Calculating the consequences of recovery, a European Model for Inhabited Areas

Tom Charnock[1], Arthur Jones[1], Lucia Singer[1], Kasper Andersson[2], Jørn Roed[2], Soren Thykier Nielsen[2], Torben Mikkelsen[2], Poul Astrup[2], Jan Christian Kaiser[3], Heinz Müller[3], Gerhard Pröhl[3], Wolfgang Raskob[4], Steen Hoe[5], Lars Henrik Jacobsen[6], Leo Schou Jensen[6], Florian Gering[7].

[1] Health Protection Agency, Radiological Protection Division, Chilton, Didcot, Oxon OX11 0RQ,UK. [2] Risø National Laboratory, PO Box 49, NUK-201, DK-4000 Roskilde, Denmark. [3] Helmholtz-Zentrum Muenchen, Ingolstädter Landstr. 1, D-85764 Neuherberg, Germany. [4] Forschungszentrum Karlsruhe, IKET, Bau 433, Postfach 3640, 76021 Karlsruhe, Germany. [5] DEMA – Danish Emergency Management Agency, Datavej 16, 3460 Birkerød, Denmark. [6] PDC – Prolog Development Center, H. J. Holst Vej 3C – 5C, DK-2605, Brøndby, Denmark. [7] Bundesamt für Strahlenschutz - SW 3.2, Ingolstädter Landstr. 1, D-85764 Oberschleißheim, Germany.

INTRODUCTION

The European Model for Inhabited Areas (ERMIN v1) was developed under EURANOS, an integrated project of the EC Sixth Framework Programme. It is both a model and a software tool. As a model it simulates the behaviour of radionuclides in the inhabited environment and calculates the exposure of the population as well as other relevant endpoints. As a tool it allows a user to explore different recovery options following the contamination of an urban environment with radioactive material and to refine a strategy. It has been designed to be implemented within the RODOS and ARGOS Nuclear Emergency Decision Support Systems (DSS) or as a standalone application.

The need for a tool with the capabilities of ERMIN v1 was identified during the EC Fifth Framework programme. In particular, work during the EVATECH project indicated that decision makers recognised the need to address recovery issues by sub-dividing the area of concern on the basis of, for example, land use, deposition level and the emergency actions taken; and to explore the combined consequences of applying different packages of countermeasures within those subdivisions (Brown *et al.,* 2004). Such a flexible approach could not be readily handled by the tools then available and it was clear that the flexibility required could only be achieved when the user was able to interact directly with a dynamic model.

THE ERMIN V1 MODEL

Input data required by the model include a description of the environment, initial deposition of radionuclides on to a reference surface and a description of countermeasures. ERMIN v1 can accept deposition from an atmospheric dispersion model, surface measurements and the Inhabited Area Measurement Module (IAMM) – a data assimilation module also developed under EURANOS for implementation in RODOS and ARGOS (Kaiser and Pröhl, 2007). Countermeasures include decontamination, tie-down, shielding and relocation.

Output information generated by the tool includes the average doses to members of the public from external exposure to gamma and beta radiation from deposited radionuclides and inhalation of resuspended radioactivity, the contamination on urban surfaces, the air

concentration, the doses to workers undertaking the recovery work, the quantity and activity of waste generated and the cost and work required to implement the countermeasure.

The model uses ratios to distribute deposition on the reference surface onto all urban surfaces. Empirical functions represent the long-term surface retention and migration in soil is simulated using a convective-dispersive model. A library of dose rates for surfaces in idealised environments is applied to calculate dose rates indoors and outdoors. Countermeasures are represented by the modification of surface contamination and the dose-rates. The ERMIN countermeasure database is based on the EUROPEAN inhabited area handbook also developed under the EURANOS project (Brown *et al.,* 2007).

IMPLEMENTATION AND OPERATION

ERMIN was designed to be implemented within both the RODOS and ARGOS Nuclear Emergency DSS and also as a standalone application. Each implementation uses the same underlying executable and data library components, but the tool, as presented to the user, can be very different depending on the needs of the users of a particular system. However the basic principle of operation is the same in that the user defines regions. Within the RODOS and ARGOS DSS the regions are directly drawn onto a map (see Fig. 1), in the standalone implementation – CONDO v4 developed for UK government agencies – regions are defined in a tabular fashion. Regions may represent areas of different urban environments, different deposition (although ERMIN v1 can also accept gridded deposition from an atmospheric dispersion module), different emergency countermeasures and different packages of recovery options to be evaluated. The output in RODOS and ARGOS is generally delivered as a spatial grid overlaid onto a background map for visualisation, see Fig. 2. When using ERMIN v1, the user may make the description as complicated or as simple as necessary with regard to their immediate needs. For example, for the purposes of emergency response where a broad projection of doses without countermeasures or the evaluation of a few simple countermeasure options is required, it may be appropriate to simply define a town using a single default environment, or default mix of environments, and to assume that a single countermeasure such as road sweeping is applied everywhere. In the longer term when the emergency phase of the incident has past, it may be appropriate for the user to define different urban environments within different parts of the town and to identify different regions in which countermeasure packages can be applied.

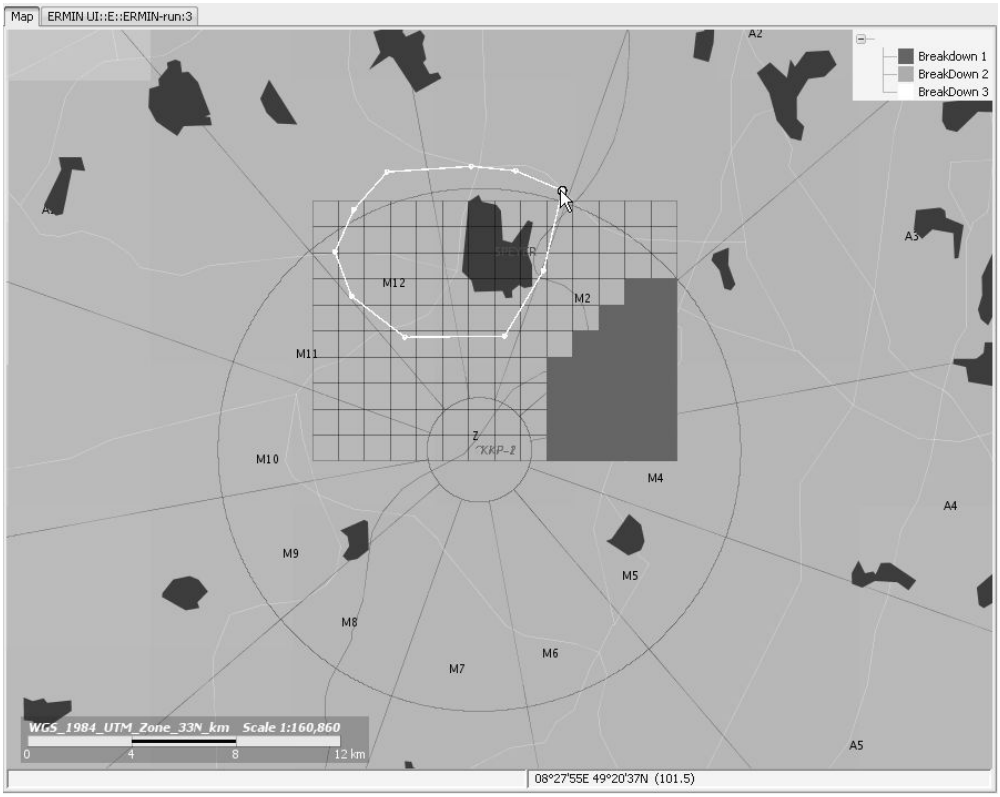

Figure 1. A screen shot of the prototype RODOS-ERMIN user interface. Here the user draws regions onto a map. In this case the regions represent different urban environments.

Figure 2. A screen shot from the ARGOS Emergency DSS, showing the visualisation of ERMIN results against background map of an urban area.

TESTING AND COMPARISON

ERMIN v1 has been applied to the Pripyat scenario developed by the Urban Remediation Working Group of the IAEA EMRAS (Environmental Models for Radiation Safety) Programme (Thiessen, to be published). ERMIN model produced results largely consistent with the other models in the original comparison. For example when compared with the model EXPURT (Jones *et al.,* 2004), at short times the results are very similar although at longer times dose-rates tend to fall away more rapidly in EXPURT than in ERMIN. This results is not surprising as the ERMIN project involved a thorough review of the latest surface retention data and in the light of that review many of the retention parameters were set at values indicating longer retention half lives than the parameters used in EXPURT, an older model (Jones *et al.,* 2007).

ACKNOWLEDGEMENT

The authors would like to acknowledge the help of Ievgen Ievdin of Ukrainian Centre of Environmental and Water Projects (UCEWP), who supplied screen shots of the prototype RODOS ERMIN user interface.

REFERENCES

Brown, J., G. Roberts, E. Carter, S. French and C. Niculae, 2004. Summary report of the UK workshops held to explore decision analysis of clean-up actions in inhabited areas after an accidental release of radionuclides, EVATECH(WP4)-TN(04)-02

Brown, J., K. Mortimer, K. Andersson, T. Duranova, A. Mrskova, R. Hänninen, T. Ikäheimonen, G. Kirchner, V. Bertsch, F. Gallay, N. Reales, D. Hammond and P. Kwakman, 2007. Generic handbook for assisting in the management of contaminated inhabited areas in Europe following a radiological emergency, parts I-VI, EURANOS(CAT1)-TN(07)-02, www.euranos.fzk.de.

Jones, J.A., T.W. Charnock, L. Singer, J. Roed, K. Andersson, S. Thykier Nielsen, T. Mikkelsen, P. Astrup, J.C. Kaiser, H. Müller, G. Pröhl, W. Raskob, S. Hoe, L.H. Jacobsen, L. Schou-Jensen, F. Gering, 2007. Description of inhabited area model. EURANOS(CAT2)-TN(05)-04, to be published, Health Protection Agency, Centre for Radiation, Chemical and Environmental Hazards, Chilton, UK.

Jones, J.A., L.N. Singer, and J. Brown, 2006. The EXPURT model for calculating external gamma doses from deposited material in inhabited areas. Journal of Environmental Radioactivity 85:314-329.

Kaiser, J.C. and G. Pröhl, 2007. Harnessing monitoring measurements in urban environments for decision making after nuclear accidents. Kerntechnik 72(4).

Thiessen, K., Environmental Modelling of Remediation of Urban Contaminated Areas, Environmental Modelling for Radiation Safety Programme (EMRAS), to be published. International Atomic Energy Agency. Vienna.