

European Model for Inhabited Areas - ERMIN 2

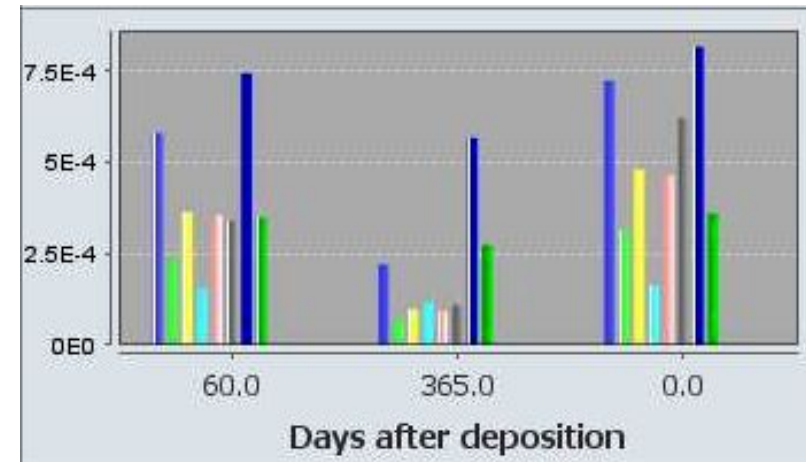
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Historical development: Inhabited areas modelling before about 2006 (pre-ERMIN)

- CONDO – CONsequences of Decontamination Options
 - Stand-alone software tool with tabular interface
 - Coupling to RODOS or ARGOS with their map-based interfaces was not possible
 - Includes dynamic compartment model EXPURT for simulating the movement of radionuclides between surfaces in inhabited areas
- EXPURT also produced data libraries for the probabilistic risk assessment programme COSYMA and dose reduction factor libraries for the Late Consequences Module Terrestrial, LCMT
 - LCMT did not allow to look at combinations of countermeasures applied to the same or different surfaces at arbitrary times, or to consider the effects of countermeasures in different kinds of urban environment

Historical development: ERMIN (ERMIN 1)

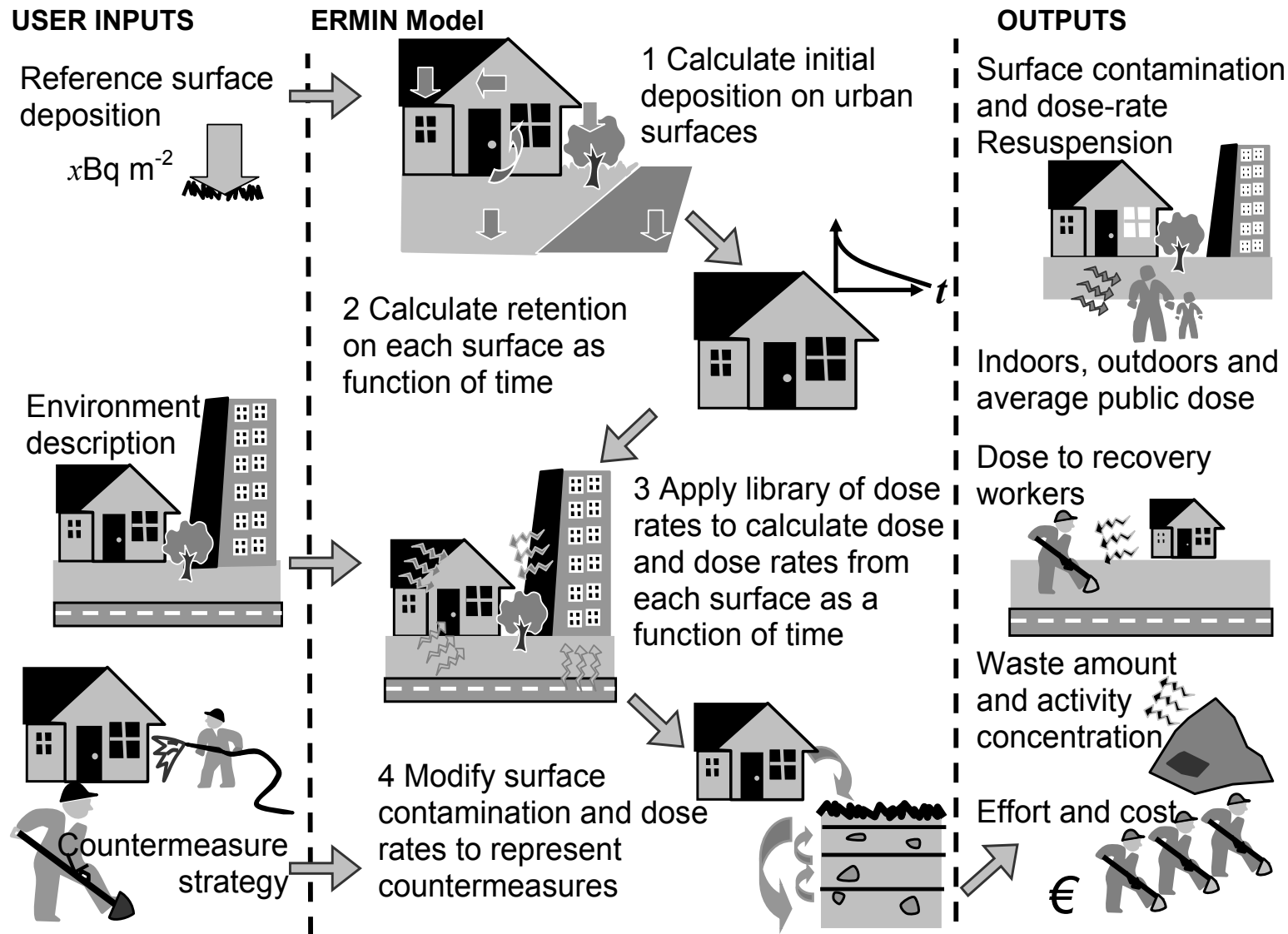
- 5th Framework EC, project EVATECH
 - Workshops with decision makers in several countries were held to explore their needs in the recovery phase following an accident
 - In many cases they addressed recovery issues by dividing the area of potential concern into sub-areas, based on the deposition level, the type of housing/industry, the actions taken during the emergency phase, etc. They then considered possible remediation approaches for each sub-area, before considering the construction of an overall remediation strategy

- 6th Framework EC funded project EURANOS: The European model for inhabited areas ERMIN brought together the expertise and lesson learnt from LCMT, EXPURT and CONDO and the insights from EVATECH; ERMIN has been implemented in RODOS and ARGOS


Historical development: New requirements

- Extend applicability of ERMIN 1 for use in connection with the new ICRP 103 (ICRP 2007) recommendations in frame of respective NERIS-TP WP2 activities for JRodos and ARGOS
 - *ERMIN should have some coupling to the ICRP 103 screening model SCREEN to enable investigating recovery measures in problem areas identified by the screening model*
- ERMIN 1 has been available to users of RODOS and ARGOS for a number of years and has been used in training courses and exercises; users and developers have identified aspects of the interface and the experience that could be improved
- Resulting tool: ERMIN2 (since end of 2013)

General features - Stages of an ERMIN calculation



General features - A little bit of theory

- Range of gamma rays in air: up to a few hundred metres
 - Gamma dose rate at a point depends on the distribution of activity within a few hundred metres of the point; any material between the point where the radionuclide decays and the point where the dose is calculated can attenuate the gamma rays
- 
- Calculating the gamma dose rate at any point is complicated
 - Problem is complex; there are no analytical formulae which give realistic values for the dose rates per unit deposition on each surface => obtain such values from Monte Carlo calculations
 - Values in ERMIN Dose Library base on M.C. calculations
 - Detailed treatment of a real urban settlements that has been contaminated is desirable but not feasible due to a lack of data
 - Solution: Introduction of idealised urban settlement types
 - Selected urban settlement types cover the majority of those found in Europe (*in the 1980s*)

General features - ERMIN public individual doses and dose rates endpoints

- The ERMIN “Outdoor” and “Indoor” doses/dose rates are for hypothetical individuals who stay in a given environment zone continuously and spend time in the different environments specified in the environment breakdown either continuously outdoors or continuously indoors, respectively; each respective idealised environment is assumed to extend infinitely in all directions
- The ERMIN “Outdoor”, “Indoor”, and “Normal living” doses and dose rates are useful quantities for developing countermeasure or measurement strategies
- The ERMIN doses/dose rates do not in general represent values at a specific location in a real environment (!)

General features - User input for ERMIN

- Definition of a grid over the area to be analysed (the "area of interest")
- Definition of areas representing different levels of initial deposition on a reference surface
 - Reference surface \Leftrightarrow short lawn surface at some distance from paved surfaces, buildings, trees and shrubs
 - Deposition input can be the output of some atmospheric dispersion and deposition calculation, the output of an Inhabited Areas Monitoring Module (IAMM) analysis, or deposition values directly entered via the user interface
- Definition of areas representing different types of urban environment
- Definition of and zones where different recovery countermeasures are applied

General features - Environment description

- Idealised urban settlement types in ERMIN

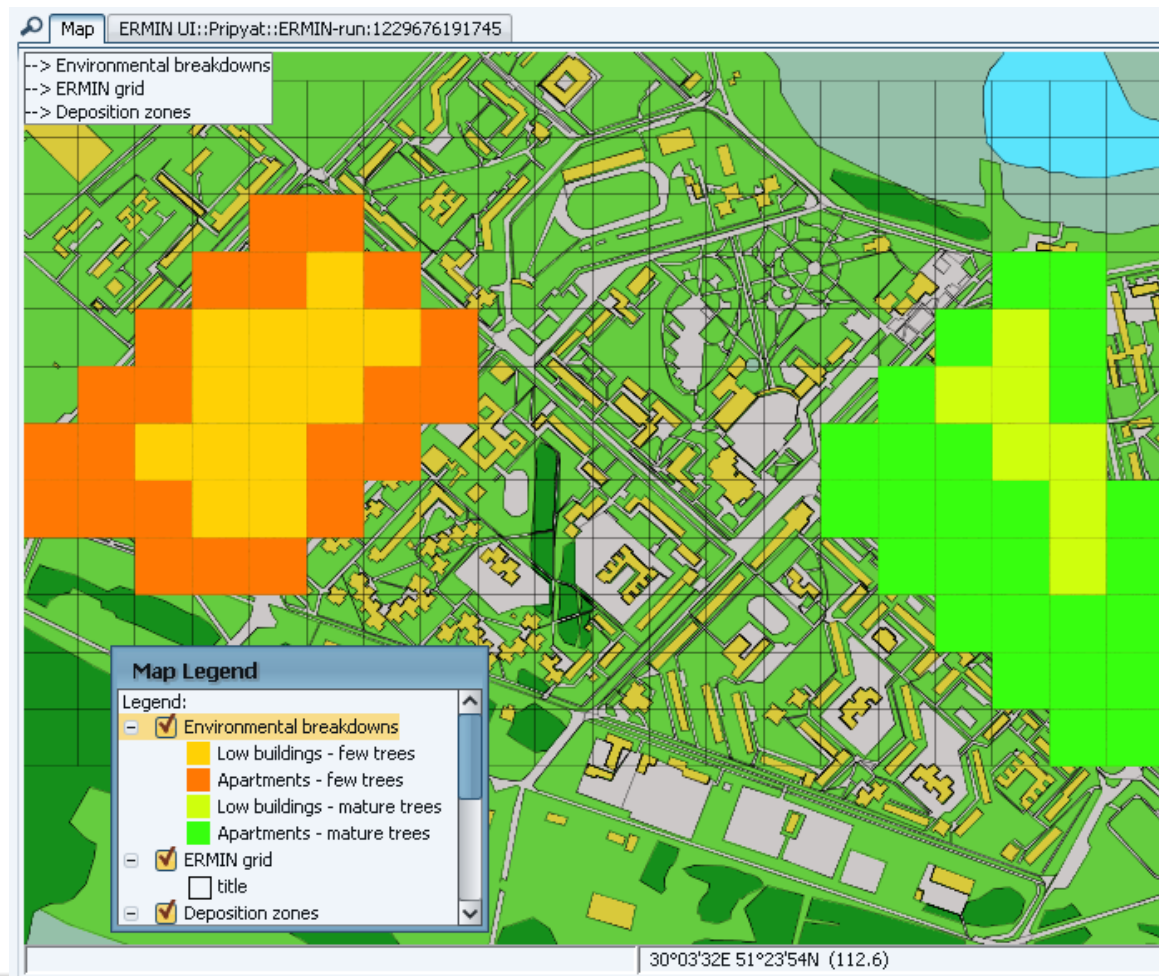
| | |
|---|-----------------------------|
| Street of detached prefabricated houses | Meckbach et al, 1988 |
| Street of semi-detached houses with basement | Meckbach et al, 1988 |
| Street of semi-detached houses without basement | Jones et al, 2006 |
| Street of terraced houses | Meckbach, 1988 |
| Multi-storey block of flats amongst other house blocks | Meckbach, 1988 |
| Multi-storey block of flats opposite parkland | Meckbach, 1988 |
| Industrial site (Incomplete dose library) | Kis et al, 2003 |
| Large open area | Jones et al, 2006 |

General features - Environment description

- The user describes the environmental breakdown of the area to be analysed with ERMIN in terms of the seven idealised urban settlement types

Input example:
Pripyat scenario)

Source:
Tom Charnock,
PHE-CRCE



General features - Countermeasures in ERMIN



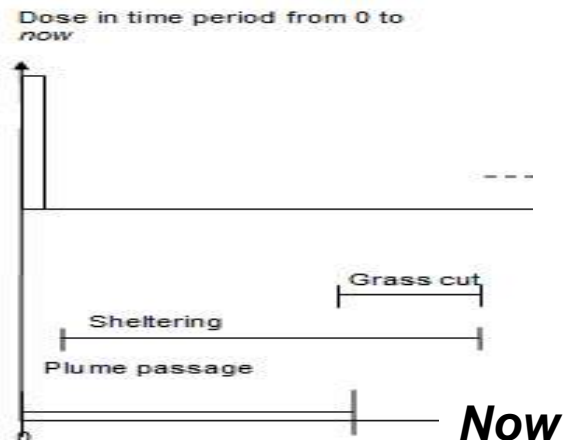
- ERMIN considers about 60 countermeasures, adapted from those in the European recovery handbook for inhabited areas
- The countermeasures can be divided into five broad groups:
 - 1. relocation
 - 2. decontamination by removing some of the activity from particular surfaces (e.g. fire hosing outdoor surfaces, removing soil etc.)
 - 3. dose reduction by shielding of ground level outdoor surfaces
 - 4. dose reduction by mixing activity within the soil column (digging, ploughing)
 - 5. actions which fix material to a surface (e.g. coating of surfaces)

Countermeasure strategies in ERMIN 1

- To start with, the user performs a "without recovery countermeasures" run
- Then, the user specifies a set of techniques applied over different regions as an alternative strategy to be compared with the 'without countermeasures' strategy;
- This process can be repeated with different strategies
- *Approach does not account for recovery countermeasures that may have already been applied in the past (example: fire hosing roads in the immediate aftermath of the emergency). If this is the case, it is not helpful to compare alternative strategies with a 'without countermeasures' strategy which is no longer an option*

Countermeasure strategies in ERMIN 2

- New concept of a 'now' which is a user-specified time after the start of the scenario



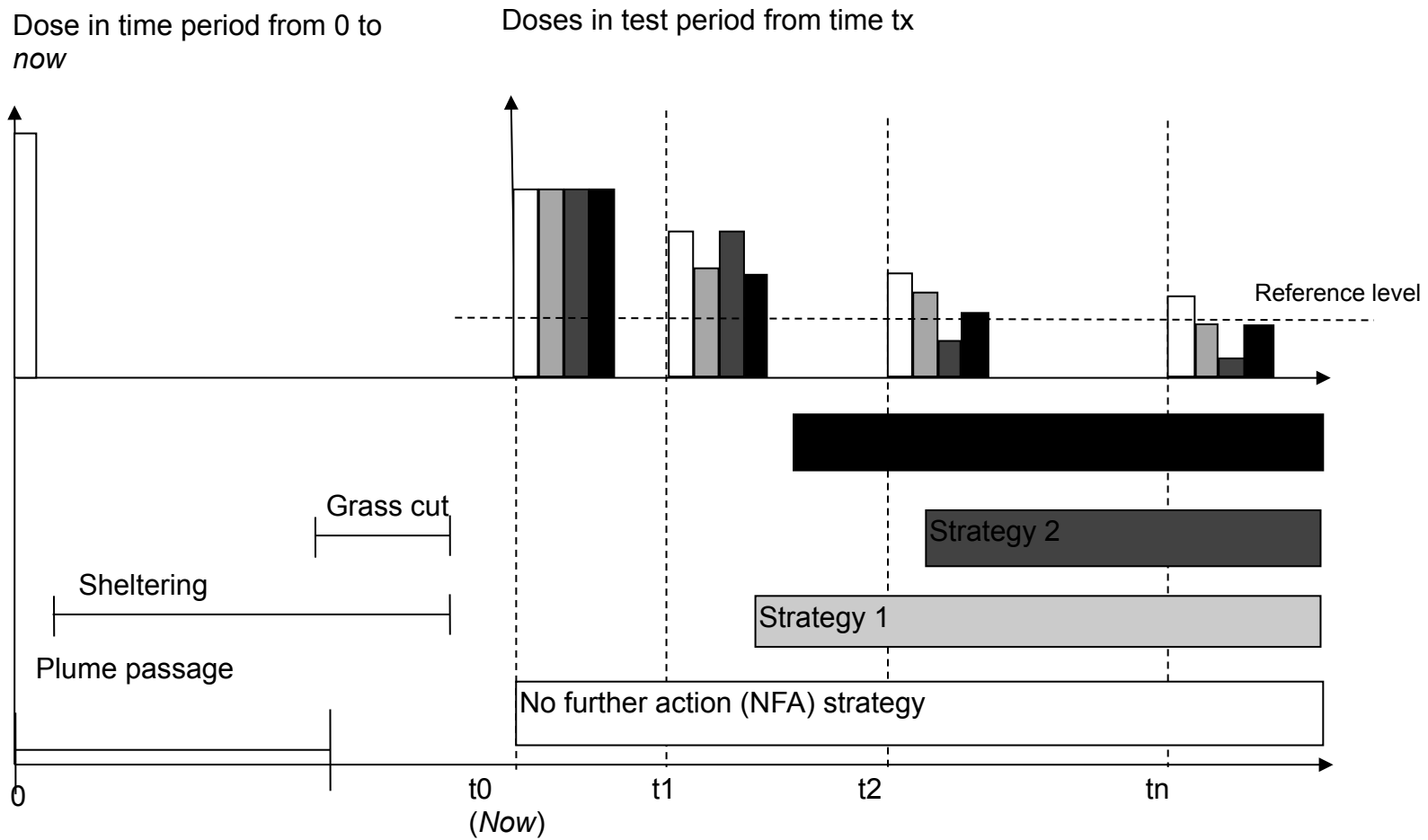
Example where several events have occurred before now: Plume passage over the area, sheltering during that time span, grass cutting soon after plume passage

- The public will receive a dose in this period but this dose has happened in the past
 - *ERMIN estimates the components of dose coming from the external irradiation from deposited material and inhalation of resuspended activity pathways, but not the components directly from the plume so ERMIN's estimate of dose in this period is incomplete*

Countermeasure strategies in ERMIN 2 - User input

- The user specifies a time for now and defines the 'no further action' strategy (NFAS) in terms of times and locations of emergency and recovery countermeasures that have been implemented before now
 - *All alternative strategies include the options in the NFAS and cannot contain options that are incompatible with those in the NFAS. For example grass cutting cannot be implemented after ploughing of the same surface.*
- In order to evaluate the success of strategies including the NFAS, the user specifies a reference dose level and integration period (typically a year). ERMIN then estimates the residual public doses at a number of times under each strategy

Countermeasure strategies in ERMIN 2 - Example



Countermeasure strategies in ERMIN 2 - Explanations to the example

- New form of presentation of projected public dose: Sequence of bar charts with a reference level imposed
- In the example, for the first test period no strategy brings the projected residual dose below the reference level
- In the second test period the effect of the countermeasure strategies can be seen but still no strategy can bring the projected dose below the reference level
- By third test period strategy 2 is predicted to bring the dose below the reference level and the projected doses with strategy 3 are very close
- On this information alone strategy 2 would be selected. However ERMIN provides other information such as worker doses, waste generated and cost that might rule strategy 2 out and the user may prefer to refine and implement strategy 3

Stages of user interactions with ERMIN 2

- The interface for interacting with ERMIN 2 is implemented in JRodos as a tabbed panel (a sequence of tabs)



- Operating ERMIN 2 consists of
 - a **set-up stage** which proceeds in a number of steps
 - an **interactive stage** in which the user The user can explore different strategies and look at results, using tab sheets [Recovery Countermeasures] and [Countermeasure Wizard].
- The transition between the two stages is characterised by executing the benchmark "No further action" case

Countermeasure Wizard - What does/can it do?



- First version: Filters out all possible countermeasures for the surfaces that contribute more than a given limiter value to the overall dose, in "wizard analysis zones" ("WZs") defined by the user

The wizard analyzes for each WZ and ERMIN2 test time T , the dose sum from the contribution of the surfaces s in the environmental breakdowns covered by the WZ:

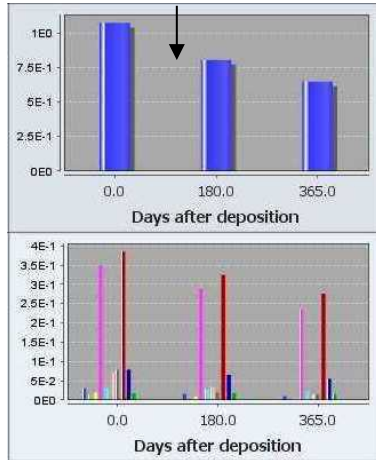
$$SD(s; WZ, T) = \sum D(s, g; T) \text{ for all } g \in WZ$$

D : individual effective dose from surface s resulting from the user specified pathways to members of the public for output time T

*The wizard then makes a ranked list containing all $SD(s)$ doses: maximum value, next smaller value, ..., smallest value. When this is done, all actions are collected that are applicable to the encountered surfaces. This process starts with the surface belonging to the dose that contributes most to the dose sum SD , continues with the surface belonging to the dose with the next smaller contribution, and so on, down to doses that are given a factor lower than the maximum value - the "**dose cut**" value. By default, doses are considered until they are by a factor of 10 lower than the maximum value, (user selectable).*

Application example (Trnava 2013 scenario)

Wizard analysis →
of NFA run



Surfaces

- Road
- Pavement
- Other paved
- Roofs
- Walls
- Internal surfaces
- Trees
- Small area of grass
- Small area of plants
- Small area of soil
- Large area of grass
- Large area of plants
- Large area of soil

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8: Small area of grass  1.05E1 Sv
Found the following applicable recovery actions of 'generally applicable' type
 9:Cover with clean soil; incompatibility value 0%
11:Rotovating; incompatibility value 0%
16:Cover with asphalt-small scale; incompatibility value 0%
33:Tie-down with water; incompatibility value 0%
39:Mechanical top soil and turf or plant removal and soil replacement; incompatibility value 0%
37:Mechanical top soil and turf or plant removal; incompatibility value 0%
41:Mechanical top soil and turf removal, soil replacement and return; incompatibility value 0%
43:Mechanical top soil and turf or plant removal, soil replacement and reseed; incompatibility value 0%
54:Grass cutting; best applied soon after dry deposition; incompatibility value 0%

4: Roofs          9.56E0 Sv
Found the following applicable recovery actions of 'constraints on application' type
 8:Firehosing roofs; applicable after any deposition conditions; incompatibility value 0%
15:Roof brushing; incompatibility value 0%
19:Roof cleaning with pressurised hot water; incompatibility value 0%
27:Peelable coatings; incompatibility value 0%
63:Roof replacement; incompatibility value 0%
64:High pressure hosing roofs; incompatibility value 0%
32:Tie-down to buildings with vinacryl; incompatibility value 0%

9: Small area of plants 2.15E0 Sv
Found the following applicable recovery actions of 'generally applicable' type
 9:Cover with clean soil; incompatibility value 0%
11:Rotovating; incompatibility value 0%
16:Cover with asphalt-small scale; incompatibility value 0%
33:Tie-down with water; incompatibility value 0%
39:Mechanical top soil and turf or plant removal and soil replacement; incompatibility value 0%
37:Mechanical top soil and turf or plant removal; incompatibility value 0%
43:Mechanical top soil and turf or plant removal, soil replacement and reseed; incompatibility value 0%
56:Plant removal; best applied soon after dry deposition; incompatibility value 0%

7: Trees          2.15E0 Sv
Found the following applicable recovery actions of 'constraints on application' type
58:Tree removal/pruning; best applied soon after dry deposition; incompatibility value 0%
59:Tree removal and replacement; best applied soon after dry deposition; incompatibility value 0%

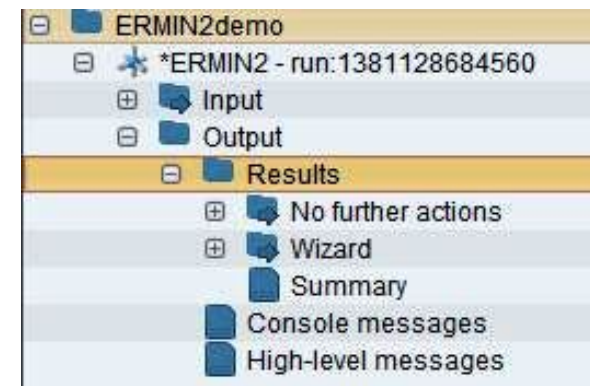
6: Internal surfaces  1.98E0 Sv
Found the following applicable recovery actions of 'generally applicable' type
22:Washing interior surfaces; applicable after any deposition conditions; incompatibility value 0%
    
```

Result selection in ERMIN 2

- ERMIN2 generates summary results and map-type results

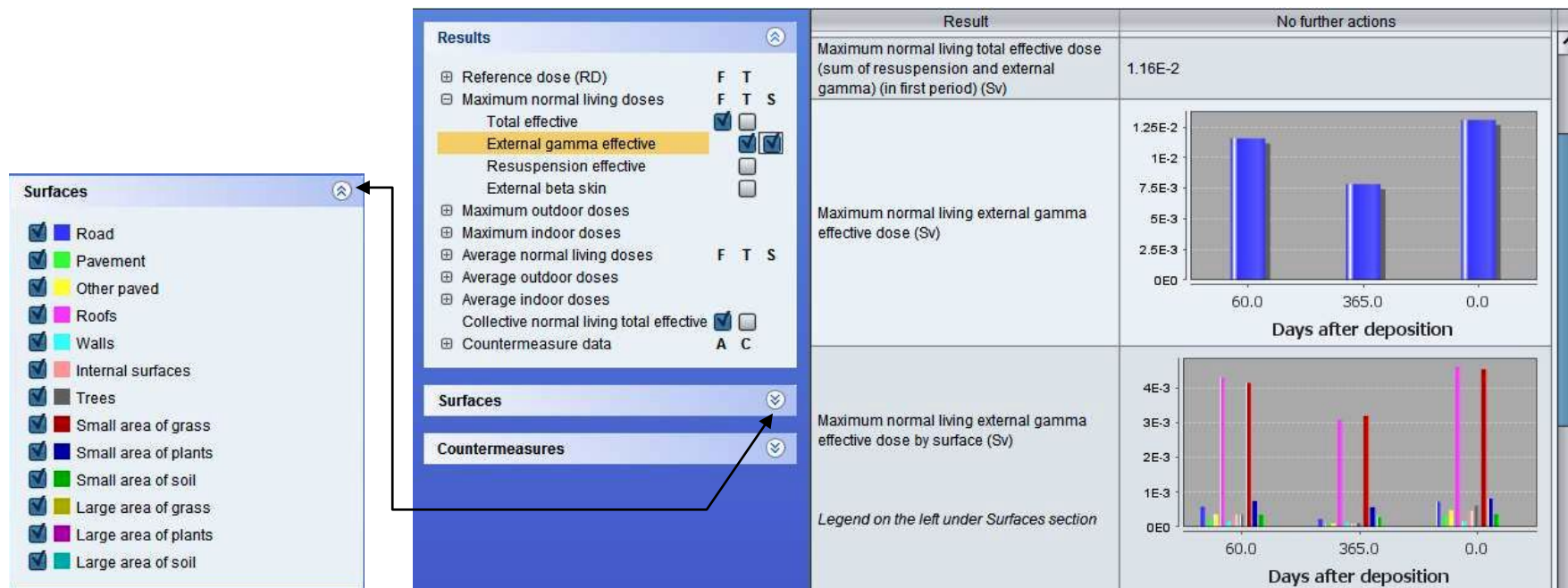
Other than in ERMIN1 you may request both results separately, by pressing the [Generate Summary] or the [Generate Maps] button

- JRodos Result Tree for a successful ERMIN2 run
 - If [Generate Maps] was requested
 - A folder for map results for the **No further actions** case
 - A folder for map results for each analyzed Recovery strategy
 - If wizard was run
 - Folder with tabular results for each wizard analysis zone
 - One leaf with the **Summary** table



"Summary Table" in ERMIN 2

- Summary results are displayed as a table (as in ERMIN 1)
- **Important new graphical element:** A "drill-down" control board allowing the user to drill down from a few headline results to more detailed results, with respect to **result type**, **test times** and **surface types**



The screenshot displays the ERMIN 2 interface. On the left, a 'Surfaces' panel lists various surface types with checkboxes: Road, Pavement, Other paved, Roofs, Walls, Internal surfaces, Trees, Small area of grass, Small area of plants, Small area of soil, Large area of grass, Large area of plants, and Large area of soil. The 'Results' panel shows a tree view of results, with 'External gamma effective' selected. The 'Result' table shows the following data:

| Result | Value |
|--|---------|
| Maximum normal living total effective dose (sum of resuspension and external gamma) (in first period) (Sv) | 1.16E-2 |
| Maximum normal living external gamma effective dose (Sv) | 7.5E-3 |
| Maximum normal living external gamma effective dose by surface (Sv) | 4E-3 |

Two bar charts are shown. The top chart, titled 'Days after deposition', shows the total effective dose at 60.0, 365.0, and 0.0 days. The bottom chart, also titled 'Days after deposition', shows the external gamma effective dose by surface type at the same time points. A legend on the left under the 'Surfaces' section identifies the colors for each surface type.

Countermeasure Wizard (continuation)

- In the **first version**, the identified possible actions are passed to the user in form of a table
 - The "implementation" of all or selected actions from the list must be carried out by hand by the user via the [Recovery Countermeasures] tab sheet
 - The [Recovery Countermeasures] tab sheet contains a new button "Table", that allows to sort actions by efficiency with respect to time, waste produced and other useful quantities. This - together with the list produced by the wizard - is already a great help for the inexperienced user to select from the more than 60 offered actions suitable ones (or maybe even more important, to avoid selecting unsuitable ones).

Following versions will make the filters more sophisticated and the reduction and selection of actions more automatic.

Application example (Trnava 2013 scenario)

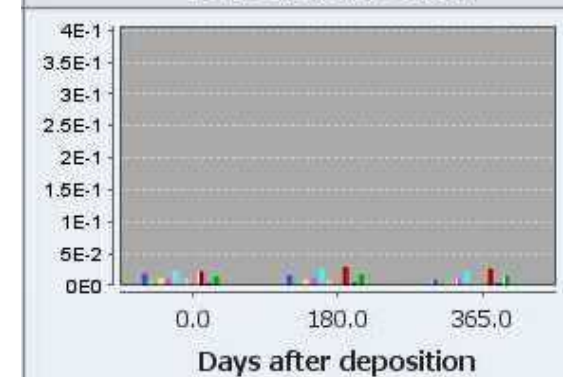
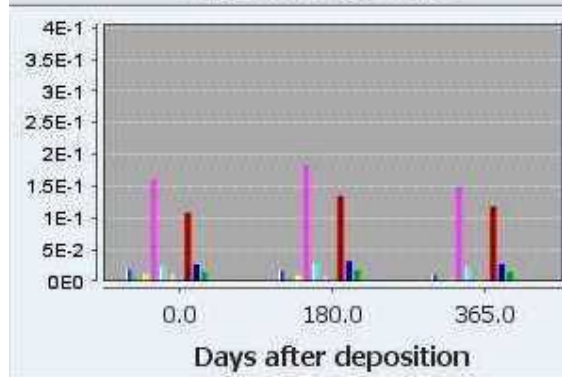
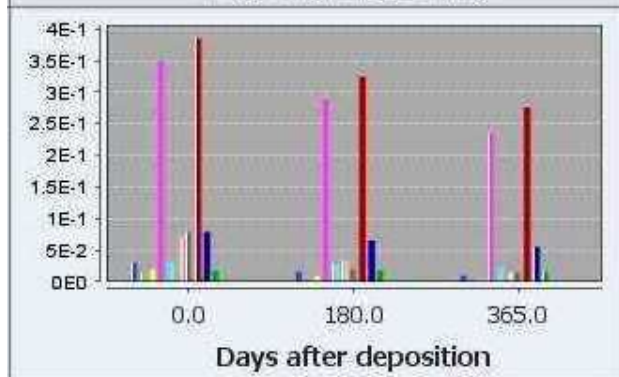
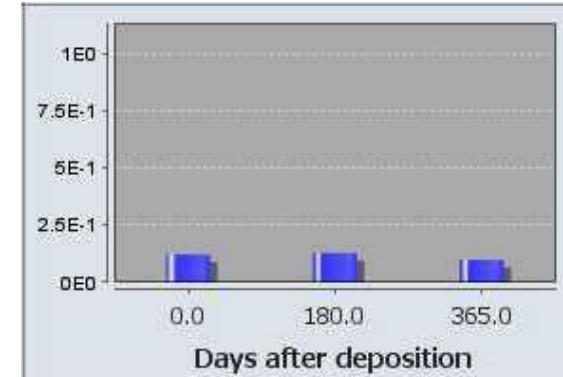
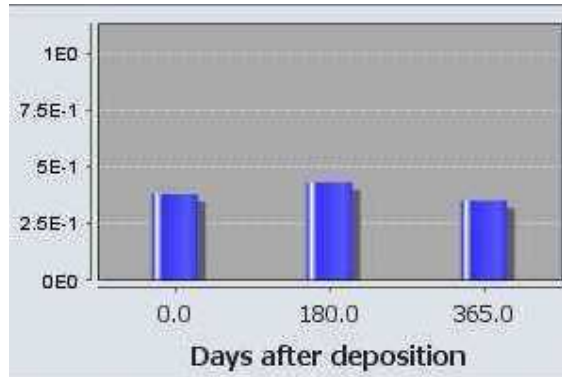
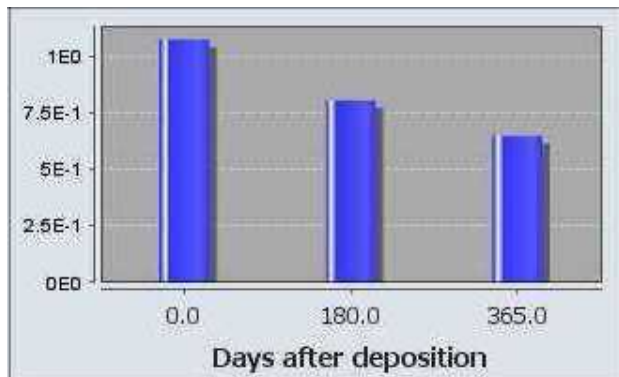


Two sets of actions ("strategies") selected from wizard table

"No further action"

"Soft" grass cutting, plant/tree removal, fire housing roofs; washing interior surfaces

"Heavier" mechanical top soil removal+replacement, roof cleaning with pressurized water; washing interior surfaces



Summary - ERMIN capability in general -

- ERMIN can help to:
 - Assist in the development of appropriate combination of clean-up and other countermeasures for an inhabited area, in particular with the aim to enact measures that reduce future doses so that normal life can resume as soon as possible within the affected area
 - Assist in the interpretation of limited data as measurements start to become available
 - Assist in the development of a measurement strategy in inhabited areas and in identifying where further measurements would be most useful
- ERMIN is not designed to provide location specific individual doses and dose rates that can substitute for actual measurements

Summary - ERMIN2 -

- ERMIN 2 is the first major update to ERMIN
- The changes have been driven by user feedback and by new ICRP recommendations
- The underlying model has not been changed. By changing the way it is presented to the user we think that it will become a much more effective tool
- The new functionalities are realised in January 2013, except e.g. for the coupling with the SCREEN model
- The wizard is operational in a first test version; it identifies most significant contributors to the dose and lists the specific recovery actions that can reduce their contributions

Thank you for your attention

Questions?