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Biologie, sciences de la terre et protection de l'environnement

RAPPORT D'AVANCEMENT DU PROJET EUROPEEN RODOS "DEVELOPPEMENT DU SYSTEME". PERIODE DU 1ER SEPTEMBRE 1992 AU 31 AOUT 1993

PROGRESS REPORT OF THE CEC PROJECT RODOS "SYSTEM DEVELOPMENT". PERIOD : 1 SEPTEMBER 92-31 AUGUST 93

95NV00023

EDF Electricité de France

Direction des Etudes et Recherches

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SERVICE APPLICATIONS DE L'ELECTRICITÉ ET ENVIRONNEMENT
Département Environnement

1994

MARCHAND O.

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Diffusion : J.-M. Lecœuvre
EDF-DER
Service IPN. Département SID
1, avenue du Général-de-Gaulle
92141 Clamart Cedex

ISSN 1161-0573

SYNTHÈSE :

Dans le cadre du programme européen "Radioprotection", le projet RODOS (Real-time On-line DecisiOn Support system) a pour but la mise au point d'un système d'aide à la décision en cas d'alerte nucléaire.

Le projet RODOS regroupe 22 laboratoires répartis dans 4 sous-projets : "Météorologie et Dispersion Atmosphérique", "Développement du Système", "Techniques d'Aide à la Décision". Le quatrième sous-projet se situe dans l'accord de coopération entre la CCE et la CEI.

EDF intervient dans le sous-projet "Développement du Système" et travaille notamment, au sein d'un sous-groupe de "Formation", à la mise au point d'un cours construit autour du système RODOS. Ce cours s'adressera aux responsables chargés d'évaluer la situation en cas d'alerte nucléaire.

Cette note reproduit le rapport d'avancement du sous-projet "Développement du Système", pour la période septembre 1992 - août 1993. Durant cette période, les travaux ont porté sur :

- le développement de méthodes d'assimilation de données, comportant à la fois des mesures et des prévisions numériques. Le but est d'obtenir une vision cohérente du terme source et de la contamination de l'environnement ;

- des améliorations des modèles de dispersion et de dépôts atmosphériques ATSTEP-CORA, du modèle de simulation des actions de confinement et d'évacuation de la population EMERSIM, de transfert dans la chaîne alimentaire et de calcul de doses ECOAMOR et du modèle de simulation de contre-mesures dans le domaine agricole FRODO ;

- les spécifications du stage de formation qui utilisera RODOS comme support ;

- l'extension des fonctionnalités du système d'exploitation de RODOS (OSY) et en particulier de RoGIS, son Système d'Information Géographique.

EXECUTIVE SUMMARY :

Within the context of the Radioprotection program of the CEC, the RODOS project (Real-time On-line DecisiOn Support system) aims at the development of a decision support system for nuclear emergencies.

RODOS involves 22 research teams, divided in 4 subprojects : "Meteorology and Atmospheric Dispersion", "System Development", "Decision Aiding Techniques". The fourth subproject is a Joint Study Project of the Agreement between CEC ad the CIS republics.

EDF is working in the "System Development" subproject and namely in the "training" group. This group aims at the creation of a specific training course for health physics managers, based on RODOS.

This note reproduces the progress report of the "Development System" project. The reporting period is : September 92 - August 93. Progress has been made within the reporting period in the :

- development of data assimilation methods incorporating both monitoring data and model predictions for obtaining consistent pictures of the environmental contamination and the source term ;

- improvement and extension of the modules ATSTEP-CORA (atmospheric dispersion and deposition), EMERSIM (simulation of emergency actions), ECOAMOR (exposure pathways and dose calculation) and FRODO (simulation of relocation and agricultural countermeasures) ;

- preparation of training courses using RODOS as illustrative tool ;

- extension of the functions of the RODOS operating system OSY, in particular of RoGIS, its geographical information system.

SOMMAIRE

Progress Report

Contract:

Development of a comprehensive decision support system for nuclear emergencies in Europe following an accidental release to atmosphere.

1)	Ehrhardt	KFK
2)	Gland	EDF
3)	Müller	GSF
4)	French	Univ. Leeds
5)	Sohier	CEN/SCK Mol
6)	Haywood	NRPB
7)	Bleasdale	Nuclear Electric

I. Summary of Project Global Objectives and Achievements

The main aim of the project is the development of RODOS, an integrated and comprehensive real-time on-line decision support system for nuclear emergencies in Europe. The system will be able to make consistent predictions from the vicinity of the release in the early phase of an accident to far distant areas and at later stages unperturbed by national boundaries. It will integrate methods, models and data which allow the continuously updated estimation of the present and future distribution of activity concentrations in the environment, which offer the possibility to simulate different intervention strategies for all kinds of countermeasures in order to assess in advance their respective merits and disadvantages in terms of dose or health effects saved and the associated social and economic costs, and which enable intervention strategies to be ranked in terms of their effectiveness, practicability and acceptance.

Within the first phase of the project, the overall structure and the hardware and software framework of RODOS have been developed as a transportable package, which supports the integration of external programs provided by the contractors. The first prototype version RODOS-PRTY 1.0 has been realised in autumn 1992 and presented internationally at several conferences to the radiation protection community. It already showed its basic functions and graphical output, however still limited in its spacial and temporal applicability.

Main objective of the present contract period is to further develop the software framework, to improve and extent the programs and data bases provided by the contractors, and to integrate the software in the version RODOS-PRTY 2.0 scheduled for mid 1995. This version will show the full functionality of the design specifications and will serve as the basis for the first pilot-version for operational use.

Progress has been made within the reporting period in the

- development of data assimilation methods incorporating both monitoring data and model predictions for obtaining consistent pictures of the environmental contamination and the source term (Univ. of Leeds, SCK/CEN Mol),
- improvement and extension of the modules ATSTEP-CORA (atmospheric dispersion and deposition; KfK), EMERSIM (simulation of emergency actions; KfK), ECOAMOR (exposure pathways and dose calculation;GSF), and FRODO (simulation of relocation and agricultural countermeasures; NRPB),
- preparation of training courses using RODOS as illustrative tool (NE, EdF, KFK),
- extension of the functions of the RODOS operating system OSY, in particular of RoGIS, its geographical information system (KfK).

Head of project 1: Dr. J. Ehrhardt

II Objectives for the reporting period

The overall project objective is the further development of RODOS-PRTY 1.0 to an operational flexible system applicable in West and East European countries. A second prototype version with full functionality is scheduled for mid 1995. To achieve this goal, KfK work is concentrated on the following topics:

(1) further development of the hardware and software framework including the functions of the geographical information system RoGIS;

(2) incorporation of software products and data provided by the contractors, test of their functions, and generation of the appropriate user interfaces, in close cooperation with the developers;

(3) further development of modules and data bases for simulating emergency actions and estimating economic costs and health effects;

(4) on-line connection of the system with radiological and meteorological information networks and processing of data;

(5) preparation of systematic course material together with illustrative scenarios for training and exercises.

III. Objectives for the next reporting period

The goals set out for the reporting period cannot be achieved within one project year. Therefore work on the topics (1) to (5) listed above will continue in the next reporting period with priorities determined by the availability of software and material provided by the other contractors.

IV. Progress achieved including publications

1. System development

Within the framework of the Commission's Radiation Protection Research Action, KfK has prepared in autumn 1992 the first prototype version RODOS-PRTY 1.0; it was demonstrated during international conferences /1,2/ and national radiation protection committee meetings. It reflects the objectives, key features and structures described in the design study and the hardware and software framework documents broadly agreed by the contractors. In particular, the RODOS operating system OSY has been developed in the programming language C as a portable package to run with a UNIX operation system, and X-Window user interface with OSF/MOTIF extensions. The data management is based on SQL standards.

Important sources of information for setting priorities in development plans will arise from the installation, use and test of RODOS-PRTY 1.0 in cooperating institutes. Ideas for extensions and improvements of models, data bases and endpoints will emerge which will help to progress towards a broadly accepted system for operational use. Therefore, a first training course for future RODOS developers has been organized at KfK from 21 June to 30 June 1993. 9 Participants from institutes involved in the RODOS project (Greece, Poland) and the associated Joint Study Project 1 (JSP1) of the CEC/CIS Joint Programme on the Consequences of the Chernobyl Accident (Russia, Ukraine, Belorus) attended the course. Copies of RODOS-PRTY 1.0 will be transferred and installed in these institutes in the second half of 1993 and the first half of 1994.

Using the experience gained during the RODOS demonstrations and the training course, the following improvements of the software framework (operating system OSY) have been made during the reporting period and partially incorporated in the prototype version PRTY 1.0, ready for release by September 1993:

- implementation of a communication server on the basis of TCP/IP-distributed computing network system for improving the interprocess communication;
- modification of the editors-user-interfaces taking into account comments of the participants at demonstrations;
- discussion, comparison and agreement on the data base management system (INGRES) and the graphics system (PHIGS) for RODOS; investigation of coupling facilities for on-line operation of RODOS;
- development of the design of RoGIS, the geographical information system of RODOS; test and implementation of basic structures;
- preparation of proposals for the layout of and the guidelines for the future RODOS documentation as recommendation for the contractors.

2. External programs

The subsystems ASY (analysing subsystem) and CSY (countermeasure subsystem) of RODOS-PRTY 1.0 contain first versions of the modules ECOAMOR and FRODO from GSF and NRPB, respectively, and the complete RESY-software from KfK /3/. It comprises the modules ATSTEP-CORA (near-range atmospheric dispersion and deposition), EMERSIM (emergency actions) together with subroutines for calculating doses, HEALTH and ECONOM (health effects and economic costs). The revised structure of ASY and CSY together with the modules for assessing consequences and countermeasures is shown in Figs. 1,2. The PAD, MCF and RIMPUFF software will be developed within the associated contract FI3P-CT92-0044 on meteorology and atmospheric dispersion.

Within the contract period, the following improvements have been made in the modules ATSTEP-CORA and EMERSIM:

- dynamic grid size for selecting arbitrary calculation areas;
- flexible input of spacial and temporal variable rain fields and of the timing of emergency actions;
- test of the "windfield"-option in ATSTEP allowing for dispersion calculations allong forecasted meteorological fields;
- development of the methodology and the structure of the simulation module EVSIM for calculating evacuation routes and times; coding of a first demonstration version.

In parallel to the further development of the RODOS system and the external programs, work at KfK together with EdF, Nuclear Electric and SCK/CEN Mol aimed at the application of RODOS for training and in exercises. During two meetings an agreement was reached on the type, content and working programme of a training course for health physics managers, taylored to the functions and possibilities of RODOS. By the beginning of 1994, the detailed structure and teaching programme of the course including illustrative scenarios and the requirements on the RODOS system (endpoints, graphics) will be finally discussed and fixed.

3. Coordination

At the beginning of 1993, the Commission's Services established the RODOS Management Group (RMG) to assist them in the overall management and coordination of the second phase of the RODOS project. The first meeting of the RMG has been held at KfK on 17 February 1993.

As agreed during this meeting, periodic RODOS newsletters will be issued in three to four month time intervals. They will help to establish an effective communication between all RODOS contractors. The RODOS newsletters will be prepared by

KfK with support of the coordinators of the subprojects and with input from the CEC and the contractors. The first issue was distributed in May 1993.

In order to coordinate work of software developers, several meetings were organized at KfK within the reporting period:

- Further development of ASY, CSY and ESY modules, 10 -12 February 1993 (NRPB, GSF, CEA, KfK);
- System hardware and software structures, 18 Feburary 1993 (ICSTM, Univ. of Leeds, KfK);
- Meteorology and atmospheric dispersion, 24 - 25 February 1993 (Democritos, ENEA, EdF, GRS, RISØ, KfK);
- Coordination meeting with CYFRONET (Poland), 11 - 12 March 1993.

A formal registration procedure for all RODOS documents has been established retroactive from 1 February 1993. The document registration and the issue of document numbers is under the control of the respective coordinators. A copy of any document is held at KfK as the central depository for all RODOS documentations.

Besides the existing close cooperation with the contractors of the projects FI3P-CT92-0044 and FI3P-CT92-0013b, a direct link exists to the Joint Study Project 1 (JSP1) of the CEC/CIS Joint Programme on the Consequences of the Chernobyl accident, in which at present KfK is also acting as coordinator.

Publications

[1] J. Ehrhardt, J. Päsler-Sauer, O. Schüle, G. Benz, M. Rafat, J. Richter
Development of RODOS, a comprehensive decision support system for nuclear emergencies in Europe,
3rd International Workshop on real-time computing of the environmental consequences of an accidental release to atmosphere from nuclear installation,
25 - 30 October 1992, Schloß Elmau, Bavaria, to be published in Radiation Protection Dosimetry

[2] J. Ehrhardt, F. Fischer, J. Päsler-Sauer, O, Schüle, G. Benz, M. Rafat
RODOS and RESY: two integrated real-time on-line decision support systems for nuclear emergencies
Proceeding of the Joint International Conference on Mathematical Methods and Supercomputing in Nuclear Applications M&C + SNA, 19 - 23 April 1993, Karlsruhe, Germany, Vol. I. p. 319 - 330

[3] J. Päsler-Sauer
Assessment and evaluation of early countermeasures and consequences in RODOS/RESY
3rd International Workshop on real-time computing of the environmental consequences of an accidental release to atmosphere from nuclear installation,
25 - 30 October 1992, Schloß Elmau, Bavaria, to be published in Radiation Protection Dosimetry

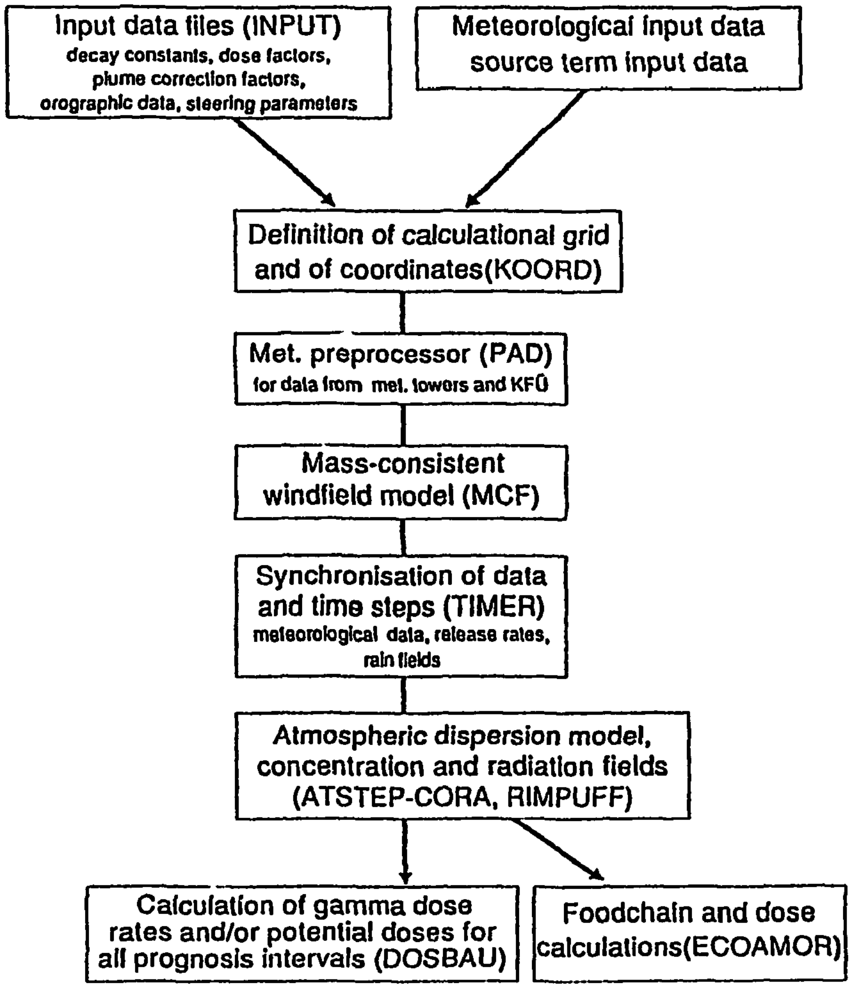

Fig. 1: RODOS-PRTY 1.0: Structure of the analysing subsystem ASY

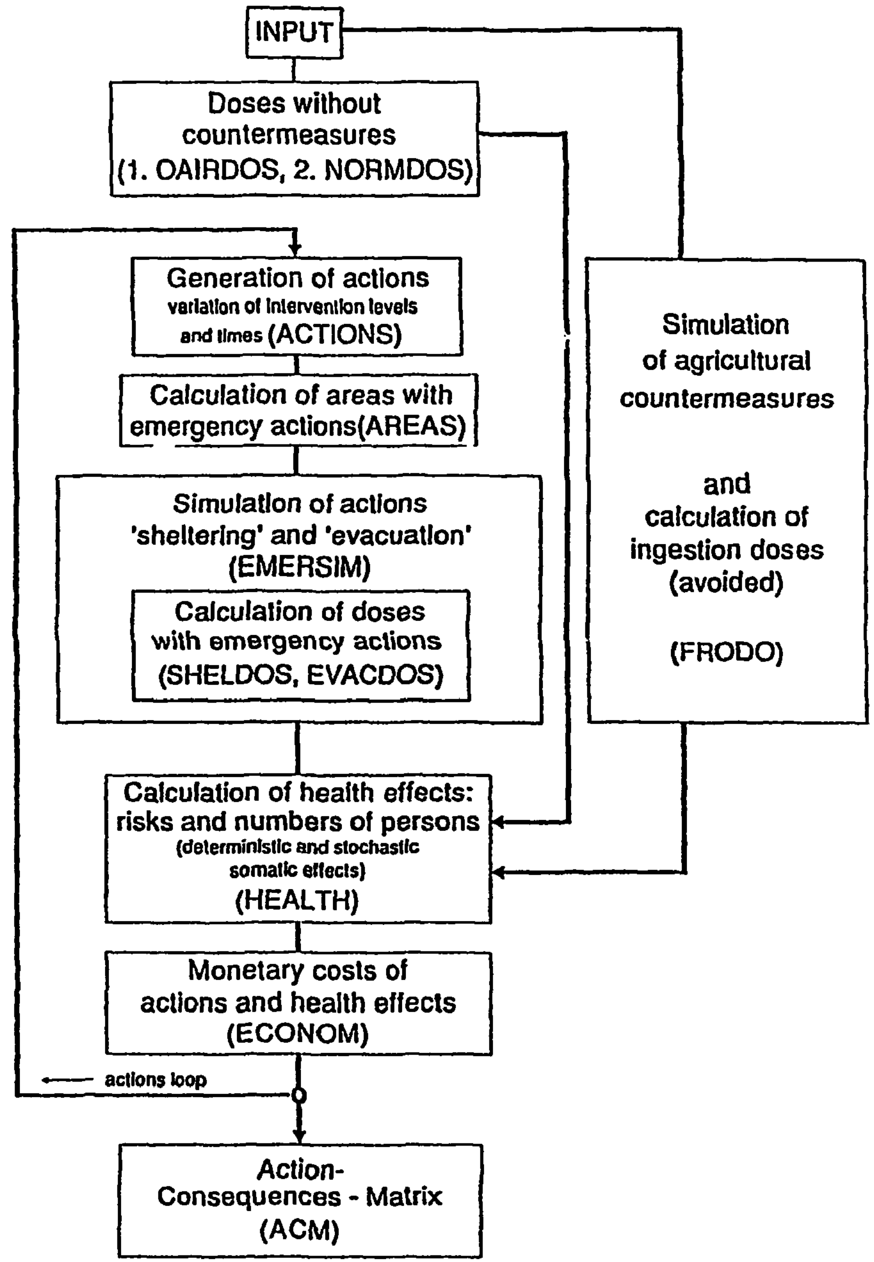

Fig.2: RODOS-PRTY 1.0:Structure of the countermeasure subsystem CSY

Head of project 2: Mr Gland

II. Objectives for the reporting period

EDF, operator of 56 power reactors, has implemented a structure to manage accident situations and has developed models designed to estimate the consequences of radioactive releases.

Within this context, EDF contributes to the development of RODOS by bringing its experience in implementing a crisis structure, in emergency training and excercising and in operating meteorological and atmospheric dispersion models.

III. Progress achieved

Mainly, EdF worked within the subgroup "training". The other participants to this subgroup are KfK, Nuclear Electric and SCK/CEN Mol.

A first meeting was held at KfK in September 1992. According to the decisions taken during this meeting, we gathered informations about the training courses dealing with radiation protection held at EDF. We made a detailed review of three of them.

The first one is a general radiation protection course. It addresses to engineers working at nuclear plant and/or involved in nuclear safety. It covers basic elements such as biological effects of radiation or general safety principles, and more specific ones such as radioactive releases or local and national EDF crisis organization.

The two other courses concern the local EDF crisis organization managers, namely our Health Physics managers and our decision makers.

EDF has organized the second meeting of the subgroup "training" (6-7 April 1993). At the end of this meeting, the participants agreed to develop a specific RODOS training course for Health Physics Managers as described in our own course. Seven course modules have been defined.

EDF will participate in the development of 3 of these modules:

- to outline the basis of potential accident scenarios and source terms (with support of Nuclear Electric),

- to describe the basic effects of meteorology and atmospheric dispersion on contamination patterns (with SCK/CEN Mol as leading institution),
- to develop monitoring strategies (with SCK/CEN Mol and Nuclear Electric).

The objective is to present the draft structure and content of each of these modules during the next meeting at Mol in November 1993.

We also participated at a RODOS coordination meeting on meteorology and atmoperic dispersion (KfK, 24-25 February 1993).

There, we have presented the concept of the ECRAN project. The aim of this research and development project was to provide real time and forecast estimates of the radiological consequences of a release, whatever the scale of the radioactive cloud dispersion. This project has been done between 1987 and 1989 and was presented at the 2nd international workshop on real-time computing of the environmental consequences of an accidental release to the atmopshere from a nuclear installation, Luxembourg, May 16-19, 1989. The concept of this project (meso scale forecast model using the results of the French Met. Office forecast model, local scale model using on line real-time meteorological data, ..) was very similar to RODOS.

Head of project 3: Dr. Müller

II. Objectives for the reporting period

The main aim for the reporting period was the further development of the modules for food chain transfer of radionuclides and for dose calculation in order to meet the requirements of the RODOS system in its prototype 2 version presently under development. In this field, the results of the modules to be presented to the user and the interfaces with other modules of the system had to be defined in detail to direct the program development to that goal. This requires close collaboration with those institutions (KfK, NRPB) who are developing the countermeasure modules for immediate and long-term actions.

In parallel to this the development of a methodology for providing information on the uncertainty of the results has been started by performing an uncertainty and sensitivity analysis for different radioecological scenarios.

III. Objectives for the next reporting period

The adaptation of the program modules according to the endpoints agreed has still to be performed rather intensively during the next working year. Several programs of the dose module have to be altered in a way that they can be used by different modules. In some parts this requires the development of an entirely new structure of the programs.

Two exposure pathways will be introduced in the dose module which have not been considered so far: inhalation by resuspended radioactive material, and external exposure from radionuclides deposited on the skin and on clothes.

The development of a methodology for providing uncertainty information will be continued but with less priority than the above tasks. In this area, an algorithm which allows to give some quick indication about the uncertainty of actual model results to the user of the RODOS system will be worked out.

IV. Progress achieved including publications

During the previous funding period, the module package ECOAMOR (ECOSYS ASY Modules for RODOS) which comprises a foodchain transport module and a dose module for the analysing subsystem (ASY) of RODOS was designed, developed and integrated into the prototype version 1 of RODOS. In this version, the calculations of specific activities in foodstuffs and ingestion doses were restricted to those pairs of nuclides and foodstuffs with the highest contribution to the ingestion dose in order to reduce calculation time and computer memory space. For the same reason the results were calculated only for a subgrid of up to 11 x 11 grid points (out of the atmospheric dispersion data grid with 41 x 41 grid points). Due to this reduction of grid points the graphical output of the ECOAMOR modules was felt to be unsatisfactory in its spatial resolution.

The program development in the reporting period was aimed to remove these shortcomings. Simply increasing the spatial dimensions of the modules leads to an enormous increase in the demand for storage space and computing time which is expected to exceed the limitations of a real time system with a cycle time of 10 minutes.

For this reason, another calculational approach for foodchain transport and ingestion dose had to be developed for ECOAMOR. In this approach, the calculation of specific activities in feeds and foodstuffs, the activity intake and the resulting ingestion dose is first performed for a normalized deposition onto the different types of deposition areas (i.e. the surface of different types of plants, and the soil). Then these normalized values are used to evaluate the specific activities and ingestion doses for a great number of locations.

This approach leads to a reduction in computing time by a factor of about 5 and a similar reduction factor in storage space for intermediate results. This allows the calculations to be performed with the desired high spatial resolution. Other advantages of the normalized calculation are an improved flexibility in the creation of results, the inclusion of all nuclides and types of foodstuffs and the possibility of getting results for groups of nuclides (e.g. iodine isotopes) and/or foodstuffs (e.g milk and milk products) with little expenditure. On the other hand, the disadvantages are that the specific activity in foodstuff is not the real interface between food- stuff transport module and dose module, and products which are based on more than one deposition area (i.e.which are produced from different types of plants) cannot be considered without further extension of the calculation procedure. But the latter problem seems not to be a severe one.

Further development of the program modules will be necessary after final agreement on the results to be presented to the user and on the interfaces of the ECOAMOR modules with the countermeasure modules developed by other contractors. In this field, a new concept for the presentation of the results has been worked out which gives high flexibility to the user in defining the output of the

RODOS analysing subsystem in the automatic and the interactive mode. For this purpose a detailed compilation of the results and interfaces has been set up which has to be further discussed with the developers of the RODOS operating system and the countermeasure modules.

The data base of dose conversion factors has been extended to include all organs. The data sets used in the food chain calculation have been partly updated due to the recent development of the radioecological model ECOSYS-87, which is the basis of the ECOAMOR modules.

The development of a methodology for providing information on the uncertainty of the results of the food chain and dose modules has been started in the reporting period. For this purpose the radioecological model ECOSYS-87 has been linked with the program package PRISM. The latter is a code developed by Oak Ridge National Laboratory for estimating the parameter sensitivity and uncertainty of model results based on Monte-Carlo-method using Latin-Hypercube sampling. This required to estimate the range of uncertainty for each of the relevant model parameters.

Uncertainty estimations have been made for different scenarios, considering different radionuclides, types of deposition (dry, wet), times of deposition (winter, early and late summer) etc. For each scenario the ranges of uncertainty (given by frequency distributions) of the calculated foodstuff contaminations and the ingestion dose have been determined, and those model parameters contributing most to the uncertainty have been identified.

These investigations will be continued in the future considering a much wider spectrum of model scenarios. After that, the resulting data base with uncertainties of model results will be used to develop an algorithm which allows to give some quick indication about the uncertainty of actual model results to the user of the RODOS system.

Publications:

[1] Mueller H., Friedland W., Proehl G.:
Uncertainty in the ingestion dose calculation.
Accepted for Publication in Radiation Protection Dosimetry

[2] Friedland W., Mueller H., Proehl G., Brown J., McColl N.P., Jones J.A., Haywood S.M.:
Modules for foodchain transport, dose assessment and long term countermeasures in RODODS, the European decision support system.
Accepted for Publication in Radiation Protection Dosimetry

Head of Project 4: Professor French

II. Objectives for the period

The primary aims of the contribution are:

1. The development of Bayesian modelling techniques to forecast and handle uncertainties in RODOS, initially focusing on the inclusion of uncertainty measures within the plume forecasting module (using the Rimpuff model) of the ASY subsystem. Specifically the following will be investigated and implemented.
   - assimilation of monitoring data;
   - estimation of release height;
   - reporting of means and variances of predictions at given sites;
   - estimate the source term with allowance for autoregression;
   - make allowances for modelling error;
   - consideration of the computational advantages of working on a variable grid.
2. Subsequently, attention will widen to consider uncertainty measures in the forecasting of the efficacy of countermeasures. We will consider passing appropriate measures of uncertainty between modules in RODOS and providing an audit trail to justify the predictions made by the system.
3. The development of methods to communicate uncertainty to non-numerate decision makers.

In addition to the above, Leeds and Warwick will also contribute general expertise on decision analysis, statistics and uncertainty modelling, numerical methods and software engineering.

III. Progress achieved including publications

Against the objectives we have achieved the following.

1. Bayesian updating techniques have been incorporated into the latest version of Rimpuff and the code optimised somewhat. The code is also being modified so that it uses monitoring data to:
   - estimate the source term with allowance for autoregression;
   - allow for unknown source height by mixing three Rimpuff models;
   - allow for uncertain wind direction by mixing three Rimpuff models;
   - pentify puffs with respect to (local) wind direction not grid co-ordinates.

   The modifications are made and are being tested against old and new data sets (e.g. Barsebeck and Guardo).

   Some theoretical work has pointed to the possibility of considerable computational advantages and enhanced statistical performance being obtained by reorganising the way that puffs are indexed and stored in Rimpuff. This will enable all the techniques currently bring developed in influence diagram and belief net theories to be deployed. A start has been made in recoding the main routine in C++ (i.e. using object oriented modelling).
2. Little has been done to address this objective yet: work is planned for Autumn 1993 and Spring 1994.

3. The puff model and the associated uncertainty has been visualised using 3-d graphics. Animations of plume spread can now be generated on Silicon Graphics machines. It is unlikely that this work will be incorporated in the versions of software to be delivered by Spring 1994 for HP machines; but it will act as a demonstrator for future development. Work is planned for Autumn 1994 to develop simple statistical plots to demonstrate the uncertainty to decision makers under the X-Windows graphical interface. This should be available within the software to be delivered in Spring 1994.

Publications

[1] French and Smith (1993) "Using monitoring data to update atmospheric dispersion models with an application to the RIMPUFF model." *Radiation Protection Dosimetry* (In press)

[2] Smith and French (1993) "Bayesian updating of atmospheric dispersion models for use after an accidental release of radiation" *The Statistican* (accepted for publication)

[3] French, Ranyard and Smith (1993) "Models, data and expert judgement in decision support systems" Institute of Nuclear Engineers Conference, Glasgow, September 1993. (Accepted for publication in proceedings)

Future objectives

Continue with further work on objectives 1, 2, 3 plus

4. Fully introduce object oriented code into Rimpuff allowing full use of the influence diagram and belief net algorithms which will improve performance and allow enhanced statistical analysis and uncertainty handling.

5. Develop software to handle uncertainty within the CSY subsystem (i.e. begin implementing some of the theoretical work under objective 2).

Head of project 5: Dr. Sohier

II. Objectives for the reporting period

The development of a methodology based on a comparison between early monitoring data and model predictions to reduce the global uncertainty about the radiological situation during the initial phase of a nuclear accident.

An algorithm was was developed to quickly reduce the uncertainty of the source term based on the utilization of fuzzy logic in case of simple situations (simple topography - simple meteorological conditions - simple source term) and was tested versus tracer experiments (passive pollutant).

In parallel to this, collaboration with other institutes to define specific training courses for the application of RODOS as a training tool and to define the mode of utilization of RODOS in such courses.

III. Objectives for the next reporting period

Consolidation of methodology and algorithm which was hitherto developed. Application to simple topography and meteorological situation but consideration of more realistic source terms : nuclide mix and time dependency. Further development of data assimilation module to consider every kind of early data. Application of methodology to available contamination data bases (e.g. gamma dose rates available at NPPRI-Trnava).

Translation of PC-DOS software to UNIX-environment considering the RODOS boundary conditions.

Independently of this, collaboration with other involved institutes for the development of illustrative scenarios and course material for inclusion of RODOS in specific training courses.

IV. Progress achieved including publications

A clear and comprehensive picture of the actual and future contamination in the environment in case of a nuclear accident is a prerequisite before any sound decision about protective actions to the population can be taken. This work is concerned with the analysing subsystem ASY of RODOS to obtain a continuously increasing confidence in the picture of the radiological contamination. Only the initial phase (during and shortly after emission) when the rapid introduction of appropriate countermeasures in the near range are of uttermost importance is considered. Several kinds of information will lead to reduction in the initial uncertainty, such as:

- pre-calculated scenarios
- in-plant and on-site data
- meteorological data & environmental data
- pre-calculated scenarios

This work is mainly concerned with the continuous comparison of model predictions, using meteorological data, with available monitoring data in the near range.

Our work performed in the framework of the contract BI6-106-B between the SCK/CEN and the CEC has indicated some basic difficulties in performing such an optimization. For example, unless a careful monitoring programme is executed, it is difficult to guarantee a unique solution. A method based purely on the adaptation of model input parameters with the help of Monte-Carlo calculations will be very time intensive and will possibly generate non physical solutions.

To tackle these difficulties some assumptions were made, assumptions to be relaxated in a later phase. Only a simple dispersion model (Gaussian-like trajectory model) is used to cope with simple situations (simple topography, meteorological situation and source term).

A routine on IBM-PC has been built to quickly obtain a best estimate of the source term as well as the wind direction and effective plume height using near-range (up to several km) data.

The basic quantity is the individual (P/O)-ratio (Prediction/Observation) for each monitoring point. Depending on its value, a (P/O)-ratio can be defined to belong to a discrete class represented by a class number and related to the quality of the ratio. If done classically, some information is lost because of the sharp transition in class number for the (P/O)-ratios near to the boundary of a class. For this reason a fuzzy set approach was introduced. For each class (5 in total : Very Good, Good, Medium, Poor and Very Poor) a membership function was defined giving rise for each (P/O)-ratio to a sequence of 5 values which represent the degree of membership to each class (ref. 1,2). For each (P/O)-ratio the quality of this ratio is obtained by the class number (0 : VG ... 4 : VP) by selecting the class with the highest value for the membership function.

The routine is divided in two parts (I and II). Part I tries to obtain as quick as possible an approximate value for the main model parameters (source term, wind direction and effective height) while part II allows for a possible refinement. Part I-1 realizes a regression in order to deduce an approximate value for the effective height based on the behaviour of the concentration downwind (e.g. localization of the maximum concentration). Part I-2 makes an optimization on the source term, the wind direction and the effective height. The source term is calibrated by minimizing the average of the class number of each (P/O)-ratio. An adaptable multiplication or reduction factor is used to accelerate the process. The wind direction is optimized by comparing the partial averages of the class number for receptors on both sides of the supposed wind direction. The wind direction is allowed to vary with distance. The optimization cycle is stopped if the difference of the values of two successive VG membership functions averaged over all monitoring points differ less than a predefined value, on the condition that the average VG membership function tends towards one.

In part II successive smaller intervals are defined around the best estimates of the source term and wind direction obtained in I. Calculations are performed for sets of values within this intervals using the "global quality" (VG membership function, averaged over all monitoring points) as an optimization criterion.

Up to now the routine has shown to be operational, when tested with available tracer experiments (Mol, Karlsruhe), for a passive contaminant for a single release. When the effective height is supposed to be known a standard error (100 * abs(best-estimate source term - real source term)/ (real source term)) lower than 200 % can always be obtained in part I and can usually be reduced to 50 % in part II. Supposing an unknown release height the standard error can still be reduced to 200 % in most cases but part II does not give rise to a significant improvement. One of the difficulties which has not been resolved up to now concerns the definition of appropriate weighting factors for points lying at a certain distance from the plume axis to take the limited validity of the model far away from the plume axis into account.

Independently from the previous part, collaboration with other institutes has been initialized to define specific training courses for the application of RODOS as a training tool and to define the mode of utilization of RODOS in such courses.

Publications

[1] Sohier A.,Govaerts P.
The use of an incomplete information data base for the assessment during the early phase of an accidental release of radioactive material.
8th International Conference of the International Radiation Protection Association : Montreal, Canada, May 1992 Proceedings , vol II, 420-423

[2] Sohier A.,Van Camp M.,Ruan D.,Govaerts P.
Methods for radiological assessment in the near-field during the early phase of an accidental release of radioactive material, using an incomplete database.
Third International Workshop on Real-Time Computing of the Environmental Consequences of an Accidental Release to Atmosphere from a Nuclear Installation. Schloss Elmau, Bavaria, Germany, 25-30 October 1992

[3] Van Camp M.,Ruan D.,Sohier A.,Govaerts P.
The use of fuzzy set theory to reduce uncertainties on the source term and the wind direction in decision aiding systems.
Joint International Conference on Mathematical Methods and Supercomputing in Nuclear Applications, April 1993 Proceedings vol I, 432-442

[4] RODOS(B)-TN(93)01
RODOS Subtask "Training": Potential implementation of RODOS in the Mol Training Courses, 26.11.92 SCK/CEN

Head of project 6: Ms. Haywood

II. Objectives for the reporting period

The first objective for the current reporting period has been to extend the development of the food countermeasures model, following the implementation of a prototype version of this model into RODOS-PRTY1.0 in 1992, and to develop countermeasures models for relocation and decontamination. The second objective has been to develop a structure for the long-term countermeasures module (FRODO) of RODOS in which to incorporate these countermeasures models and to agree with other module developers the interfaces between the FRODO module and adjacent modules of RODOS, and the way in which FRODO is utilised within the RODOS system.

III. Objectives for the next reporting period

The objective for the next reporting period is to continue the development of the FRODO countermeasures module for food countermeasures, relocation and decontamination. The countermeasures module will then be implemented into the 1994 version of the RODOS system in collaboration with KfK, GSF and other organisations. Work will continue on the development of the required countermeasures databases for use with the FRODO module which will incorporate the data from the collaborative research with institutes in the CIS on agricultural countermeasures.

IV. Progress achieved including publications

The work at NRPB during the reporting period has concentrated on the development of countermeasures models for assessing the consequences of long-term countermeasures options. The countermeasures options under consideration are food countermeasures, relocation and decontamination. The other major aspect of the work has been the development of a module structure for implementing these countermeasure models into RODOS. In particular emphasis has been placed on developing a flexible framework that can be further developed in the future under the RODOS framework.

<u>Model Development</u>

NRPB produced an example module for the consideration of food countermeasures related to milk and milk products as part of the prototype version 1 of RODOS presented at Schloss Elmau in October 1992. Emphasis has been placed in this reporting period on extending the models developed for this prototype module to be applicable for the major food groups, eg. green vegetables, root vegetables, cereals, milk and meat, and to take into account a wide range of countermeasure options both for the short term following an accidental release to atmosphere and also in the longer term.

The FRODO module will be directed to answering different types of question in the first few days after an accident than those that might be considered in the longer term when more time is available to decide on the best options for the situation being evaluated. In the first few days the module will be directed to answering scoping questions advising the RODOS user on the scale of the problem. If food is required to be banned based on a set criterion the module will consider what actions can be taken to avoid banning food and, if a ban cannot be avoided, will then consider what can be done to reduce the length of ban required and the amount of produce affected. The module will include models for agricultural countermeasures including food disposal, food processing, food storage and the feeding of uncontaminated feed to animals, to provide a robust model that can be applied to all foods considered. The user will therefore receive an idea of the scale of the problem and the options available to alleviate the problems in the short term. In the longer term the FRODO module will consider a much wider range of food countermeasure options. It is the intention that these options will be assessed, in the later decision aiding modules of the RODOS system, in terms of their effectiveness and feasibility and that this assessment will be made partially on the basis of information provided to these later modules by FRODO. Countermeasure options such as amelioration of soils, change in crops grown and change in land use will be addressed in FRODO. The module will be directed towards answering questions concerning the longer term options to reduce doses and activity concentration levels.

Models for determining the requirements for, and the consequences of, relocation have been developed in this reporting period. Two types of relocation have been considered, namely temporary relocation and permanent relocation. Permanent relocation is the removal of people from an area with no expectation of their return, although the land may be released at a much later time and subsequently resettled by different individuals. Temporary relocation is the removal of people for an extended but limited period of time. The consequences considered in FRODO relate to the areas of land interdicted, the time periods over which this occurs, the numbers of people relocated, and the doses saved as a result of relocation. Models for assessing the direct effect of decontamination on doses and also the impact of decontamination on the requirement for relocation and agricultural countermeasures are also being developed.

During the reporting period the development of databases containing information on the effectiveness of countermeasures and the associated costs and equipment required etc. has been ongoing. The data used in the food countermeasures models will, in general, be in the form of reduction factors that can be applied directly to the concentrations in the foodstuff or empirical models that can be used to modify the animal diets, levels in soil/crops or concentrations in animal products following the giving of additives in the feed. These databases are being developed in close collaboration with the CEC/CIS Joint Study Project 1 participants in the Ukraine where data on the effectiveness of food countermeasures and other relevant data are being collated.

Module Structure

FRODO will be sub divided into a series of sub-modules considering the three countermeasure options; food, relocation and decontamination. The relationship between these sub-modules is illustrated diagrammatically in Figure 1. The broad functions of each sub-module are described below.

FRODO-CONT	- controls and directs the other sub-modules
FRODO-RELOC	- assesses the consequences of relocation
FRODO-FOOD	- assesses the consequences of food countermeasures
FRODO-DECON	- assesses the consequences of decontamination
FRODO-SUMM	- manipulates output from the other sub-modules for transfer to other modules of RODOS

The structure of FRODO has been developed to enable the countermeasure options to be considered separately and provides a flexible structure into which other models or sub-modules could be added in the future.

Interactions with other module developers

NRPB attended a coordination meeting on dose and countermeasure models and links with decision expert systems in February 1993 at KfK. Discussions were held on the planned developments of the dose and countermeasures modules which are closely linked and in particular, the requirements of the two modules were identified and the interfaces between them discussed. Close interaction between the developers of the dose module and NRPB has been maintained over the reporting period to ensure a consistent approach where appropriate and to resolve problems concerning the integration of the modules together and into the RODOS system within the next reporting period. Contact has also been made with the developers of the other RODOS modules from which FRODO requires data and those which require endpoints calculated by FRODO, to enable the process of defining interfaces to commence.

Publications

[1] Friedland, W., Müller, H., Prohl, G., Brown, J., McColl, N.P., Jones, J.A. and Haywood, S.M.,
Modules for foodchain transport, dose assessment and long term countermeasures in RODOS, the European decision support system.
Rad. Prot. Dos. Special edition on Third International Workshop on Real-time Computing of the Environmental Consequences of an Accidental Release to Atmosphere for a Nuclear Installation, Schloss Elmau, October 1992 (to be published).

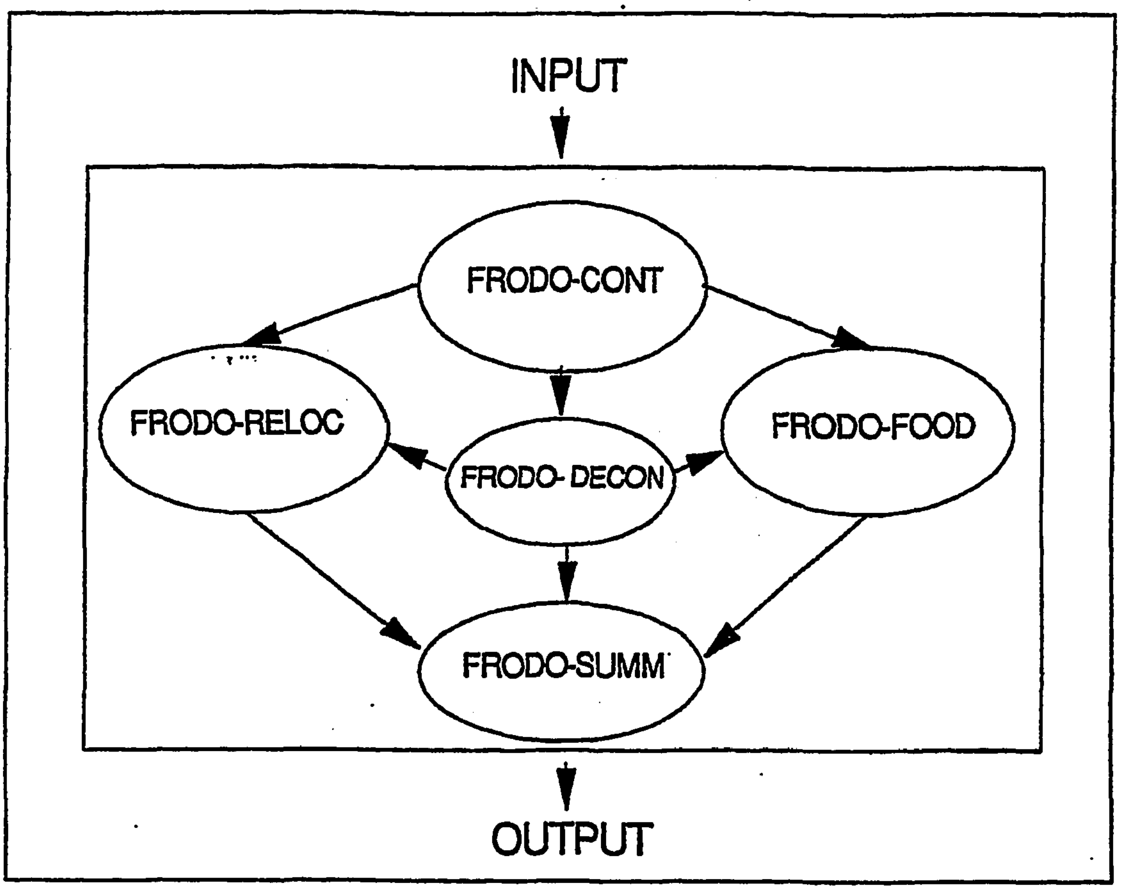

Figure 1. Proposed Internal Structure of the FRODO module.

Head of project 7: B. Bleasdale

II. Objectives for the reporting period

The objectives for the current and the next reporting period are identical and are:

1. Advise and support the project in matters relating to training and exercises.
2. Ensure the practical lessons learnt from Nuclear Electric's extensive experience in scenario development and exercise programmes are fully utilised.
3. Ensure that a systematic approach to training is used for the project.

III. Progress achieved

1. Participation at the subgroup meeting on "training" held in Karlsruhe in September 1992 and Paris in April 1993 including preparation of material in advance for discussion at both meetings.

2. Production of description of training courses in the UK where RODOS may be utilised, identifying for each course:

   Frame, aim and target group
   Duration and division
   Participants and their background
   Lecture content
   Nature of any exercise included in the course

   Additionally providing for each course an evaluation with respect to the use of RODOS within the course.

3. Utilising the systematic approach to training, production of a draft modular training package structure, identifying for each module learning objectives and assessment criteria, and developing the associated matrix of modules required for each of the target groups for the training.

4. Development and provision to the group of typical lesson plans.

5. Work currently in hand, and at an advanced stage includes

   - preparation of potential accident scenarios and source terms;

- description of benefits and drawbacks of countermeasures with respect to their effectiveness against different exposure pathways and their impact on decision making;
- monitoring strategies.

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Numéro du document : **95NV00023**

Titre : **RAPPORT D'AVANCEMENT DU PROJET EUROPEEN RODOS "DEVELOPPEMENT SYSTEME". PERIODE DU 1ER SEPTEMBRE 1992 AU 31 AOUT 1993**

Auteurs : **MARCHAND O.**

Source : **COLL. NOTES INTERNES DER. BIOLOGIE, SCIENCES DE LA TERRE ET PROT**
Serial :

Référence du document : **SANS**

Nombre de pages: **0032** Nombre d'exemplaires : **001** Support : **P**