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ARTICLE

European model for inhabited areas – ERMIN 2

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Abstract – The European Model for Inhabited Areas (ERMIN) evaluates strategies for the remediation of inhabited areas contaminated by air-borne radioactive material. The enhancements in the new version, ERMIN 2, were motivated by the new ICRP recommendations for a system of radiological protection, and by user feedback. The underlying model has not changed but the interface has been enhanced to allow the user to easily compare recovery strategies and to select appropriate countermeasure options within the context of ICRP recommendations on the residual dose.

Keywords: contamination / environmental / decontamination / emergency / radiological / decision support system / ERMIN

1 Introduction

ERMIN is a tool for analysing strategies for remediating and returning to normal use inhabited areas that have been contaminated by air-borne radioactive material (Charnock *et al.*, 2009). The first version, ERMIN 1, has been implemented in the RODOS and ARGOS decision support systems (Raskob *et al.*, 2009). This document describes the development of an enhanced ERMIN 2. The aims were to accommodate new ICRP recommendations for a system of radiological protection and to improve the user experience.

2 The ERMIN model

The ERMIN tool divides the area of interest into a grid and within each square the model is applied. Weather-dependent ratios distribute deposited radioactive material onto urban surfaces including trees, roofs, walls, roads, grass and building interiors. Empirical functions represent the long-term surface retention and soil migration. A library of dose rates for surfaces in idealised environments is applied to calculate dose rates indoors and outdoors. Finally, modification of surface contamination and dose rates accounts for countermeasures. The user specifies different types of urban environments, levels of deposition and countermeasure zones by grouping grid squares.

3 ERMIN 2

There were two motivations for the enhancement of ERMIN 1. Firstly, ICRP have issued new recommendations and secondly, ERMIN 1 has been available to users for a number of years and inevitably, they have identified aspects of the interface and the experience that could be improved.

3.1 ICRP 103 recommendations

In 2007, ICRP issued new recommendations for a system of radiological protection (ICRP, 2007). Among the recommendations is that in emergency situations two measurements of the dose are considered; the projected dose, the overall exposure with no protective measures, and the residual dose, the overall exposure with protective measures. ICRP suggests a reference level of the projected dose of between 20 and 100 mSv (either acutely or delivered over a year) and recommends that below this, protection should be optimised to lower the residual dose so as to maximise the benefits and minimise the detriments.

A new screening module has been developed for RODOS that considers all pathways of exposure (Landman *et al.*, 2013). Inevitably, there will be situations in which emergency actions fail to reduce the residual dose below the reference level. In the screening model these regions are termed the residuum area, and ERMIN 2 can be applied to this area to analyse the effect of countermeasures and predict how quickly the residual dose can be brought below the reference level.

3.2 Comparison of strategies

With ERMIN 1 the user specifies strategies which are compared with a strategy ‘without countermeasures’. However, in some cases countermeasures may have already been applied.

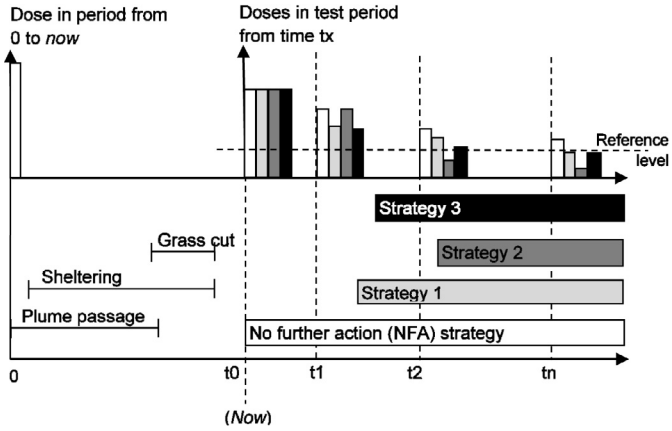

Figure 1. Illustration of the comparison of alternative remediation strategies.

These cannot be undone and it is not helpful to compare alternative strategies with a strategy 'without countermeasures' since this is no longer an option.

ERMIN 2 introduces a concept of *now*. In Figure 1, an example is given where several events have occurred before *now* including the passage of the plume and sheltering, and additionally some grass was cut. The public will have received a dose in this period, which cannot now be avoided. With ERMIN 2 the user specifies a time for *now* and the emergency and recovery countermeasures that have been implemented before *now*. This is termed the 'no further action' strategy (NFAS) and all alternative strategies must include the options in the NFAS. Further, they cannot contain incompatible options. For example, grass cutting cannot be implemented after ploughing of the same surface.

In order to evaluate the success of strategies, the user specifies a reference dose level and an integration period. ERMIN then estimates the residual public doses at a number of times under each strategy including the NFAS. Figure 1 shows illustrative results of this calculation as a sequence of bar charts with a reference level imposed. For the first test time ($t0$) no strategy brings the residual dose below the reference level. At $t1$ the effect of the strategies can be seen, but still no strategy reduces the dose sufficiently. However, by $t2$ strategy 2 is predicted to bring the residual dose below the reference level, while the residual dose with strategy 3 is very close. On this information alone, strategy 2 would be selected.

3.3 Selecting countermeasures

ERMIN 1 presents a long list of possible countermeasures but does not explicitly guide the user to the most appropriate. In RODOS, ERMIN 2 contains a 'wizard' to assist the user in this.

The wizard ranks surfaces by dose contribution as calculated by ERMIN and identifies techniques that apply to the highest ranking. It considers deposition conditions and time dependency, as some techniques are more effective soon after deposition or after dry deposition alone. Techniques in the database are categorised into either generally applicable or constrained, and either generally acceptable or constrained. Generally applicable techniques do not need specialist material, equipment or skills and are not labour-intensive. Examples of generally applicable techniques are road sweeping and cutting grass in large areas, whereas skim and burial ploughing is not because of the specialist equipment required and sandblasting walls is not because of the equipment required, the need to access private property and the requirement to work at height. Generally acceptable techniques do not damage the environment, leave activity in situ or overly disrupt normal life. An example of a generally acceptable technique is sandblasting walls, whereas ploughing may not be acceptable because it leaves all the radioactivity in place, and relocation because it is very disruptive. The classifications are deliberately broad and intended to allow the wizard to suggest a few techniques that are likely to be both effective and feasible.

3.4 Enhancements to the results interface

All ERMIN 1 results are given as maps including the public dose, worker dose, radioactivity concentration on surfaces, concentration in air, waste amount, waste radioactivity, work and cost. All the information is available but not in a form most useful to users. Differences in strategies are not obvious and important contributing surfaces are difficult to identify. ERMIN 1 also provides a table of aggregated results such as the maximum public dose, maximum worker dose, collective public dose and total waste amount. It shows differences between strategies, but information is lost in the process of aggregation.

In ERMIN 2 the number of maps is reduced to include only the basic endpoints; the public dose and dose rates, surface concentration of each radionuclide and concentration in air. In addition, a new map shows the time that the residual dose is above the reference level in each grid square. The table has been enhanced to give more information, but in a way that is useful and does not overload the user.

Among the new endpoints is the maximum time that the residual dose exceeds the reference level, and the user can drill down into this result to see both the area and the population in the area where the reference level is exceeded as a function of time. This drill-down facility has been implemented for all the endpoints. The table initially presents a small number of 'headline' results but the user is able to drill down to more detailed results given by time, surface and other dimensions as appropriate. Figure 2 shows the implementation of the drill-down facility in RODOS and it also shows graphical elements of the dose by surface and time displayed as a bar chart at the bottom. Additionally, the user can also specify smaller areas within the entire region of interest. Again, they initially see a headline result for the entire region but can drill down to see results for individual reporting regions.

4 Conclusions

ERMIN 2 is the first major update to ERMIN since it was made operational. The changes have been driven by user feedback and by new ICRP recommendations. The underlying model has not been changed, but by changing the way it is

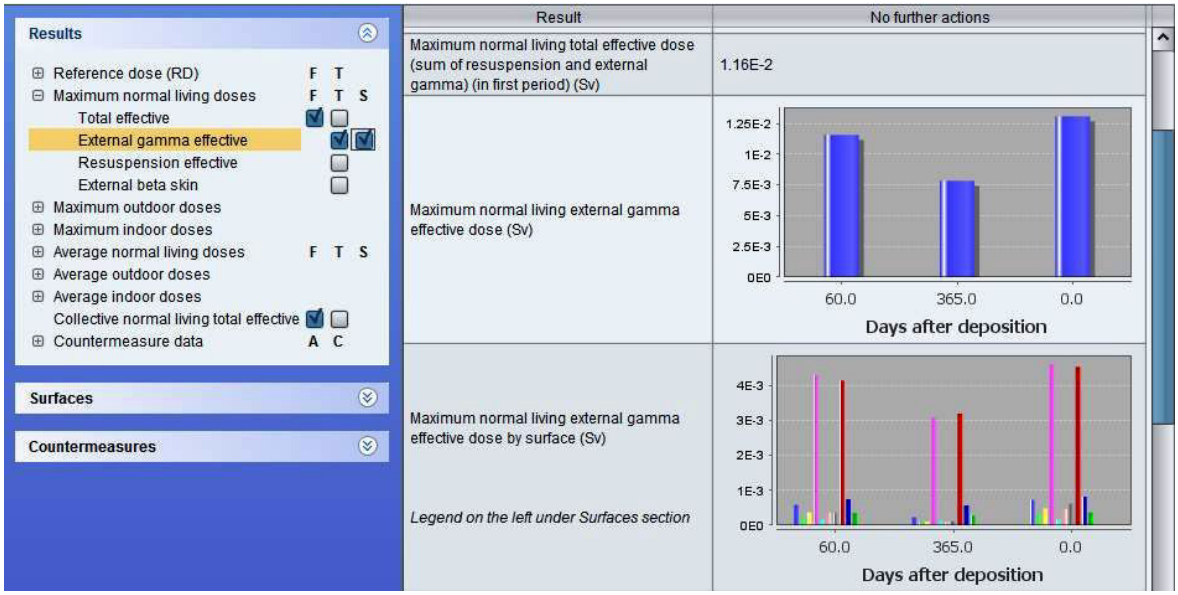

Figure 2. The RODOS ERMIN tabular interface, showing the drill-down system and use of graphical elements.

presented to users it is anticipated that it will be a much more effective tool. At the time of publication, the implementation of ERMIN 2 within RODOS is completed; within ARGOS it is ongoing.

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