have to be based on the plant status and cannot be based on dose predictions, which depend on the progress of the accident in a NPP. 'What-if' analyses are used to gain additional insight on potential consequences. In this exercise very little information about the plant status was included.

An actual release was detected at 12:00. The estimated source term provided for the release was lower than the earlier estimation. RODOS was rerun using the updated source term assessment and weather information. Individual and collective doses as well as designated areas for sheltering, distribution of stable iodine for children and adults, respectively, were recalculated and used to revise the previous recommendations on countermeasures.

Second joint exercise

A hypothetical exercise scenario was developed for the second joint comparison exercise of the RUG. A nuclear accident was assumed to happen in a fictitious NPP. This plant was sited in the respective countries of the players so that they could exercise in their own national environment and base the calculations on their own data. The PWR was assumed to have a large, dry steel containment and its thermal power to be around 2000 MW(t), and to be of typical European design. Modules for atmospheric dispersion and deposition calculations (QUICKPRO), for early phase emergency simulations (EMERSIM), for calculating the activity concentrations in the food-chain (FDMT) and for agricultural countermeasures and decontamination (LCMT) were provided within RODOS. Only those countermeasures that were expected to be most effective at reducing the dose to the population were considered, e.g. iodine prophylaxis, sheltering, evacuation, selected food countermeasures and agricultural decontamination.

The exercise covered the first week of the accident, i.e. from the first notification of the emergency to the time when fallout pattern and composition were measured. The magnitude of the release was adjusted so that the area of interest covered roughly 320 by 320 square kilometres.

The meteorological situation was given as a time-series of wind direction, wind speed, diffusion category and rain intensity. The wind directions were listed in degrees relative to a suitable direction and it was left to the players to rotate the reference direction in such a way that the scenario produced a reasonable and not a too complicated emergency situation in the respective countries.

The chosen time of the accident was during a working day at the end of June. The accident started with a fire in one of the electrical cabinet rooms and caused a successful shutdown of the reactor. The effects of the fire and an independent failure of the emergency core cooling system prevented core cooling. The containment was isolated. Core heat-up started 3.5 hours after shutdown and one hour later the vessel breached at high pressure. Containment sprays started and operated successfully. It was not possible to cool the debris in the cavity and its temperature reached 2500K seven hours after the shutdown. At T_0 + 12 hours, the temperature of the debris was stabilised at 1600K. Due to the temperature of the core debris, large quantities of hydrogen and carbon monoxide were generated. Combustion occurred at 43 hours after shutdown, resulting in containment failure and the release of radionuclides to the environment.

The release scenario was based on a containment failure classification. There are several possible containment event tree branches in each containment failure group. These were assessed by nuclear safety experts and based on their decisions the release fractions given in Table I were calculated. Using the releases estimated for the stated fractiles of the cumulative distribution functions[1] the impact of each release could be assessed in terms of the scale of countermeasures required and the probability of the release occurring.

[1] The cumulative distribution gives the probability that a release magnitude is less or equal than the particular magnitude.

Table I. *Source term assessment of the hypothetical accident. The release fractions of the 5%, 50% and 95% fractiles of the release distribution are given.*

Nuclide group	**Release fraction**		
	5% fractile	**50% fractile**	**95% fractile**
Noble gases	$8.0 \cdot 10^{-1}$	$8.5 \cdot 10^{-1}$	$9.3 \cdot 10^{-1}$
Iodine total	$8 \cdot 10^{-4}$	$1.3 \cdot 10^{-2}$	$7 \cdot 10^{-2}$
Alkaline-group (Cs, Rb)	$7 \cdot 10^{-4}$	$1 \cdot 10^{-2}$	$6 \cdot 10^{-2}$
Tellurium-group (Te, Se, Sb)	$1 \cdot 10^{-10}$	$1 \cdot 10^{-4}$	$2 \cdot 10^{-2}$
Alkaline earth-group (Sr, Ba)	$< \cdot 10^{-10}$	$< \cdot 10^{-10}$	$1.5 \cdot 10^{-6}$
Ruthenium-group (Ru, Mo, Tc)	$< \cdot 10^{-10}$	$< \cdot 10^{-10}$	$5 \cdot 10^{-8}$
Lanthanide-group La, Nb, Zr, Cm, Ce, Nd, Pm, Sm, Eu, Pu, refr. Ox. Nb, Zr)	$< \cdot 10^{-10}$	$< \cdot 10^{-10}$	$7 \cdot 10^{-8}$

The release began 43 hours after shutdown, at 08:00, and lasted for 12 hours. The release rate was not constant, and it was assumed that the initial rate of release diminished roughly exponentially within 12 hours. The effective release height was 100 m, which corresponded roughly to an initial heat release rate of a few megawatts (the actual release height was 60 m).

Immediately following the release the source term was reassessed using plant status information, plant instrumentation and field measurements. The source term was estimated to correspond to the 5% fractile given in Table I.

Conclusions of the exercises

A number of RUG members participated in the exercises and each team prepared a short summary of their performance in each exercise. The main findings were reviewed and discussed during the meetings of the RUG and are presented below.

Regarding the first exercise, it was remarked that the scenario description was too vague in several aspects, e.g. neither the plant status nor the time behaviour of the release was known. There was no information on the resources needed and available for implementing countermeasures. There was no data on schools, hospitals, factories, etc. The second exercise overcame some of these shortcomings by locating the accident in each player's own country.

Thus national geographic and demographic information was available. But the scenario of the second exercise not only added more realism, it also provided the opportunity to carry out more extensive calculations.

The operation of RODOS takes considerable training. Since not all participants had sufficient training, features and tools within RODOS remained undiscovered. This deficiency was sometimes attributed to the design of the RODOS software.

For some participating organisations, both the decision-makers and their advisors (RODOS users) and RODOS operators were all in the same room during the exercise. This would not correspond to usual practice. It was noticed that the occasional observer or end-users of results got lost in the number of windows that appeared before the required information was available. It is recommended therefore that the end-users only receive concise outputs that are sufficiently annotated. They should not be directly confronted or concerned with the operation of RODOS.

If decision-makers are presented with all the information that can be produced with the RODOS system, there is danger that they will base decisions selectively on information they grasped, or anchor to the first or most recent information given. Therefore, there were attempts to define a default information set that would be provided to the stakeholders. This set would contain the necessary up-to-date supportive data in a concise but clear format to facilitate their decision-making. More detailed information would be supplied only upon an explicit request. The following information was considered as ‘default information’ in the joint case studies.

Thematic maps:
- plume arrival time;
- effective dose in normal living conditions;
- thyroid dose in children/adults from inhalation of radioiodine in normal living conditions;
- effective dose from ground, integrated over a relatively short time;
- effective dose from cloud during plume passage;
- time integrated activity concentration of I-131in air;
- ground deposition of Cs-137;
- nuclide specific concentrations in food- and feed staffs;

- population distribution;
- proposed intervention areas for sheltering, evacuation, iodine tablets, food ban areas etc.

Tables containing:
- collective doses in the proposed countermeasure areas when actions are taken and when not, i.e. estimation of the avertable doses;
- monetary cost of the actions;
- number of people affected by the actions.

Time plots:
- nuclide specific deposited activity;
- nuclide specific activity concentration in feed and foodstuffs.

3.3 RODOS and other DSS in participating countries

RODOS is installed in most of the RUG member organisation. Past activities and the current status of the installations and their adaptations to national needs is described in this section. Comments are also made on the use of RODOS in exercises, training and planning.

Radiation and Nuclear Safety Authority (STUK), Finland

General

STUK has been actively involved in the RODOS project since 1996 and since then different prototype releases of the RODOS software have been installed on a HP Workstation (Model 715), modified for Finnish conditions and tested at the Research and Environmental Surveillance Department. The last RODOS version that was developed and released during the EU's 4th Framework Programme (1994-1998), i.e. RODOS PV 4.0 F, was reported to be stable and fit for use by the end users. Although it was still termed pre-operational and the development was ongoing, STUK decided to install it in its emergency centre.

Current status

In September 2000 STUK purchased a new HP Workstation (HP Visualize 3600) to operate the RODOS software in its emergency centre. The RODOS version PV 4.0 F, released on 7 Dec 2000, was installed on that workstation on 3 January 2001. The system was tested and configured during January 2001 and deployed in the emergency centre. From 1 February 2001 RODOS has been in continuous operation. Being a pre-operational version, the system performance was and continues to be tested and evaluated.

The RODOS modules installed have been adapted to varying degrees to Finnish conditions. Vector maps and population data on a grid that covers the whole of Finland were installed. Plant and inventory parameters for the Finnish NPPs at Loviisa and Olkiluoto were inserted into the database. Available data for the NPPs in neighbouring countries (Forsmark, Oskarshamn, Barsebeck, Ringhals, Sosnovi Bor, Kola, Ignalina) was also included. The parameterisation of the milk pathway has been modified to local conditions, but work is still needed to further revise the parameterisation of FDMT and LCMT to the radio-ecological conditions in Finland. Agricultural production data has, as yet, to be provided in the appropriate format for inputting into RODOS. Real-time weather mast data from the two Finnish NPP sites are received on a regular basis, but data entry routines have to be written. The provision of HIRLAM data from the Finnish Meteorological Service is not yet agreed but it is hoped that an agreement can be reached during 2001. An optional interface to the approved Finnish long-range atmospheric transport model is being investigated.

Two operators received training in the use of RODOS (one participated in the training course for operators organised by FZK in Nov 2000). Personnel involved in emergency management, i.e. experts in radiation protection, environmental surveillance, health physics, etc., were introduced to RODOS and instructed in its use. Procedures for the operation of RODOS in the emergency centre were drafted and will be adjusted as experience is gained during the present and coming year.

Use

During the last few years STUK has used and tested RODOS on different occasions. The most recent occasion (September 2000) was its participation in the second joint exercise of the RUG. Later phase issues were the main concern of this exercise and the RODOS modules QUICKPRO, EMERSIM, FDMT and LCMT were used and evaluated. A year earlier (August 1999) STUK participated in the first joint exercise of the RUG, which dealt with early phase issues and QUICKPRO and EMERSIM were the RODOS modules tested.

RODOS was also used to provide crucial input and support for the different workshops on analytical decision making that STUK arranged in co-operation with the System Analysis Laboratory of the Helsinki University of Technology (Hämäläinen et al. 1998 and 2000). The first series of workshops were held in 1997 and these workshops dealt with countermeasure planning and decision-making in the early phase of a nuclear accident. One of the accident scenarios studied was re-examined in the following year, when early phase decision-making issues were examined using an interview technique. In May 2000 a facilitated workshop on decision making was held which embraced the early and late phases of the accident. In the preparation of and during these conferences it was STUK's responsibility to analyse the radiological situations and to assess the need for countermeasures. RODOS was the main tool that supported this work.

Since it's installation at STUK, RODOS has also been used routinely in parallel with the existing tools during emergency exercises. For these exercises an X Window emulation program was installed on a Windows NT workstation at the emergency centre and used to accessed RODOS remotely via the Intranet. Normally these exercises stopped at the threat phase. However a recent (September 2000) exercise dealt explicitly with later phase issues and RODOS/FDMT was successfully used. In another later phase exercise, held earlier in spring 2000, RODOS was used to describe the radiological consequences of the accident and to simulate measurement data during the exercise.

In January 2000 RODOS was used to carry out an interim investigation into the potential threat that exists for the Finnish population from a worst case accident scenario at the neighbouring nuclear installations.

Nuclear Protection and Safety Institute (IPSN), France

General

IPSN was involved in the RODOS project since 1996. During the EU's 4th Framework Programme it developed, in collaboration with STUK, a model for forest ecosystems. In 1996, two HP workstations were purchased and installed at Fontenay-aux-Roses and Cadarache. The RODOS version 3.11 was installed on both. At the beginning of 2000, IPSN installed the RODOS version 3.17 and performed, in June 2000, a French-German exercise at the border of the two countries and Switzerland.

Current status

At Cadarache the RODOS system was used to develop the forest module and not as a tool for emergency management. This is the reason why IPSN did not participate in the first joint exercise. The RODOS software has not been adapted to French conditions. Difficulties in operating the system during the second exercise prevented us from providing results. In 2001, two operators will be trained at FZK.

Karlsruhe Research Center (FZK), Germany

General

In its role as the main developer of the RODOS system, the FZK contributions to the RUG activities of the RODOS team have concentrated on

- informing the members on the project planning and the status and functions of the different RODOS versions;
- giving advice on the hardware and software components of the RODOS system and its networking during the installation at the members' institute;
- distributing the RODOS versions PV3.1, PV3.13 and PV4.0 to the RUG members and supporting their installation and operation by telephone or E-mail contacts;

- providing technical advice and data during the preparatory phase of the two emergency exercises;

- answering questions and problems emerging during the use of the system, in particular when preparing and performing emergency exercises;

- receiving, evaluating and responding to suggestions for further improvement of the system or modifications of its functionality.

Activities

In both, the first and the second exercise, the RODOS Team at FZK played the role of an observer and evaluator giving support in interpreting the results and any inconsistencies observed by the various institutes. In addition, FZK participated at the first emergency exercise.

For the first exercise, it was assumed that the site was located at FZK. To play the scenario as a realistic table top exercise would have required an operator for the RODOS system, a radiation protection counsellor for defining the tasks to the operator and demanding the results needed from RODOS for the emergency management team. Personnel for the first two tasks was available, but FZK as a research institution has no direct access to the management staff of the Federal States of the Federal Government. Within the given time scale of the exercise, it was not possible to organise a corresponding decision making conference.

Therefore it was decided to concentrate on assessments, using RODOS, of the potential early emergency actions for the two accident situations provided in the scenario description, and only marginally touch the problem of decision making. The work performed in connection with participation at the first exercise and the results achieved are documented in Ammann et al., (1999).

NCSR "Demokritos", Greece

General

The Environmental Research Laboratory (EREL) of NCSR “Demokritos” has participated in the RODOS Project as a Contractor since 1993, and has been developing modules for the mesoscale meteorology and atmospheric dispersion of pollutants over highly irregular terrain. EREL has been a Contractor of the RUG since September 1998. The goal of the EREL in the framework of RUG is to examine RODOS from the operational point of view and establish communication links with other RODOS users in order to exchange information. The long term aim is the incorporation of RODOS in the Greek national emergency system.

The nuclear emergency management system is a responsibility of the Greek Atomic Energy Commission (GAEC), which has the task to predict and evaluate the effects of the radiological events in Greece. Since no nuclear power plant exists in Greece the main concern is to assess the effects in the Greek territory from nuclear accidents that may happen in other countries. EREL provides support for the GAEC to accomplish this task, by operating RODOS which is a consistent and complete system for evaluating the effects of nuclear accidents.

Current status

RODOS is presently installed and operated in the EREL. All the previous RODOS versions (2.*, 3.*) were installed on an HP 735 workstation, while the latest PRTY 4.0 and PV 4.0 F have been installed on an HP K260 server.

In view of the special Greek requirements, the following matters have been identified as necessary to be solved for an operational function of the RODOS system:

- computing environment
- databases with data on NPPs in Europe, accident scenarios and source terms, topography, land cover, meteorology, population, food production, radiological data
- communications - networks

Some of the above requirements (such as the list of the NPPs in Europe, and the accident scenarios and source terms) have already been covered in the latest RODOS versions or are planned to be included in the future versions. For the rest of the items, actions have been undertaken by EREL during the period of the RUG project. More specifically, with the aid of a Geographical

Information System, the construction of databases for topography and land cover for all Europe has started and is still continuing. Concerning the meteorological data, after some discussions with the Greek National Meteorological Service, the latter is providing on a daily basis Numerical Weather Prediction data that cover most of the European continent, with 6 hours prediction steps and 3 days forecast length. These data can be used for calculations of long-range atmospheric dispersion. Planned work for the future includes the completion of the databases with population and food production data and the connection of RODOS with the network of monitoring stations operating on the Greek territory.

Use

EREL has participated in the 2nd benchmark exercise organised by RUG. The basic aim in performing this exercise was to examine the operation of RODOS from the point of view of a user, for a nuclear emergency situation and under the specific conditions that apply in Greece. Specific targets were to use the whole model chain of RODOS as far as possible, identify the output that is useful for Greece, communicate eventual difficulties and problems to the users and developers communities, and identify the missing items for customising RODOS for operational use in the country.

Since no nuclear power plant exists in Greece, the Kosloduj NPP was selected, which is the closest to the Greek borders. This distance (275 km) posed a problem in applying the model chain QUICKPRO- EMERSIM-FDMT and LCMT, as agreed in the specifications of the exercise, since QUICKPRO is valid for atmospheric dispersion from local to meso-scale. However it was decided to neglect this inconsistency and perform the exercise to test the operation of RODOS, without referring to the physical significance of the produced results.

After the insertion of the accident site and source term in RODOS, the calculations grid was defined to cover the distance up to Athens. The suitable wind direction was selected, to direct the plume towards Greece. The atmospheric dispersion calculations were successfully performed but problems have been encountered in operating the countermeasures and food chain models. Problems were also encountered in the graphical presentations of the results.

The experiences acquired from the performance of the benchmark exercise have been communicated to the systems developers during the last RUG meeting. Other conclusions drawn from the exercise concerned mainly the necessity of completing the underlying databases of the system, as are the NPPs in Europe, geographical, food production and radio-ecological data.

Radiological Protection Institute of Ireland (RPII), Ireland

General

Under the National Emergency Plan for nuclear accidents, the Radiological Protection Institute of Ireland has responsibility for carrying out a technical assessment of the potential or actual consequences of any nuclear accident and for recommending what measures should be taken to minimise the radiation exposure of members of the public. In 1998 it was agreed that a decision support system (DSS) would be of great assistance towards carrying out this responsibility and steps should be taken to obtain and install an appropriate system at the Institute.

At this time the RUG was being established and as a potential user of the system, we were accepted for membership of this group. Membership of the group would provide an introduction to other users and assist us in gaining a good appreciation of both the administrative and technical support requirements required to operate such a system.

Activities

To obtain a good understanding of the requirements for the operational a reliable RODOS system, we met with the RODOS operational and development teams at FZK, Karlsruhe. Following this meeting doubts as to the capability of our Institute to operate and maintain such a complex system were raised. The Institute have a small staff and could not dedicate sufficient staff numbers to be assured that RODOS would be maintained and operated successfully. These fears were re-enforced through RUG meetings and the apparent difficulties that larger organisations were having with the operation of RODOS.

While not rejecting RODOS, it was decided that other PC operated systems should be investigated. We obtained a copy of the Danish decision support system, ARGOS NT, for a trial period. This system is much simpler than that of RODOS and more manageable within our staffing constraints. It was therefore decided to make a commitment to ARGOS NT rather than to RODOS. As links existed between the RODOS and ARGOS NT communities, and future developments and extensions to ARGOS NT would incorporate programmes used in RODOS, we remained members of RUG. We could therefore continue to contribute to the discussions on the needs of users of such systems, and their use in emergency planning.

We are currently finalising contractual terms for the use of ARGOS NT and arranging for the transfer of HIRLAM data to the Institute from the national meteorological service. ARGOS NT will be commissioned and operated by staff at our Institute.

In the absence of a fully functional DSS, our participation in the RUG exercise was somewhat limited. However our participation has been very useful and highlighted areas that need to be addressed in regard to how such DSSs would be used in an emergency. These would include the best format for presenting data to the decision makers and how much detail should they be given, especially in the case where a choice of options based on the probabilities of different release scenarios exist.

We will continue to keep in touch with the DSS community through attendance at relevant DSSNET meetings that are open to non-members of the concerted action group.

RIVM, the Netherlands

General

The Laboratory of Radiation Research (LSO) of the RIVM was the Dutch representative in the RUG. The national emergency information centre for nuclear accidents (IDC) as well as the management for the National Monitoring network for Radioactivity (NMR) are located at the institute. This centre supports the policy making process with information on all kinds of radiological measurements and model results and reports directly to a governmental management team.

The emergency management system that is currently in place at the IDC is some nine years old and is presently being upgraded. In this framework RIVM was and is interested in the possibilities of the RODOS system. Because of this we were first of all interested in installing the RODOS system at our institute for evaluation and testing. Implementation, as the Dutch nuclear emergency management system, may afterwards be considered. The RUG was and continues to be seen as a platform where not only information on problems but also on software developments can be exchanged. It was a growing source of "user knowledge".

Activities

As a member of the RUG concerted action at least one representative of RIVM participated in several of the RUG meetings. These meetings were important from the view of collecting information on RODOS and meeting people from other countries and institutes involved in the RODOS system.

Two courses on RODOS (early effects and countermeasures and late effects and countermeasures) were attended at FZK in November 1997 and April 1999.

In April 1998 we assisted NRG (Petten, the Netherlands) in organizing a Decision Conference in the Netherlands using the RODOS system for the intermediate phase, i.e. the phase where the cloud has passed by and where measurement results are just starting to come in. This meeting took place in The Hague, 27-28 May 1998, at the Ministry of the Environment. In preparation we visited FZK from 23-24 April 1998. The results of the Conference were reported by NRG (van Hienen et al., 1998).

Current status and future plans

Although we just recently joined the RODOS community we already have a series of installations behind us: March 2000 we received version 3.13, but that happened to be a 64-bit version (or 2.0 architecture) which at that time could not be installed on our machines. In the months that followed we received new hardware and were able to install the 64-bit version of RODOS that had evolved into version 3.16 by June 2000. In September 2000 version 4.0 was downloaded from the FZK site. Although we didn't yet fully take advantage of the earlier version, this new version was to be used in the last exercise of the RUG. Unfortunately this version had several unexplained crashes. As a result we are now, January 2001, at the brink of installing 4.0F, the ‘final’ version, and a hopefully more stable software version.

During the installation process and during the testing period we expected to gather a better understanding of the data sets and specific applications needed for a more permanent installation or even implementation in an operational emergency management system. However, because of the number of installations up till now, we have not yet succeeded in reaching this goal. This was mainly due to the fact that RODOS was too long ‘under development’. Hopefully this problem will be resolved in the near future, during the DSSNET programme.

Although the RUG now has come to an end, we will not abandon the RODOS system. We are now involved in DSSNET, the successor to the RUG. Furthermore, most of the data needed for an installation of RODOS are available at the RIVM. This refers to most of the geographical information on the Netherlands that is needed (topographical maps, population data, data on NPP’s, source terms, land use etc.). It might be that specific updates will be needed (for instance land use). Meteorological data has also to be converted to the specific needs of RODOS or its components. Because we use HIRLAM for our present long-range transport code, this should not be too big a problem. We therefore will proceed with the installation.

Our first concern now is to adapt the system to our needs, i.e.:

- connection to other databases (e.g. GIS data, laboratory data, meteorology data);
- producing data sets (resolution needed, possibilities of exporting RODOS data to GIS);
- management of data sets (update frequency, validation);
- possibilities of coupling with other systems (measurement networks, our own dispersion models, other computer systems, communication with and presentation at other locations other then that of the RODOS system e.g. through web pages).

National Atomic Energy Agency, Poland

General

IEA has been engaged in the RODOS project since 1994 through the PECO and INCO-Copernicus programmes under 3rd, 4th and 5th Framework Programmes of the European Union. In addition, the implementation of the RODOS system within the national emergency preparedness arrangements in Poland and the Slovak Republic has been progressed through a one year project (ECHO) set up for this purpose. RODOS version 3.13 has been installed and implemented in the Centre for Radiological Events (CEZAR) of the National Atomic Energy Agency (NAEA). IAE is responsible for providing the technical support to CEZAR and also for the customisation of the system to national conditions.

Current status

The RODOS v. 3.13 system is used as a non-official tool at CEZAR and is operated on a cluster of 2 servers (HP R/390). The readily available software "Service Guard" from HP was installed to provide continuous operation of the system in the event of a failure of one of the servers. The communication lines between CEZAR and the Institute of Meteorology and Water Management (the national weather data provider), the Central Laboratory for Radiological Protection (responsible for radiological monitoring network based on PMS part of the ARGOS NT system) and the Institute of Atomic Energy (the location of the only Polish nuclear installations, in particular the research reactor MARIA) were established.

In the process of customisation of the RODOS system a particular emphases was put on the following activities:

- preparing numerical maps of different scales (from 1:10,000 for the area around IAE and up to 1:1,000,000 for the whole territory of Poland);
- collecting data for radio-ecological regions mainly for use in FDMT and LCMT modules;
- setting the parameters in the radio-ecological models for Polish conditions.

The process of customisation of the system to national conditions is not easy and demands great efforts. It has been recently decided by FZK to prepare a special document on all procedures relating to this problem.

The RODOS system was successfully tested in accordance with the test procedures developed by FZK. The system was also verified in operational mode i.e. with on-line real-time data delivered to the system. Because of the lack of some data, a special procedure was prepared to produce artificial data to simulate the real conditions.

RODOS operating procedures for use in emergency and normal situations were written for specific staff members of the CEZAR. Training courses based on material obtained from FZK and STUK were developed and organised for the operators and other users of the system.

The same version (3.13) has also been installed and implemented in IAE and can be used locally in the Swierk Centre.

The RODOS 4.0 beta version has been installed in IAE and the final 4.0 F version is being implemented at present. After implementation, this version will be also installed in CEZAR. The main problem in implementing the operation of the system is the lack of technical documentation describing how on-line, real-time data should be delivered to the system. According to FZK, such a document will be available soon, so it can be expected that at the end of the first quarter of 2001 the process of full implementation of RODOS v. 4.0 F in emergency centre should be completed.

Use

The RODOS 3.13 system was carefully tested and verified in real conditions i.e. with on-line connection to measurement data. As there is no nuclear plant in Poland the main area of interest lies in long range calculations, which will be available after the installation of RODOS version 4.0 F. The current system can be usefully employed for nuclear facilities, in particular the research reactor MARIA. A special exercise based on a simulated accident at the MARIA reactor has been developed. The aim of this exercise is to test RODOS capabilities in real conditions. The exercise is planned to take place in the near future.

On completion of the ECHO project the RODOS system was presented to local authorities. In this presentation all the important features of the system were shown using a simulated emergency situation at a fictitious nuclear plant located somewhere in Poland.

IAE and CEZAR participated also in the exercises developed by STUK as a part of RUG activities. As a result of the training courses organised within the ECHO project, the staff of CEZAR had only minor problems with the operation of the system. The system produced a lot of useful information. However there is still a need for decision-makers to be trained on the effective use of the data provided by the system, particularly in relation to mid- and long-term countermeasures. In these cases, many different possible countermeasures exist and it's not easy to select the optimal strategy. The other point is that up to now a comprehensive tool such as RODOS has not been available for the staff of the emergency centre. This means that appropriate training will play a key role in the future use of the system.

It would be also of great importance to organise exercises with on-line and real-time data supplied to the system. This unique feature of the RODOS system should be carefully verified and tested in a real situation. Up to now because of the lack of full technical description of the system it hasn't been possible to test all capabilities of the system.

Direccao Geral do Ambiente (DGA), Portugal

General

DGA is formally associated to the RODOS project since 1995 when an agreement was signed with the European Commission for the use of the software and the system. In October 1998 DGA joined RUG. In 1999 DGA and several European partners put forward a project (DSSNET) proposal to the EU 5th framework programme. This proposal was approved on October of 2000.

Current status

The RODOS PRTY 4.0 F version is now installed, and reconfiguration for the national environment is being performed. Several actions have been taken to configure the network, mainly firewall configuration and internal architecture.

It is now possible for FZK to remotely access the DGA machine. Due to the increasing requirements of the RODOS system on both hardware and software, the acquisition of a new machine is necessary.

The management of the national meteorological network is the responsibility of the Meteorology Institute (IM), which is also responsible for the analysis and forecast of the meteorological conditions in the Portuguese territories. Several products are now being supplied to DGA by the IM:

- wind direction and magnitude at sea level and at 850 hPa, with a 6 hours time sampling for a period of 72 hours and the accumulated precipitation every 12 hours for a period of 72 hours, for a 1 coverage of the area between 30 N and 40 N and between 20 W and 4 E;

- parameters indicating the height of the boundary layer, and an indicator of the stability, but only over an area between 35 N and 45 N of latitude and 10 W and 0 W of longitude with a spatial step of 0.5 degrees;

- real time data acquired from meteorological stations are available at 13 locations in the Portuguese territories, with a sampling time of 3 hours, consisting of magnitude and wind direction at the surface, air and dew point temperature and 1-hour accumulated precipitation. These stations are placed at the same locations of the automatic environmental radiological survey network (RADNET).

The 13 stations of the RADNET record continuously data on external gamma radiation (with an integration period of 1 minute). Integration of the radiological data with meteorological data has been completed.

The integration of on-line meteorological and radiological data with RODOS will be attempted in 2001. Customisation of the local network for the exchange of data between the RODOS system and the central units has been completed.

To customise RODOS to the Portuguese needs, geographical information has been compiled.

All the digitised maps at DGA are in SHAPE format. From these only the following were found relevant to this phase of the project: basin and runoff information, lakes and dams, major river maps, maps of major roads, railway network and location of the major urban centres.

Information on population density, urban occupation, full road network, land use and crops distribution are being processed at DGA.

Use

On January 1998, within the framework of the Portuguese-Spanish Agreement regarding the Safety of Border Nuclear Facilities between CSN (Consejo de Seguridad Nuclear) and DGA, an exercise involving a simulated accident in a nuclear ship off the north coast of Portugal took place. Consideration was only given to the early phase of the accident, and real meteorological conditions were used. The consequences of the accident were assessed by DGA using the RODOS system (version PTRY 3.0). Input meteorological files were constructed using the real forecast data provided by IM (Meteorological Institute) and the functionality of the pre-processing data programs was tested.

In July 1999 the first RUG exercise took place and simulated an accident at a NPP in a fictitious country. The assessment focused on the early phase of the accident and the near site consequences.

In November 2000 the second RUG exercise was undertaken. It simulated a severe accident at a NPP placed on national territory and the emphasis was primarily on late phase consequences.
The RODOS system was also applied in the development of a national response plan in case of a nuclear submarine accident at Lisbon harbour.

In all these exercises, but mainly following the RUG comparison exercises, the conclusions were relayed to the developers and several improvements to the system followed.

Future plans

- the updating of the system with the new revised versions delivered by the development team;

- completion of the customisation of the system with local specific data;

- training on the operation of the RODOS interface during emergency exercises;
- use of the system in the training of experts from the institutions potentially involved on decision making and/or decision advising in case of nuclear emergencies in Portugal;
- maintaining communication with other system users in order to solve arising problems;
- customisation and configuration of the automatic mode of the RODOS system.

"Horia Hulubei" National Institute of Physics and Nuclear Engineering, Romania

Activities

The main activities of our RODOS related research programs in the period October 1999 to November 2000 have been:

- to evaluate the consequences and the associated risk of tritium emission at the Cernavoda CANDU-NPP in both normal operation and nuclear emergencies/accidents;
- to model tritium deposition from the atmosphere onto the soil, its transport into deeper soil layers and the resulting depth distribution; also tritium re-emission from the soil to the atmosphere;
- to develop a dose assessment model with the objective of routinely controlling, without underestimating the dose, the emission of tritiated water into the atmosphere;
- to create an FDMH database for the southern area of Romania and to test the sub-modules of FDMH together with the improved modelling of the tritium transfer in animal products (from feeds, breathing and water);

- to develop and install software for a set of models that address the radioactive contamination both of surface (swallow) waters and underground waters;

- to provide additional/supplementary on-line and real-time data from met-towers and radiological data from the Cernavoda CANDU-NPP;

- to co-operate with NRG-KEMA group (The Netherlands) regarding installation of RODOS PRTY 3.13 on their computer, the testing of the latest version (February 2000) of HYDRO-RODOS and LAKEKO-A & LAKEKO-B model validation for Northern Europe lakes;

- to adapt RODSO PRTY 3.13 (received at the end of 1999) to Romanian conditions and fully integrate the FDMH module.

Current status

The installation of RODOS PV 4.0 (beta) in Romania is aimed at following objectives:

- to test the compatibility of the Romanian geographic and radio-ecological databases with the new RODOS prototype version. The scenario from RUG's second joint exercise was used for this purpose;

- to check that all code contained in RODOS PV 4.0 is compatible with our already five years old HP 9000/735 workstation;

- to verify that FDMH operates correctly with the Romanian database;

- to revise the CANDU source term files, following the requirements of the new RODOS version, in order to account for 7 instead of 3 radionuclide groups;

- to clarify how tritium will be used in RODOS version and how it will be inserted in the CANDU source term database.

The RODOS system currently runs properly when used in the interactive mode option for early phase prognosis. But we encountered problems in using FDMT and LCMT and it cannot be operated in real-time based on our on-line meteorological data.

The Romanian RODOS team has presented the hardware and software requirements for a RODOS system installation in a Nuclear Emergency Center to the state authorities. At the same time, IFIN-HH advised the Central Commission for Nuclear Accident and Falling of Extra-Atmospheric Objects (CCANCOC) to include in its general annual plan of activities the installation of the RODOS system in the Emergency Centre. This should include the training of the personnel in the use of the RODOS system, with the assistance of our institute specialists.

VUJE Trnava Inc. – Engineering, Design and Research Organisation, The Slovak Republic

General

VUJE Trnava Inc. has been largely involved in development and implementation of comprehensive decision support system RODOS under the RODOS R&D and Thematic Network projects within the 3rd, 4th and 5th Framework Programmes. With support from the European Commission's ECHO programme RODOS PV 3.13 was implemented in the Slovak Republic. The RODOS system was installed for use within the emergency arrangements in a "pre-operational" capacity.

Current status

All pre-conditions from computer hardware and communication links to procedures for normal and emergency operation and training of operators and users for the operation of the national RODOS centre were established in one year during the period of 1999-2000. Within the project, RODOS was adapted to country specific conditions.

Institutions and their role within the projects for RODOS implementation in the Slovak Republic are as follows:

- Nuclear Regulatory Authority of the Slovak Republic (NRA SR): National RODOS Centre;

- Slovak Centre for Radiation Monitoring (SCRM): radiation monitoring and measuring systems; passive user, data supplier;

- VUJE Trnava Inc.: Technical Support Organisation; interactive user;

- Slovak Hydro-Meteorological Institute (SHMI): real-time meteorological monitoring data, providing access to the national radiation monitoring network (NRIS) and to WMO; passive user, data supplier;

- NPP EBO Jaslovske Bohunice: plant radiation monitoring system, source term data; passive user, data supplier;

- NPP EMO Mochovce: plant radiation monitoring system, source term data; passive user, data supplier.

The equipment is based on a cluster of 2 servers (HP type R 390) installed at the Emergency Response Centre (ERC) of NRA SR. The communication links necessary for the functions of RODOS in Slovakia are established. Passive users and data providers are SCRM and SHMI in Bratislava, as well as two NPP sites (Bohunice and Mochovce). VUJE is an interactive user.

The RODOS installation was adapted to country specific local conditions. This work included mapping data of land use, build-up areas, traffic networks, borderlines of regions and other geographical data; statistical data on grids such as population distribution, radioecological region number, agricultural production data, soil type, elevation data, hydrological data; data for radioecological regions; site and plant characteristics for the Slovak NPPs; emergency management data for early emergency actions and intermediate/late countermeasures. Real-time on-line radiological and meteorological data interfaces are under development.

The testing of the RODOS installation on all remote locations, as well as testing of integral operation of RODOS system with all remote users using communication links were performed according to the test procedures developed by FZK.

The development of the operational procedures for the national RODOS centre was performed by VUJE. The procedures cover all operational phases and all interfaces. The procedures were written for different tasks identified as necessary for operating the RODOS centre. The task related approach in the Nuclear Regulatory Authority of the Slovak Republic fits better in existing emergency preparedness arrangements. Operational procedures were additionally tested in “real“ situation during training courses.

The training was developed and performed by VUJE for operators and users of the RODOS system. Lessons learned were summarised, described in more details with each individual task and presented to the RUG participants during the Rhodes, Brussels and Prague Meetings.

RODOS PRTY 4.0 was installed in VUJE and adapted to local conditions. At present, RODOS PV 4.0F is being implemented.

Use

The RUG members from the Slovak Republic, namely VUJE and NRA SR participated in the second joint exercise of the RUG. RODOS PRTY 4.0 adapted to the Slovak conditions was used for the simulation of a severe accident in Bohunice V-2 NPP.

Slovenian Nuclear Safety Administration, Slovenia

In June 2000 a meeting was held between the Slovenian Nuclear Safety Administration, potential beneficiary, Hydrometeorological Institute, data provider, and Jozef Stefan Institute, potential subcontractor, to present to them the characteristics of the RODOS system and highlights of the terms of reference (TOR) for the RODOS contract. In November and December 2000 the general TORs proposal was customised for Slovenia (i.e. determination of users, layout of the communication network was proposed, equipment needs were specified, and a list of potential subcontractors was proposed). In December 2000 two participants from Slovenia were sent to RODOS Operators Course to FZK, Karlsruhe. On 13 December 2000, FZK, and EU, visited Slovenia and gave a presentation on the RODOS system to all potential users in Slovenia: Slovenian Nuclear Safety Administration, Hydrometeorological Institute, Civil Protection Administration and the Krško NPP, the representatives of Jozef Stefan Institute and Ministry of Agriculture, Forestry and Food also attended the presentation. On the occasion of this visit the parameters for RODOS TOR were discussed with the representatives of the Slovenian Nuclear Safety Administration, FZK and EU.

Consejo de Seguridad Nuclear (CSN), Spain

General

The Consejo de Seguridad Nuclear (CSN) is the Spanish nuclear and radiological safety authority. Apart from those functions related to the licensing and controlling the nuclear and radioactive facilities, CSN has assigned some important responsibilities and functions in emergency planning and preparedness and during emergency situations. The main functions of CSN in emergency situations are as follows:

- CSN participates in the formulation and approval of nuclear and radiological emergency plans;

- CSN provides technical support to the authorities in the event of a nuclear or radiation emergency. This technical support relates to nuclear safety and radiation protection matters. CSN has to make a diagnosis and prognosis of the operational status of the affected facility and of the off-site radiological consequences. It formally proposes countermeasures intended to protect the public;

- CSN surveys and monitors environmental radiation levels both around the facilities and the countrywide, in normal and in emergency situations;

- CSN monitors the radiation doses that workers and the members of the public may receive;

- CSN is, in general, responsible for the execution of actions and interventions related to its specific missions (nuclear safety and radiological protection) and is supported by other national bodies (Ciemat, Enresa, and National Institute of Meteorology).

CSN has an Emergency Centre, called SALEM, which is staffed continuously by specialised engineers. This centre constantly receives information in electronic formats on nuclear power plant operations and on environmental radioactivity parameters. This on-line information includes the following data:

- safety parameters of each nuclear reactor in the country. SALEM has duplicated connections to the process computer of each reactor;
- real time local meteorological data. SALEM is connected to the NPP's meteorological towers;
- national meteorological data and forecast from the National Meteorological Service (Instituto Nacional de Meteorología, INM). SALEM has a connection to the INM process and forecast computer. Spanish Meteorological Service receives HIRLAM data;

SALEM centre has direct access to the main on-line radiological networks of Spain. The CSN monitoring network, called REVIRA, has its control centre in the SALEM. This centre has also access to the monitoring networks of some regional governments. The REVIRA control centre is connected to more than 40 stations, where gamma dose rate and the air concentrations (alpha, beta, Rn and I-131) are monitored. Additionally, the Salem is connected to the Spanish Radioactivity Alert Network comprising of more than 900 gamma dose rate monitoring stations nation-wide.

That on-line information is complemented by the direct information received from the NPP operators. SALEM has redundant communication systems to connect to the facilities, authorities and other emergency operation centres. Finally, SALEM is provided with complex calculation systems to process all the information coming to the centre. These help to determine the status and evolution of the events at the NPP, the atmospheric dispersion and the radiological consequences of a radioactive release.

CSN decided to use RODOS in the SALEM centre as an additional tool to support its functions in emergency situations.

Current status and future plans

In October 1998 CSN signed a formal agreement with FZK, the representative of the RODOS Consortium, on the use of the RODOS system. In April 1999 CSN joined the RUG Concerted Action. Currently, CSN is participating in the DSSNET project of the Commission with other RODOS users as partners. The formal agreement on DSSNET was signed by CSN in November 2000.

In February 1999 CSN installed a pre-operational version of RODOS on a new server (HP server, PA-8200, 256 MB RAM memory, 18 GB disk memory) at its computer centre. At SALEM two X-terminals were installed which allowed a connection to the RODOS system. The system was updated whenever a new version of RODOS was released. Currently RODOS PRTY 4.0 is installed. We plan to install the RODOS version PV 4.0 F in the coming weeks.

The current RODOS system available at CSN is not yet customised to Spanish conditions (national model for emergency management and local and national databases). Some other priorities have precluded the required development of these subjects. Recently CSN has determined a project to internally co-ordinate the development of the CSN RODOS system. This project includes the participation of experts of various CSN departments: Radiological Protection, Emergency Planning and Computers. We intent to determine a two years plan in order to reach a satisfactory development of the project. This plan will include:

- the installation of a new GIS at SALEM, to serve RODOS and other support systems, and integration of required fixed databases;
- the connection of some on-line databases (radiological, meteorological) which are accessible at SALEM. We will start connecting NPP local meteorological stations, and then we will extend the connection to other meteorological and radiological monitoring systems;
- determining the interface between RODOS and other SALEM systems. Mainly, we intent to connect RODOS to the plant analysers systems (these systems, currently available at SALEM, permit the evaluation of the operational status and the calculation and forecast of source terms);
- participation in emergency exercises both at national and international levels, including those defined in DSSNET project;
- training of operators and system management specialists. Some operators received training in the use of RODOS in courses organised by FZK in the past. A staff member of CSN attended the course on RODOS in FZK in

November 2000. Some others will attend the courses to be held in March and in the autumn of 2001.

Use

In July 1999 CSN participated in the first RUG benchmark exercise. This exercise focused on the first (urgent and intermediate) phases of an emergency and on the near range. Unfortunately, the RODOS system at CSN was not fully operational at the time of the exercise and it was no possible to make calculations. Nevertheless we used the generic calculations provided by STUK and combined them with the Spanish national model for nuclear emergencies (planing zones for automatic countermeasures, specific intervention levels). Graphical presentations, i.e. iso-dose curves, could be made with RODOS as its Graphics Server was working. Conclusions of this exercise were presented during the RUG meeting that was held in Rhodes in September 1999, and are also included in the RUG report of the first benchmarking exercise (Ammann et al., 1999). They primarily concerned the ability of RODOS to support decision-makers in nuclear emergencies, but also some improvements to the RODOS software were suggested.

Unfortunately, it was not possible for CSN to participate in the second RUG benchmark exercise.

4 DISCUSSION

To achieve the objectives set out in chapter 2, RUG established a WWW homepage, planned and jointly performed two comparison exercises and organised four meetings for RODOS users.

Technically, the Web page operated very well. State-of-the-art Internet technology provided an efficient communication channel at low cost. It was easy to make announcements and discuss unresolved issues (*discussion forum*) and to store and retrieve any kind of information in arbitrary formats (*document archive*). The page was intended to replace, whenever beneficial, mutual e-mail communications with an open discussion forum. But apparently there was a barrier to overcome in regard to publicly discussing unresolved issues and members of RUG stuck to traditional means of communication. On the other hand, it is obvious that such a page needs a relatively frequent update and a lively discussion in order to be revisited, i.e. there must be a critical mass of subscribers in order to succeed. Because of the rather small membership base of the RUG, this was hard to achieve. Furthermore, the RODOS project maintained a Web page and, being the page of the relevant R&D community, this was considered the page for 'first-hand-information'. Therefore it is recommended that only one central page for dependant projects be maintained and that it should be frequently updated.

The main objectives of the jointly performed exercises were achieved. The accident scenarios, applied methods and settings of the exercises can be utilised in future exercises, provided that they are critically revised and modified to suit the objectives. A common scenario proved to be an appropriate means of highlighting issues that needed to be discussed between users and developers. Secondly, jointly performed exercises stimulated the users to share their operational knowledge of RODOS.

Operating RODOS while preparing for and during an exercise stimulates and motivates the end users to maintain and further develop DSSs. It also maintains activity in the field of emergency preparedness. In order to ensure the necessary commitment of the participants, it is important that exercises are as realistic as possible. However, the planning, organisation and implementation of such exercises are time consuming, laborious and expensive. It is therefore very important that the maximum benefit is achieved from such exercises. The experience from the RUG exercises suggests that the following points need to be considered in greater depth before future exercises are undertaken. When designing the accident scenario, performing the exercise and assessing the results the use of analytical evaluation methods could be better employed, e.g., prescriptive and descriptive decision analysis techniques. The writing of scientific reports that document various aspects of the exercises could also enhance the benefits derived from them. It would be useful in this context to formulate a framework that could provide scientific levels of merits and guarantee the full documentation of the work and effort invested. To reduce the workload in designing exercises for RODOS, all opportunities to use RODOS in international exercises should be taken and the results could be analysed at RODOS or DSSNET meetings. The inclusion of directors and other high-ranking officials in the exercises would provide an additional stimulus.

To maintain motivation and know-how in the field of emergency preparedness it is essential that users can contribute to the development of models used in DSSs, and whenever possible, participate in R&D work. Users with expertise and responsibility in the field of emergency management have to be familiar with the relevant models of the supporting DSS. They have also to be aware of the level of reliability of the calculated results and the limits and conditions applying to the model predictions. Models should be as simple as possible while still retaining their suitability for emergency management or research. A DSS must also be as flexible as possible, since organisation and national procedures of emergency management vary from countries to country.

Throughout the period of the project, a number of key areas were addressed. Many of these actions were initiated by RUG and will continue during the DSSNET project:

- a survey on the possibility of obtaining numerical weather prediction data at an European level for use within RODOS was carried out. The results indicated that different data formats, models, national terms, etc. exist between countries;

- an initiative to collect 'neighbouring' NPP data (type, construction, inventory/thermal energy);

- an initiative to list errors and proposals for improvements at the RODOS homepage;
- an initiative to support training courses and to provide miscellaneous technical support etc.

To keep DSSs operational, there is a need for continuous on-going development. This is emphasised by the rapid developments occurring in the field of Information Technology. One important development would be the extension of RODOS to include a standardised query language interface (e.g. SQL) and a facility to use commercial geographic information systems (GIS).

Comprehensive real-time decision support systems like RODOS are recent additions in the field of emergency management of nuclear accidents. To date there is not much experience of the type of information they should supply or the format to be used. Nuclear accidents occur infrequently and unexpectedly. No two accidents are likely to be the same in regard to their consequences and public reaction. A flexible and dynamic query interface is therefore required to cope with this variability. For example, the assessment of contamination through a particular pathway or a selection of pathways may be required; or from a specific nuclide or a selection of nuclides. Assessments may be requested to cover a specific time period, for a specific organ, age group etc. Thus, it might be easier to define the content and form of the calculation database within RODOS and to have an interactive SQL interface to provide the results for these numerous and variable queries. To try and foresee all possible combinations of assessment requests and to provide static selections for all of these may prove too difficult.

There are software systems in operation and under development in end user organisations that manage (store, retrieve, etc) measurement data and other data with spatial information, e.g. demographic and product data, in relational database management systems (RDBMS). Such systems include Spatial WARE systems to present the data on maps. It would be clearly advantageous to have a standardised interface to such systems.

The Graphics System of RODOS provides only the most basic tools for display and data analysis. For more advanced tasks data has to be exported to a full featured GIS. To our knowledge, only a rather rudimentary method is available at the moment to export calculated results, i.e. graphical output data can be dumped to text files and imported, after some filtering, by another GIS. There is certainly a need to improve and 'standardise' the interface to a third party GIS.

Many of the 'shortcomings' and difficulties experienced in the work of the RUG were due to the fact that the project was initiated at a rather immature development stage of the RODOS software. This caused some extra work and delay. Nevertheless it brought together, for the first time, the users and developers, which was a rewarding experience for both. The developers received the feedback they needed for the achievement of their goal, i.e. providing a system that is fit for use in emergency centres. The users got demonstrations of the latest additional features to the system, experience in using them and a formal means of providing their comments on the system to the developers.

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