# 'EURISOL Desktop Assistant Toolkit' (EDAT): A Modeling, Simulation and Visualization Support to the Preliminary Radiological Assessment of RIB Projects

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***Abstract:***

The paper describes an approach taken within EURISOL-DS project (*European Isotope Separation On-Line Radioactive Ion Beam Facility*) to a number of safety and radioprotection issues raised by the advent of radioactive ion beam facilities in the cutting edge area of particle accelerators. The ensuing solution emerged from a collaborative effort of the investigating team-in-charge, affiliated with *'Horia Hulubei' National Institute of Physics and Nuclear Engineering* in Bucharest, with expert colleagues at the Physics Institute in Vilnius, and at CERN, within the participation in the EURISOL-DS project, *SubTask B: Radiation, Activation, Shielding and Doses* of the *Safety and Radioprotection* Task 5. The work was primarily geared towards the identification of knowledge and data in line with validated, accepted and nationally/internationally-recommended methods and models of radiological assessment applied within the nuclear power fuel cycle, deemed to be suitable for assessing health and environmental impact of accelerator operations as well. As a result, a computer software platform code-named 'EURISOL Desktop Assistant Toolkit', was developed. The software is, *inter alia*, capable to assess radiation doses from pure or isotopically mixed open or shielded point sources; emergency response-relevant doses; critical group doses via complex pathways, including the air, the water, and the food chain and Derived Release Limits for the normal, routine operations of nuclear facilities. Dedicated data libraries and GIS (Geographic Information System) facilities assist the input/output operations.

# 1. INTRODUCTION

## 1.1. The Framework

A major scientific and engineering enterprise of, potentially, vast financial and logistic complexities, project EURISOL-DS had to a large extent revolved around a feasibility study [1] and a design study [2] intended '*to provide detailed engineering-oriented studies and technical prototyping work for the next-generation ISOL*[1] *Radioactive Ion Beam (RIB) facility in Europe*'. The study and the documentation generated in its trail had determined that the facilities in the respective class would produce exotic ions '*in quantities which are orders of magnitude higher than those currently available anywhere else in the world*'. As a

[1] ISOL – Isotope Separator Online (a.n.)

consequence, it was contended, a '*drastic increase*' of the radioactive inventory is expected - which in turn should take Safety and Radioprotection issues several steps higher on planner and operator agendas.

The novelty of the situation and the scope of the problem have determined the project's scientific management to first seek advice in an area where a consolidated expertise is available: in the physics and engineering of the nuclear power industry. It is in this context that IFIN-HH/DFVM[2] was called upon to investigate ways and means to transfer relevant knowledge and data, and adapt and develop appropriate methods and tools to assist the management of safety and radioprotection at RIB facilities [3].

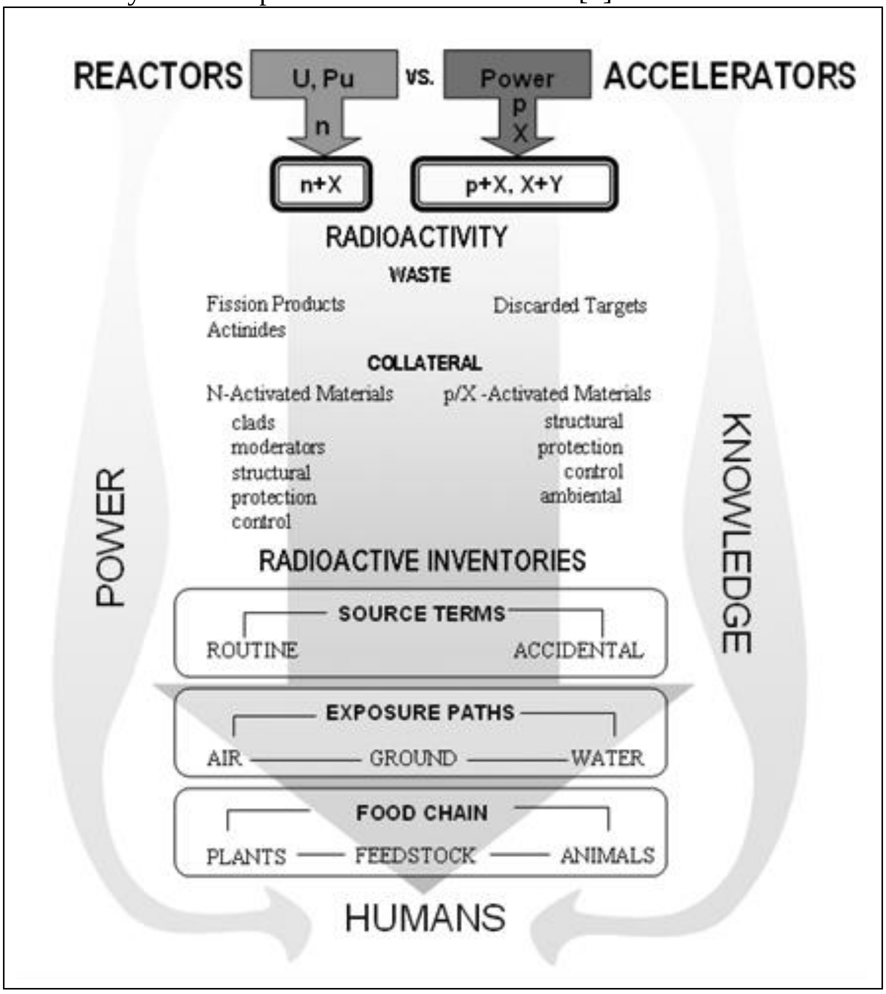


Fig.1 NPPs and Accelerators – differences and commonalities.

## *The Approach*

The mindset adopted by the investigators was patterned by the seminal observation that, despite vocational differences, the nuclear power and the particle accelerator businesses present several commonalities with respect to radiations handling and impacts (Fig.1). In essence, both activities dwell in large *radiation flows* and *flow rates* that may result in *large absorbed doses* and, inadvertently, *effective doses*.

The notable factors that, traditionally, made a difference between reactors and accelerators were that (i) reactors emphasized *radioactivity inventories* whereas accelerators emphasized *beam intensities*; and (ii) the main concern on potential health and environmental impact of reactors was *offsite* and targeted *the population at large*, whereas the concern on accelerator impacts was mainly *onsite*, and in regard with *occupational exposure*.

[2] DFVM – Department of Life and Environmental Physics

With the advent of RIBs these differences are largely gone, for indeed RIBs are also prone to generating and having to manage considerable activity inventories which, both under routine operations – as *waste*, or following loss of confinement accidents – as *leaks* may reach the offsite environment and, eventually, the population at large, via a variety of entangled pathways.

Once the commonalities were pointed out, the primary goal was to identify *models and methods* in the business of safety and radioprotection of nuclear power plants that may candidate for suitable tools to assess *radioactivity-related exposures* originating in RIB facilities. The solutions - as proposed and accepted by the EURISOL-DS management – were based on the authors' bias resulting from their affiliation to the *radiological assessment of the health and environmental impacts of the nuclear fuel cycle* in general, and the *radiological emergency preparedness and management* in particular (see e.g. [4 - 8]).

## 1.2. Objectives

From the outset, *an effective deliverable* was set as an objective, in the form of *a standing assessment capability* consisting in computer-based *problem solvers* ('*abaci')* and the supportive *knowledge and data libraries* – a toolkit intended to serve RIB facility planners, designers, and 3rd party assessors/auditors. The software embodying the concept came to be known as the '*EURISOL Desktop Assistant Toolkit'* (EDAT) (Fig.2).

The deontological posture adopted was to primarily focus on models and methods that are *validated*, *accepted*, and/or *recommended* by reference-national, and international, nuclear regulatory bodies.

The scope was determined so that the tools as developed would suit both the realm of emergency preparedness and response, and the monitoring of normal, routine operations.

The work has also been performed so that all deliverables, irrespective of nature and format, would organically relate to the declared priorities of the respective EURISOL task, namely:

- Provide a defendable calculation of radiation production and activation;
- Specify and characterize a sufficient shielding against prompt radiation and for the containment of activity;
- Determine the terms of a safe handling of targets and, in particular, of the disposal of spent targets;
- Display a demonstrable conformity with the regulations.

Consistently, the deliverables present such features as to provide for:

(i) ***independent verifications*** of most of results, or at least of the most sensitive results – the ones likely to have a heavier bearing on the radioprotection costs and effectiveness;

(ii) ***a standing working capability*** consisting in on-the-desk/on-the-shelf computer-based *knowledge and data libraries*, and *online abaci*, for the accelerator facility planners, designers, and 3rd party assessors/auditors.

## 1.3. Summary of the work

At the substantive level, the work covered:

- The identification, within the specialist literature, of primary knowledge and data sources as well as of *validated*, *accepted* and *recommended* by national and international regulatory bodies methods and models for assessing the health and environmental impact of nuclear facilities.

- The identification of knowledge, data, methods and models from the radiological assessment business as applying to the nuclear power fuel cycle, suitable for the accelerator physics (see Fig.1).

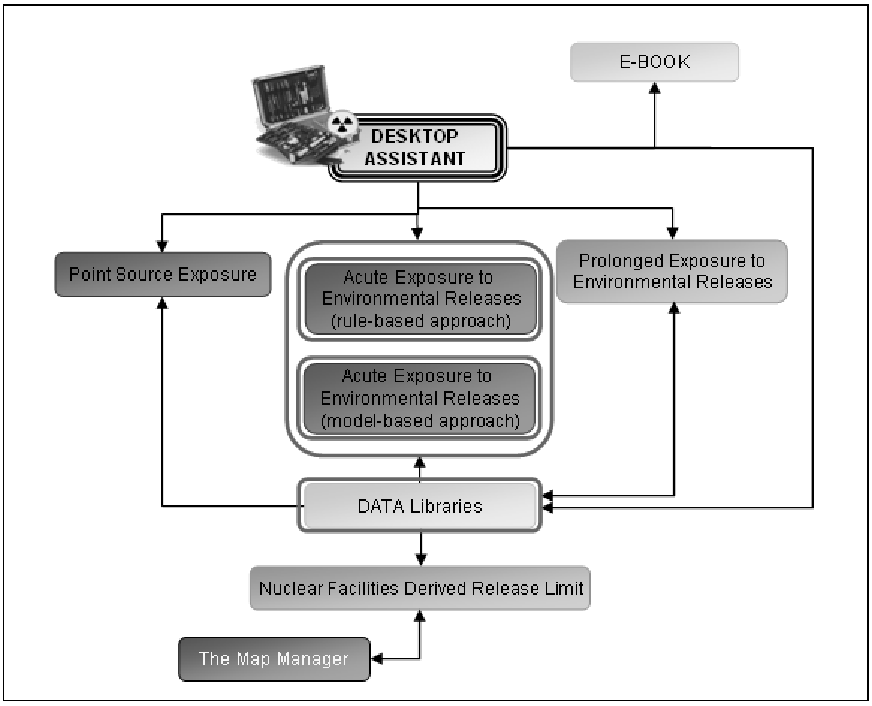


Fig.2 *EURISOL Desktop Assistant Toolkit'* (EDAT) – The structure.

- The development of the data and knowledge software libraries.
- The design and development of the general framework of the software platform for the assessment of the health and environmental impact of the nuclear facilities.
- The implementation of a set of models for:
  - The assessment of shielded/not shielded point-source exposure from pure- or isotopically-mixed open sources, given as dose-to-distance correlations.
  - The exposure- and intervention-relevant dose assessment, from direct correlations to known/estimated source terms, either isotopically-pure or mixed.
  - Critical group exposure via complex pathways, including the air, the water, and the food chain.
  - The assessment of health impact following normal, routine operation of the facilities (Derived Release Limits).
- The design, development and implementation of a custom, application-tailored Geographic Information System (GIS) to provide sufficient metric and other, useful features among which a doable solution to terrain elevation monitoring; raster land-scanning for cadastral categories; object-land scanning for identifiable assets; raster-oriented area statistics; object-oriented area statistics.
- The initiation of a wide scope, multimedia, object-oriented database.
- The integration of the space-sensitive assessment modules with the GIS as described.

A presentation of the modeling, simulation and visualization capabilities of EDAT is given in the sequel.

# 2. THE TOOLS.

## 2.1. THE OCCUPATIONAL EXPOSURE ASSESSOR

Targeting occurrences of direct irradiation, the occupational exposure assessment facility is based on a conservative Point Source Exposure method documented by the NRC-issued *RTM-95 International Technical Response Manual* [5]. This problem solver evaluates *exposures* (mR), *effective dose equivalents,* and *bone dose equivalents* (mrem) acquired from shielded or unshielded sources featuring pure isotopes or nuclide mixes. In this simplified, rule-based emergency-oriented model, build-up is not taken into account. The results of the code computations are given as *exposure/dose-to-distance* correlations (Fig.3). According to the reference authors, the model - that would primarily address radiation workers, may also be used for estimations of exposures and doses to the public in the event of, e.g. Goyana-type incidents.

The computation is performed based on a *Working case* (containing an isotope or a mix of isotopes) and various *values required by the computational procedure*.

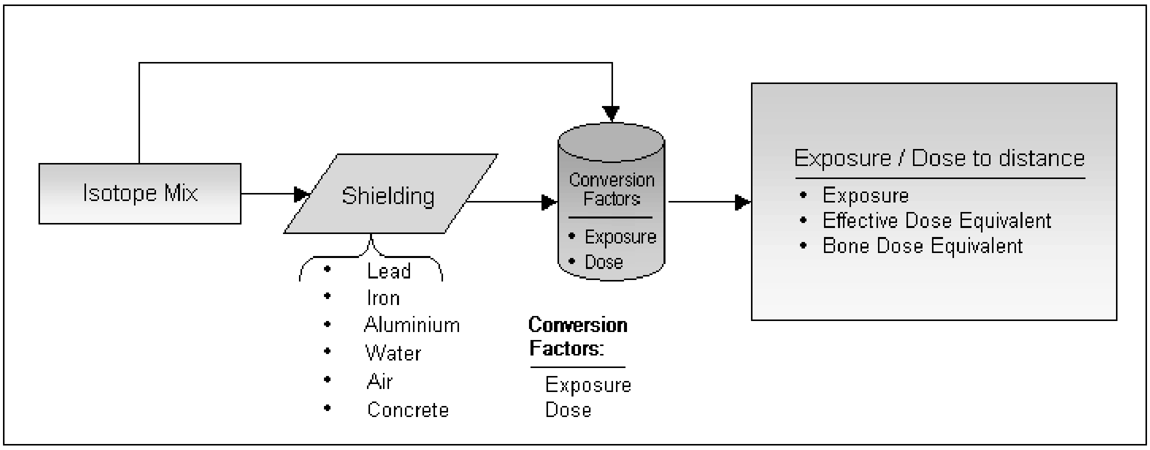


Fig.3 The Point Source Exposure Module– Workflow.

### 2.1.1. The Assessment

A *working case* is characterized by *nuclide related* code-extracted features (the Exposure Conversion Factor – *ECFp* , the Total Effective Dose Equivalent (TEDE) – *DCFp*, and the Bone Conversion Factor – *DCFpab*) and by *case-specific user-inputs* (the *relative proportions* of each nuclide in the total mix, and the *source total activity* [Ci]).

The *working case* is part of the input of the assessment phase. In addition, the assessment also requires: the *time of exposure* (hrs), the *shielding material* (nature and *thickness* of the shielding materials in cm), the *cut-off distance* (representing the distance down to which the computation is performed) and the *computational step* (the computations are performed in a *step*-by-*step* manner form the source origin down to the *cut-off distance*).

The results of the Point Source Exposure tool are given (i) in numerical format – a summary text file holding the case inputs and the assessment results (*exposure/dose-to-distance* correlations, provided in a tabular form), and (ii) as *graphical representation* of exposure/dose vs. distance based on the results from the output file. In-between the computed values the results are obtained through linear interpolation.

## 2.2. THE POPULATION EXPOSURE ASSESSOR

Targeting the observance of *protective action guides* (PAG) and *intervention (response) dose levels* (RDL), in the early-to-late phases of *accidental (short-term) environmental releases* with offsite consequences, the population exposure facilities articulate a series of utilities, including (i) a *radioactive inventory* manager; (ii) a release *source term* assessor; and (iii) an *atmospheric dispersion* evaluator integrating the effects of the meteorology of events - that all serve the acute (short-term-exposure-induces) *dose assessment engine*.

Two angles of treatment - and the respective computing facilities have been developed within EDAT, reflecting the major methodological approaches in the business: (i) the *rule-based* approach, comprehensively implementing FRMAC and NRC's *RTM Technical Response Manual* series starting 1991 and on, as well as the *International RTM-95* manual, endorsed in practice by the IAEA in Vienna – providing a fast, yet conservative assessment capability requiring minimum input data, and (ii) the *analytical* approach – a set of methods based on analytical solution of Gaussian equation, similar as have been used in PC-COSYMA atmospheric dispersion model [11], providing a greater flexibility in terms of input data and assessment options (dose conversion coefficients, meteorological conditions, dispersion coefficients, etc.).

All components work in close I/O (input-output) relationship with the overall platform's *data libraries*, and *geographical information system* (GIS).

Both sets of modules compute in the first phase the *organ doses for bone (red-marrow)* - $D_{bone}$, *lung* – $D_{lung}$, and *thyroid* – $CDE_{Thy}$, the doses from *cloud immersion* – $H_{air}$ and *groundshine and resuspension* $H_{grd}$. and the *commited effective dose equivalent (50y)* – $CEDE_{50}$. Having such values as contributors, the following *total doses* are computed in the second phase, as:

*TABD* - TOTAL ACUTE BONE DOSE

$$TABD = D_{bone} + H_{air} + H_{grd}$$

*TALD* - TOTAL ACUTE LUNG DOSE

$$TALD = D_{lung} + H_{air} + H_{grd}$$

*TEDE* - TOTAL EFFECTIVE DOSE EQUIVALENT

$$TEDE = CEDE_{50} + H_{air} + H_{grd}$$

While TABD and TALD would mainly relate to *health effects* of irradiation - both non-stochastic and stochastic, TEDE is relevant in *emergency response* (countermeasure) planning and execution.

The modules handling the occupational exposure are *Acute Exposure to Environmental Releases* (for the model-based approach) and *Acute Exposure to Environmental Releases (Rule Based)* for the rule-based approach.

### 2.2.1. The Rule Based Solution

#### 2.2.1.1. Description

The module computes the set of doses starting from a source term, taking into account the *release characteristics* – ground / elevated; the *meteorological conditions* – precipitation, stability class; and *sheltering.*

The results are given as dose-to-distance relationships, for the following emission types: *ground-no-rain, elevated-no-rain, ground-rain,* and *elevated-no-rain.*

The computation procedure implements a simple, straightforward, conservative method that may be summarized as follows: starting from pre-calculated Release Conversion Factors[3] (RCF) [mSv/kBq] corresponding to (i) distances smaller than 500 m, and (ii) distances between 1.5 and 2.0 km, the doses are adjusted (based on given, pre-calculated graphs) for different distances and to take into account the release types, meteorological conditions including atmospheric stability, and sheltering. The adjustment graphs are digitized and integrated into the assessment module.

The numerical results thus obtained can be rendered as dose to distance graphs (Fig. 4 a,b) and are also exported to the EDAT GIS system in order to obtain impact maps featuring isodose lines (Fig.4 c,d,e,f).

### 2.2.1.2. Modus Operandi

Under this module, the assessment is based on *scenarios*. A scenario is defined by (i) the isotope mix, (ii) the environmental / meteorological conditions (iii) sheltering assumptions. The scenario is run for different assessment running settings, depending on the user needs.

***The computational phase***

The computational phase starts from a *nominal source term* (isotope mix and their correspondent share).

The *nominal source term* is then adjusted to match the scenario requirements (total amount [Ci], [Bq] of released activity). EDAT provides the capability of performing the assessment also by taking into account the so-called *spent fuel pool fire nuclide-specific fraction* (see e.g.[5]) , to deal with the respective type of emergency .

The scenario is then fetched with the emission and meteorological data. Due to the nature of the approach - that compresses entire assessment sequences such as plume rise or rain effect into rules - only the *Pasquill stability class* and the *wind speed* are required as inputs.

Shielding factor may be considered for *external* and *inhalation* contamination. However, a different approach is taken, compared to the Source Point module: shielding is now considered as depending on the location of the subject being irradiated [5]. Shielding mitigating values may be selected from the pre-defined ones (open space, in a vehicle, in a wood-frame house – no basement, etc.) or may be user-defined.

The doses are computed on a step-by-step basis for distances ranging from 0 (release source) up to the *maximum downwind distance*. The *crosswind distance* may also be user-defined.

The results are reported in an output file containing the source term description, the working inputs and assumptions, the reference doses and the dose-to-distance outputs of the computational phase in a tabular format holding all the doses considered, for all possible combinations of release height and rain status.

***Results assessment***

The assessment phase requires opening an output file and examining the results either in numerical form, in a visual representation of dose to distance, or by mapping results on situation maps. This last feature proves useful especially in emergency situations when,

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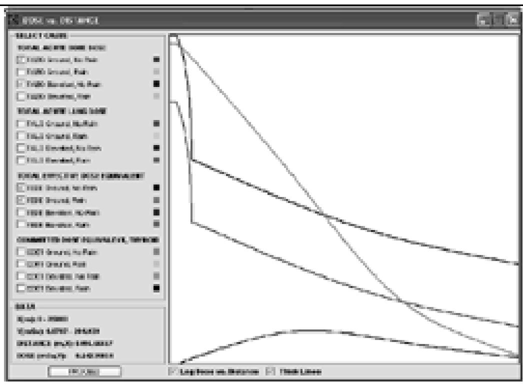
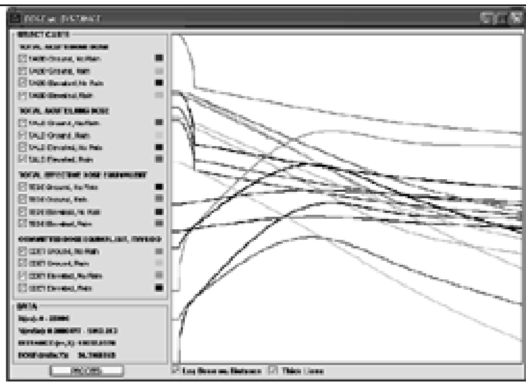
[3] The Release Conversion Factor (RCF) … when multiplied by a release quantity (kBq) will give a dose estimate for a ground level release with no rain, and relatively close to the source (1.5-2.0 km) / close to the source (<=0.5 km) [5]

combined for instance with Protective Action Guide (PAG) values, such maps are an expressive manner of communicating decision support elements to the response teams out in the field.

Protective Action Guides and Health Effect Levels are conveniently rendered at the interface, to assist the result assessment.



(a)



(b)

(c)

(d)

(e)

(f)

Fig.4 Acute Exposure to Environmental Releases (Rule-Based) Module (simulation).
(a),(b) Dose to distance interactive charts.
(c) isodose curves (impact areas): same source, same wind speed and direction, different dose limits: RED – TEDE GNR, 1 mSv, YELLOW – TEDE GNR, 1.5 mSv, GREEN – TEDE GNR, 2 mSv
(d) isodose curves (impact areas): same source, same wind speed, same dose limit, different wind directions
(e),(f) Results exported to Google Earth

## 2.2.2. The Analytical Solution

Looking at the same objectives as the rule-based approach, the *Model-based Acute Exposure to Environmental Releases* module implements a *dispersion engine* and a *dose estimator*, under the following sections:

- *Short Release – Area Assessment.* To be used in order to get the impact area of a given release.
- *Short Release – Spot Assessment.* To be used for determining the radiological impact of a given release at specific measurement points. The spot assessment should also be used when a dose-to-distance type of result is required.
- *Long Release.* To be used in order to get the impact area of a given, long-term release.

The sections share the same dispersion and dose estimator engines, as well as a backbone assessment methodology (Fig.5).

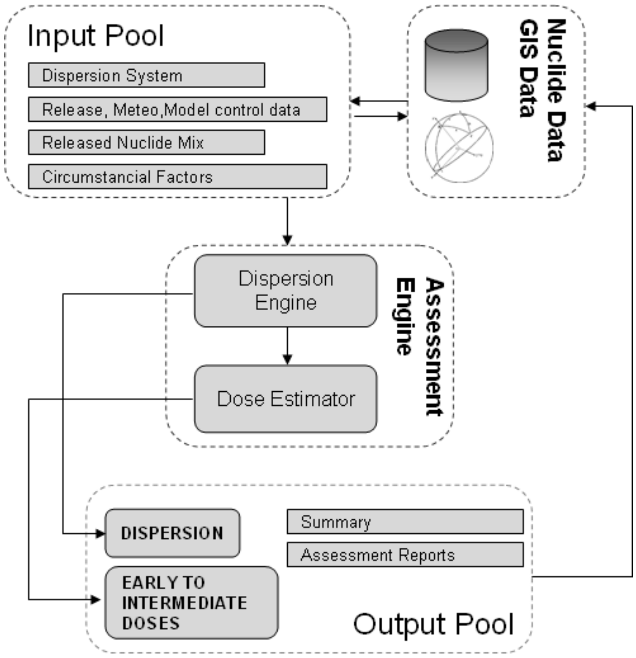


Fig.5 Model-Based Workflow

***The Input Pool***

The Input Pool contains all relevant data for the assessment process. Information of the Input Pool is nuclide-, environment-, and case-specific. The information comes partly from the user / analyst, and also from the EDAT geographic information system and the nuclide database system.

*The Dispersion System*

Specifying a dispersion system requires a choice of the $P_y$, $Q_y$, $P_z$, $Q_z$ values used in the computation of the horizontal and vertical standard deviations $\sigma_y$ and $\sigma_z$, as well as of the *reference boundary layer height* and the *vertical wind shear exponent*. Values are to be given for each of the six Pasquill stability classes (A-F).

EDAT offers four dispersion systems:

- COSYMA (default) – in fact, the Karlsruhe-Julich coefficients, computed for *mild hilly land, Central Europe,*
- Brookhaven – characteristic for *industrial areas*,
- St. Louis – suitable for *U.S. cities - the tall building areas*,
- Klug – *for water mirrors and bare flat land*.

As recommended in the EU guidance [12], whenever feasible analysts should seek to perform realistic assessments by taking into account site specific conditions, as opposed to generic, or screening, assessments.

Custom dispersion coefficients (new or edited on the existing ones) may be created by running a ‘Dispersion Data Editor’.

*Release, meteo, model control data*

This mainly organizes the input data required by the dispersion engine. The inputs characterize the emission, the meteorological conditions at the time of emission and several model and computational parameters that may be used for tuning the assessment.

The release-related inputs include the *release height* (mAG), *plume rise* (m) and *release duration* (s).

The meteorological data are: the *reference height* (mAG) – the normal height for wind speed measurement (anemometric wind) - usually 10 m above ground; *wind at reference height* (m/s); *wind direction* (decimal degree, from N by E); *atmospheric stability* (A-F) – Pasquill; *rain duration* (s); *rain intensity* (mm/h)

The model and computational parameters comprise: the *initial (building wake-induced) horizontal standard deviation* (m); *initial (building wake-induced) vertical standard deviation* (m); *maximum number of inversion cap reflections*; *accepted error in computing dry depletion integral (Simpson)*; *maximum number of iterations in computing dry depletion integral (Simpson).*

At the core of the 'Source Term' is the *nuclide mix* - a list of the nuclides released, along with case- and model required nuclide-specific data. Every nuclide of the mix is described by *name*; *activity (Bq or Ci)* – the activity of the specific nuclide in the mix; *halflife (d)*; $DCF_{e,50}$ $\left(\frac{mSv/h}{kBq/m^3}\right)$ – dose conversion factor for the Committed Effective Dose Equivalent (CEDE); $DCF_{bone}$ $\left(\frac{mSv/h}{kBq/m^3}\right)$ – dose conversion factor bone (red-marrow); $DCF_{lung}$ $\left(\frac{mSv/h}{kBq/m^3}\right)$ – dose conversion factor lung dose from inhalation; $DCF_{gi}$ $\left(\frac{mSv/h}{kBq/m^2}\right)$ – dose conversion factor dose from groundshine; $DCF_{ai}$ $\left(\frac{mSv/h}{kBq/m^3}\right)$ – dose conversion factor dose from cloud immersion.

***The Assessment Engine and the Output Pool***

The computational phase is dealt with at the Assessment Engine level. The computation mainly entails the determination of *time integrated concentration* in the first phase (Dispersion Engine) then, in the second phase, the computation of the *doses* subject to the assessment (Dose Estimator).

The Assessment Engine is used in different ways, depending on the selected assessment module (Area Assessment, Spot Assessment, Long Release). However, for any single call of the engine (assessment in a single point, for a single nuclide), the following results are provided:

**DISPERSION RELATED (Dispersion Engine Output)**

RAW NORMALIZED DILUTION (1/m2)
RAW EFFECTIVE DILUTION (s/m3)
Plume Travel Time (h)
Effective Rain Time (s)
Effective Plume Centerline Height (mAG)
Effective Wind Speed (m/s)

Horizontal Standard Deviation (m)
Vertical Standard Deviation (m)
Generic Dry Depletion Factor

**EARLY TO INTERMEDIATE DOSES (Dose Estimator Output)**

Dose Equivalent from Air Immersion, $H_{ai}$ (mSv)
Dose Equivalent from 2-day Groundshine and Inhalation of Resuspension, $H_{g1,i}$ (mSv)
Dose Equivalent from 7-day Groundshine and Inhalation of Resuspension, $H_{g2,i}$ (mSv)
Committed Effective Dose Equivalent, 50-year, from Inhalation, $CEDE_{e50,i}$ (mSv)
Acute (2-day) Bone Dose from Inhalation, $D_{bone,i}$ (mSv)
Acute (2-day) Lung Dose from Inhalation, $D_{lung,i}$ (mSv)
Committed Dose Equivalent to Thyroid, $D_{thyroid,i}$ (mSv)
TOTAL ACUTE BONE DOSE (mSv)
TOTAL ACUTE LUNG DOSE (mSv)
TOTAL THYROID DOSE (mSv)
TOTAL EFFECTIVE DOSE EQUIVALENT (mSv)

The intermediate results are passed on to the Output Pool. Basically, at the Output Pool level the assessment results are formatted, different kind of reports are generated, the cases (scenarios) are archived and prepared for the evaluation phase.

***The shared assessment workflow***

Despite the natural differences specific to the different tasks served, the Acute Exposure modules have been designed so as to observe the same basic workflow, as follows.

***Step 1.*** Select the Dispersion System
***Step 2.*** Set / Open Case Data
***Step 3.*** Open / Create the Release Mix
***Step 4.*** Set Source Scaling Factor
***Step 5.*** Set the Exposure Duration
***Step 6.*** Set the Resuspension Factor
***Step 7.*** Set Predominant Iodine Form (aerosol associated, $I_2$ or $CH_3I$)
***Step 8.*** Other Module-Characteristic Inputs
***Step 9.*** The Case Assessment
***Step 10.*** Results wrap-up
***Steps 8*** and ***10*** are presented separately, for each assessment module.

### 2.2.2.1. Acute Exposure to Environmental Releases. Spot Assessment.

The Spot Assessment module has been designed to serve the following purposes:

(i) obtain an assessment of an atmospheric release at user-specified measurement points (*Spots-by-Map*); or

(ii) get a dose-to-distance type dose assessment (*Spots-by-Map*).

*Spots-by-Number Specifics*

In terms of additional input data, the Spots-by-Number requires the following case-related information: the *downwind distance* – distance up to which the computation is performed, starting from source; the *crosswind distance* – horizontal distance on the Y-axis; the *vertical distance* – the elevation from ground; the *step* – the computational step (assessment resolution).

The chief results of an assessment performed with the Spot Assessment Module – Spots-by-Number are wrapped-up in an output file, containing (i) the case description (input data) and (ii) a list of individually assessed spots downwind to the *downwind distance*.

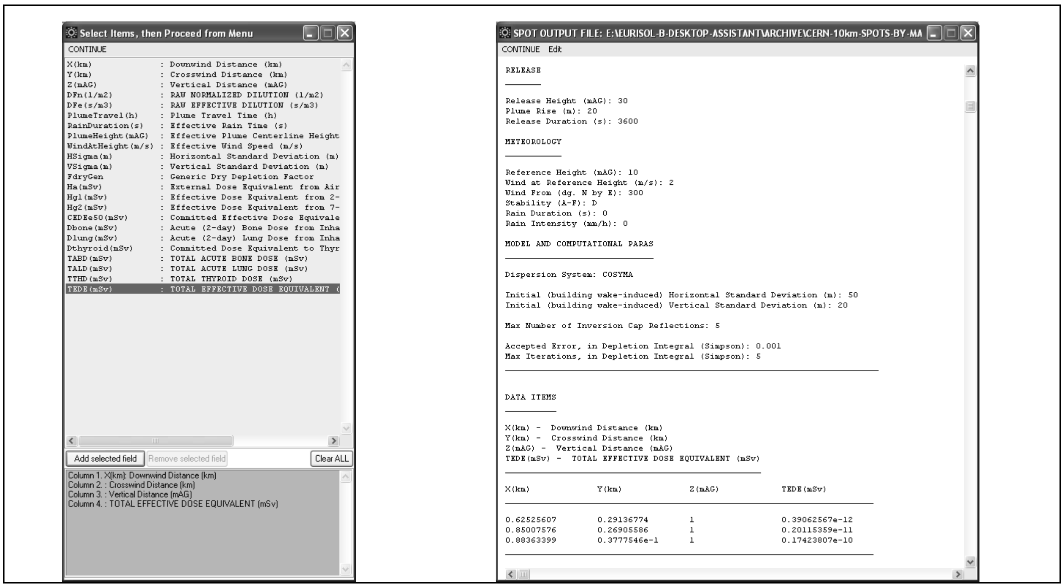



Fig.6. ‘Organizing’ output. Snapshots

The results may be 'organized' – the output is rearranged in a table-style format, containing the user-relevant results. The user may choose the outputs to be contained in the table-style result. Fig.6 shows the 'ORGANIZE' window; the X, Y, Z and TEDE values have been selected for displaying.

*Spots-by-Map Specifics*

'Spots-by-Map' works in conjunction with EDAT’s integrated GIS. Accordingly, the workflow is changed as follows:

*Step 8. Spots-by-Map*

In a typical working sequence,

8.1. The user is prompted for a situation map.
8.2. The *release source* is interactively selected from the situation map (‘click-and-get’).
8.3. The *Spots of Interest* are chosen (‘click-and-get’)
8.4. The user is advised to repeat Step 8.3 for each desired spot.

The EDAT 'GIS engine' is responsible with all the metric operations employed in Step 8. Thus, once the release source is set, the spot-to-source relationships required by the assessment engine are determined by the GIS (effective, downwind and crosswind distances, the angle between wind direction and source to spot ray, etc.) This is a typical case of the GIS being used both for feeding the assessment engine, and as a result representation media.

The output may also be formatted by using the 'Organize' feature. The structure of an organized file is:

1. Release description cartouche.
2. Case Meteorology cartouche
3. Model and Computational Parameters.
4. Data Items cartouche – lists the selected output information to be displayed
5. The Data Table holding the assessment results for each spot considered.

In addition, the results may be 'Google Earth-ed', that is - represented on the Google Earth (TM) client-side web platform. The considered spots are exported as *pinpoints*. The assessment results are attached to each pinpoint (See Fig.7)


(a)

(b)

Fig.7. Spots by Map results on Google Earth ™ (simulation)
(a) Situation Map; (b) Assessment result as pinpoint description

#### 2.2.2.2. Acute Exposure to Environmental Releases. Area Assessment

The Area Assessment module should be used for determining the impact area of an atmospheric release. The impact area is the region where a given variety of dose, relating to either a health effect or a required countermeasure is higher than, or equal to a prescribed level. *Impact maps* (static and dynamic), *statistics* of the affected area and *worksheets* are the chief results of the assessment (Fig.8a).

The module implements a stack-filling algorithm for determining the reference isodose / dilution factor bounded area. In a second phase *raster* (color-based) and *object* statistics are performed in order to get quantitative impact values (area affected, land-use, buildings, etc.)

The assessment phase intensively relies on the GIS engine. To begin with, the *release source* is interactively selected from the situation map on a 'click-and-get' manner.

The *reference value* (affected area bounding) refers both to a *target quantity* and to a *threshold limit*. Any of the quantities provided as results by the Assessment Engine (Dispersion Engine and Dose Estimator Engine outputs) may be chosen as *reference value*. The *threshold limit* may be either interactively selected – by choosing a reference location on map – or given in numerical form.

In the first case, a full radiological assessment is performed at the reference spot specified by the user. The *threshold limit* may thus be selected from the values returned by the assessment. The GIS engine handles the spatial operations (determination of downwind and crosswind distances) and also performs some consistency checks, e.g. eliminating irrelevant locations falling behind the release source with respect to wind direction. Directly providing the threshold limit in numerical form is obviously required when relating the assessment with PAG limits (e.g. getting the *sheltering* area according to the IAEA sheltering PAG – TEDE >=1000 mrem in less than 7 days).

The map results may be augmented with descriptive reports resulting from (i) an *Object Statistics* process identifying the relevant landmarks (hospitals, schools, administrative buildings, etc.) within the affected area that are queried against the spatial databases, and (ii) a *Raster Statistics* process – a color-based raster analysis of the situation map (e.g. land-use).

The assessment results are available as a *statistics result file*, a HTML *assessment report* and *static and dynamic* (Google Earth ™) *situation maps*. The report contains all the relevant case-data and assessment results. Among these one may find: the Static Source Map, the Static Situation Map, the Analytic I/O summary, as well as a link to the Dynamic Situation Map (*Google Earth* kml file).

#### 2.2.2.3. Acute Exposure to Environmental Releases. Long Release

This module handles the health and environmental impact of long term (in the order of days) radioactive releases to atmosphere. The assessment is conducted over a 16 sector wind rose, considering the wind distribution per sector.

Using this module implies two phases: (i) a scenario simulation; and (ii) the result examination and mapping. In addition to the inputs shared with the other acute exposure modules, the assessment engine should be provided in this case with: the *assumed release duration* (s); *the meteorological data file* containing the meteorological characterization of each of the 16 wind sectors considered; the *downwind distance* (m) – distance up to which the computation is performed, starting from source; the *crosswind distance* (m) – horizontal distance on Y axis; *vertical distance* (m) – elevation from ground; the *step* – the computational step (assessment resolution).

Each wind sector *i* is characterized by: the *sector fraction* (%) – the percentage of time over which wind blows within the sector; the *sector stability fraction* for each of the 6 Pasquill stability classes – the percentage of time the wind blows in sector *i* and stability class is A-F; the *wind at reference height* (m/s); *wind direction* (degree, from N by E) ; the *rain duration* (s); the *rain intensity* (mm/h); the *release height* (mAG), and the *plume rise* (m).

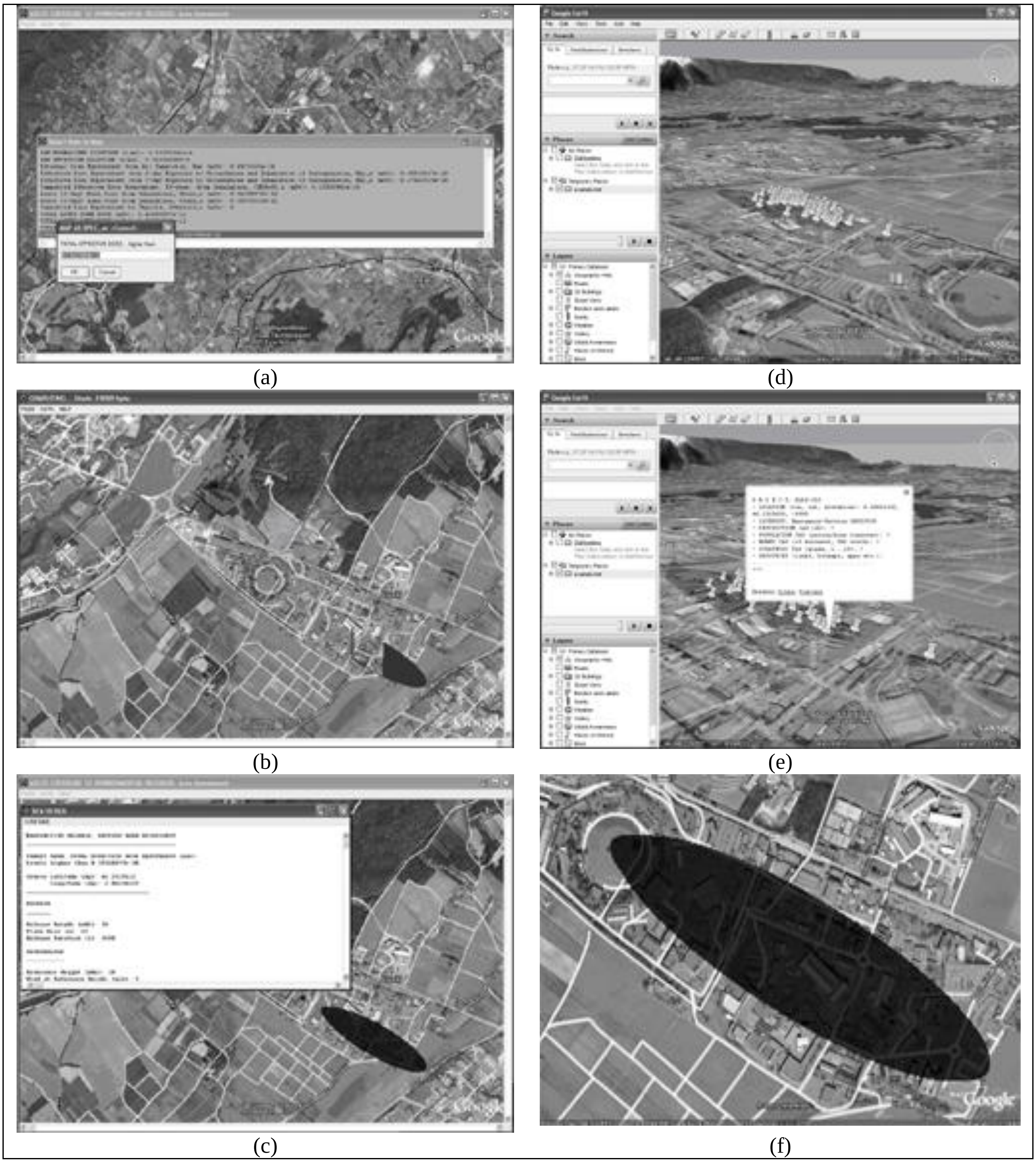


Fig. 8 Area Assessment (simulation) – snapshots.
(a) setting-up simulation; (b) stack fill algorithm; (c) results; (d,e) spotwise information; (f) area information.

Running the long-term emission scenario requires looping through the following operations, over the 16 wind sectors:

- Compute dilution factors from source to *downwind distance,* with the given *step.*

- Determine average dilution crosswind in all stability classes (A-F) , weighting classes by the fractions each class manifests itself.

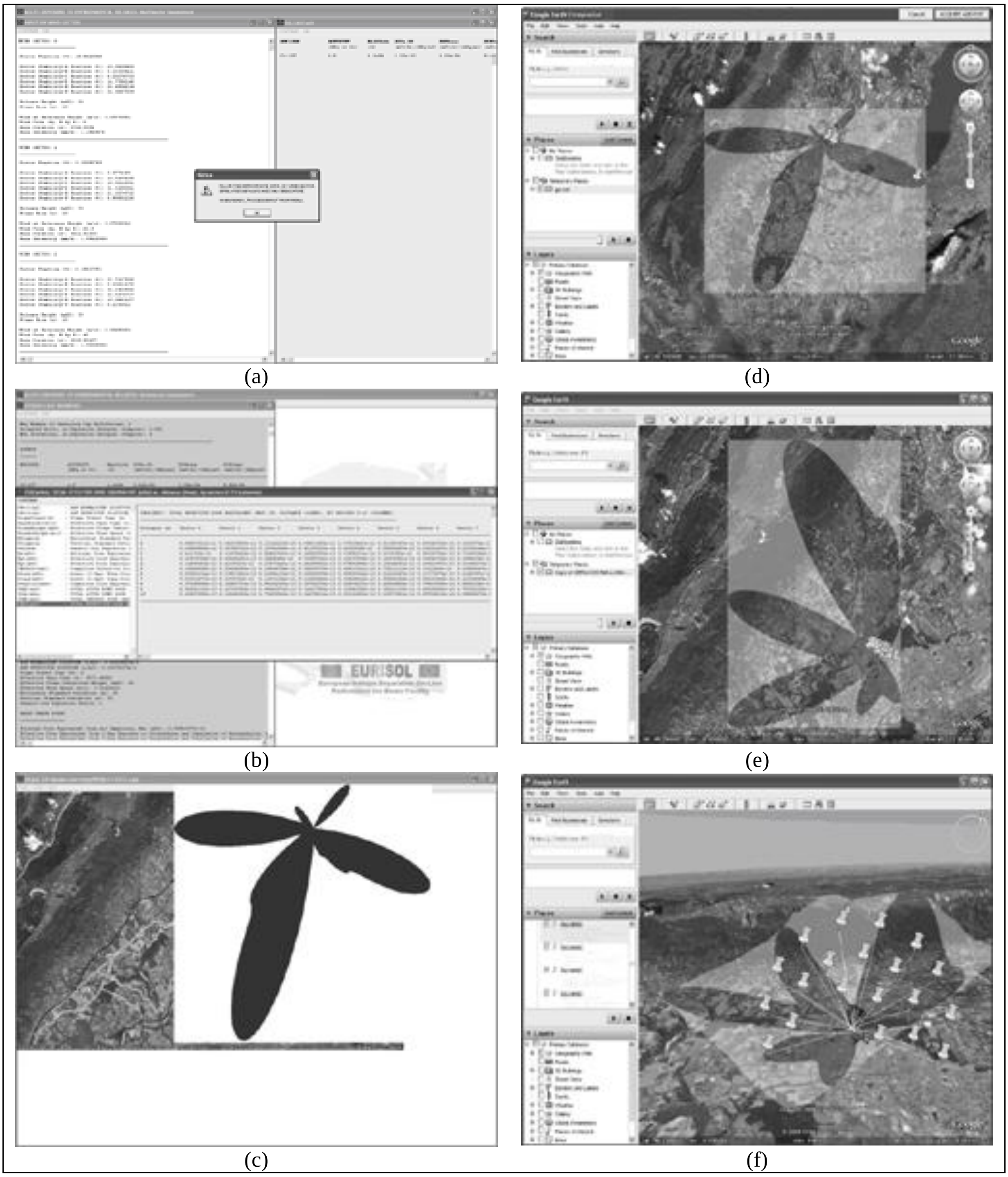



Fig.9 Long-Term Assessment (simulation) – snapshots
(a) setting-up simulation; (b,c) assessment phase; (d-f) results

- Ponder dilutions thus obtained by the fraction of time over which the wind blows in the respective sector.

- Perform a dose assessment using the dilution obtained in the preceding step.

The code workings are illustrated in figure 9. The results of running a scenario-based session are gathered in an assessment file, per sector and per distance. Again, the result examination and mapping are performed by using an 'Organize' feature. In this case, ‘organizing’ consists in:

- focus on a relevant computed quantity (dilution or dose);
- let EDAT create a table-style excerpt of the output, having the reference quantity values on each sector on columns and computation distance on lines;
- focus on a relevant value of the reference quantity. EDAT will determine the downwind distances, in every sector, up to which the dose is higher than the reference value, thus obtaining a 'wind rose' for dose/dilutions;
- a cosine polar interpolation of the radii thus obtained is then performed, marking the area affected by dilution / dose values in excess of the targeted threshold;
- an object-oriented statistics is conducted, to get the affected GIS-objects within the affected area;
- the affected area together with the statistical results are then mapped (exported) to *Google Earth* ™, overlay-fashion. The user may then acquire the mapped result as an *EDAT work map* directly from Google Earth (GE), by using the EDAT-GE communication facility developed in EDAT GIS.
- a set of HTML reports and GE .kml files are automatically generated. The basic sections in a report are: Release site description; Release site static map; Situation static map (area affected, reference quantity and value); Link to *THE ANALYTIC FILE* – reports on the site; meteorology; source term; the consequent doses expected; the possible health effects; Link to *GIS-based CONSEQUENCE ASSESSMENT* reports on the areas affected by release, and the GIS objects within the respective areas; Link to *THE Google Earth VIEWER* offering a dynamic rendering of the release-affected area.

Fig. 9 holds snapshots of the Long Term Emission module.

## 2.3. THE REGULATORY-ORIENTED FACILITIES

The regulatory-oriented facilities focus on the determination of health and environmental impact of *routine (technologically-normal) environmental releases* resulting in *prolonged exposures* of the radiation workers onsite and of the population outside.

The objectives where to provide tools for monitoring the radioactivity management during routine operations and to equip EDAT with a facility for determining the *Derived Release Limits* (DRL) – the DRLs being expected to qualify as fundamentally important in the siting and authorization processes of any nuclear installation.

The assessments are conducted following IAEA-recommended methods [10], which cover a comprehensive collection of radiometric and dosimetric models. Chief intermediate results are the *Total Effective Dose Equivalents* (TEDE) computed for two critical population groups – 'adults' and 'infants' (1-2 years-old), as well as for radiation workers. When related to the *dose constraints* legally in effect, the TEDEs produce the Derived Release Limits, that are originally obtained per single isotope, single exposure channel (wind sector or sewer), single release mouth (an installation may have several), and single receptor site (the source-to-receptor axis always implying a certain meteorological, wind-relating, conditioning).

On the other hand, even though the actual site of the contemplated EURISOL facilities is still an open matter, the project will most certainly involve *more than a single* isotope, release mouth, and environmental drain, to both air and water, the odds also being that the RIB installation(s) be accommodated on premises of other, pre-existent, and operating nuclear compounds featuring radioactive releases in their own right. In such cases a defendable methodology should be applied, conducive in effect to a sound *planning and management of technological (routine) radioactive releases on multi-source nuclear compounds*. The authors here have proposed that the IAEA approach to a similar problem occurring with the *Derived Intervention Levels* that are instrumental in nuclear emergency response procedures be employed. In short, this implies that, in a first phase, separate computations be performed to get the derived release limits as depending on the emission source, relevant receptor site, critical group, exposure pathway (air, water), and nuclide. The results are given as *Annual Average Discharge Rates* (Bq/s) and the consequent *Total Admissible Annual Discharge* (Bq in 1a). Then, in a second phase a conformity criterion is introduced as

$$C[g,r] = \frac{\sum\sum\sum L(p,s,n)}{DRL(g;r,p,s,n)} \leq 1$$

where $L(p,s,n)$ are the measured, or expected, levels of the emission rates (Bq/s) and $DRL(g;r,p,s,n)$ are the aforementioned, individually-determined derived release limits. In the equation above $g$ is a critical group identifier; $r$ indicates a receptor site; $p$ discriminates between air, and aquatic paths; $s$ marks a source (release mouth); and $n$ refers a released nuclide. Thereby, ensuring that the conformity criterion is satisfied is, in actual fact, to ensure that the legal dose constraints are duly observed, *all along the overall nuclear compound operation*. The EDAT modules addressing the regulatory-oriented issues are *Prolonged Exposure to Environmental Releases* and *Nuclear Facilities Derived Release Limits* – to be introduced in the sequel.

## 2.3.1. THE PROLONGED EXPOSURE ASSESSOR

The task of this module is to perform a comprehensive *radiological* and *dosimetric* assessment of radioactive discharges to the environment considering: the *discharge type* (atmospheric, surface waters); the *ground deposition*; the *concentration in crops*; and the *food chain*.

Chief results are the *Total Effective Dose Equivalents* (TEDE) computed for two critical population groups – ‘Adults’ and ‘Infants’ (1-2 years-old).

The computational workflow follows the general assessment approach presented in the reference document (see Fig. 10).

Depending on the release type, the radiometric assessment procedure consists of:

A. ASSESSING RELEASES TO ATMOSPHERE (THE ATMOSPHERIC PATH)

**Main input:** ***Average discharge rate for radionuclide i (Bq/s)***
entailing the *Ground Deposition Assessment*, followed by the computation of *activity concentration* in: *vegetation*; *pasture*; *animal feedstock*; *milk*; *meat*.

B. ASSESSING DISCHARGES TO SURFACE WATER (THE AQUATIC PATH)

**Main input:** ***Annual average rate of radionuclide discharge, directly into the water body (Bq/s),*** entailing the computation of *activity concentration* in *crops*; *vegetation, pasture*; *animal feedstock*; *milk*; *meat*; *aquatic food*; *sediments*; *sewer sludge*.

The dosimetric assessment is performed based on the results obtained in the radiometric assessment phase. Using appropriate dose conversion factors, the following doses are computed, for the target groups (Adults, Infants 1-2 years):

C. DOSE ASSESSMENT

**ADULTS / INFANTS, 1-2a**

**The Atmospheric Path**

D01. Annual Effective Dose from External Exposure to Air Immersion (Sv in 1a)
D02. Annual Effective Dose from Skin Exposure to Air (Sv in 1a)
D03. Annual Effective Dose from Ground Deposition (Sv in 1a)
D04. Annual Effective Dose from Inhalation from Air Immersion (Sv in 1a)

D05. Annual Effective Dose from Ingestion of Air Deposition-Contaminated Crops (Sv in 1a)
D06. Annual Effective Dose from Ingestion of Milk, Air Deposition-Contaminated Pastures (Sv in 1a)
D07. Annual Effective Dose from Ingestion of Meat, Air Deposition-Contaminated Pastures (Sv in 1a)

**The Aquatic Path**

D08. Annual Effective Dose from Submersion in Water (Sv in 1a)
D09. Annual Effective Dose from Shore Sediments (Sv in 1a)
D10. Annual Effective Dose from Irrigated Garden and Ground Deposition (Sv in 1a)
D11. Annual Effective Dose from Ingestion of Filtered Surface Water and Beverages (Sv in 1a)
D12. Annual Effective Dose from Ingestion of Sprinkler-Irrigated Crops including fruits, vegetables, grain, potatoes (Sv in 1a)
D13. Annual Effective Dose from Ingestion of Milk, Sprinkler-Irrigated Pastures (Sv in 1a)
D14. Annual Effective Dose from Ingestion of Meat, Sprinkler-Irrigated Pastures (Sv in 1a)
D15. Annual Effective Dose from Ingestion of Fresh Water Fish (Sv in 1a)
D16. Annual Effective Dose from Ingestion of Marine Fish (Sv in 1a)
D17. Annual Effective Dose from Ingestion of Marine Shellfish (Sv in 1a)
D18. Annual Effective Dose from External Exposure to Sludge (Sv in 1a)
D19. Annual Effective Dose from Inhalation of Sludge Resuspension (Sv in 1 a)

The above-mentioned doses are the contributors to the *Total Effective Dose Equivalent* (TEDE).

Due to the complexity of the assessment procedures the module has been designed so as to assist the analyst throughout the work session. The computation is performed in a step-by-step manner. The worksheet is generating itself as the process moves on, in a narrative, easy to follow format. Thus, each step is accompanied by the description of the model employed; the model equations; the model data; the 'Inherited Inputs' cartouche (results of previous steps required as input by the current one); the 'New Inputs' cartouche.

Different model parameters can be modified by simply text-editing the worksheet.

## 2.3.2. THE DERIVED RELEASE LIMITS ASSESSOR

This facility is designed for supporting the computation of the Derived Release Limits (DRL). According the IAEA, the DRL is defined as *the radioactive release over a year that would expose members of the critical group to the regulatory dose limit* [13]. Therefore, the facility is intended to be a solver for the following problem: what is the *radioactive release over a year* (Bq/year) that a nuclear facility is allowed to *emit to environment* (air, surface water, sewer) so *that the total dose acquired by an individual* (total effective dose equivalent – TEDE) from the *critical group* would not exceed (within a reasonable assurance) the *regulatory dose limit*?

In other words, using this tool would ensure that a multi-source nuclear compound is operated in such a manner that, taking into account *all the individual installations*, *all the nuclides* released to the environment, and *all the exposure pathways*, the Total Effective Dose Equivalent – TEDE potentially acquired by an individual from the critical group be less than, or equal to a fraction, in principle negotiable, of the regulatory dose limit.

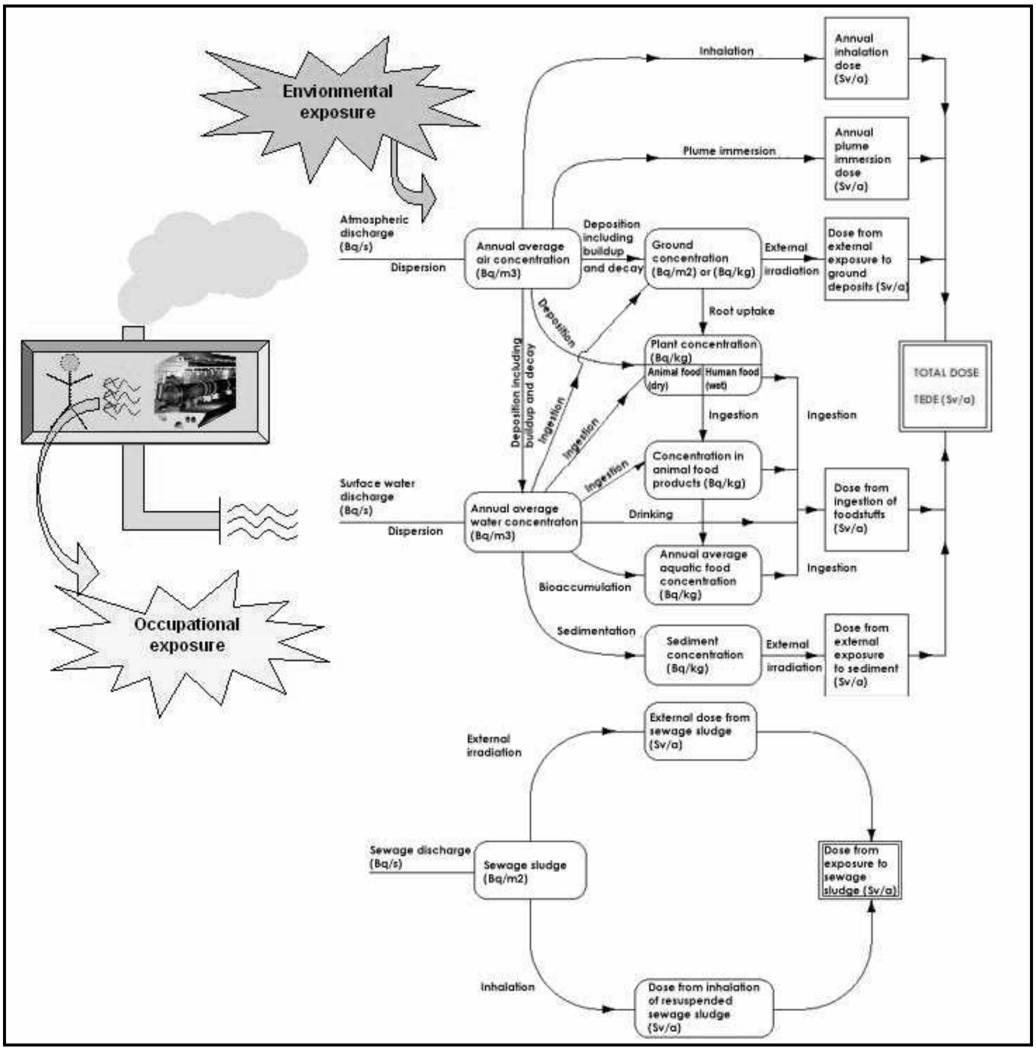



Fig.10. Prolonged Exposure to Environmental Releases – flowchart
Source: IAEA, Vienna [10], edited.

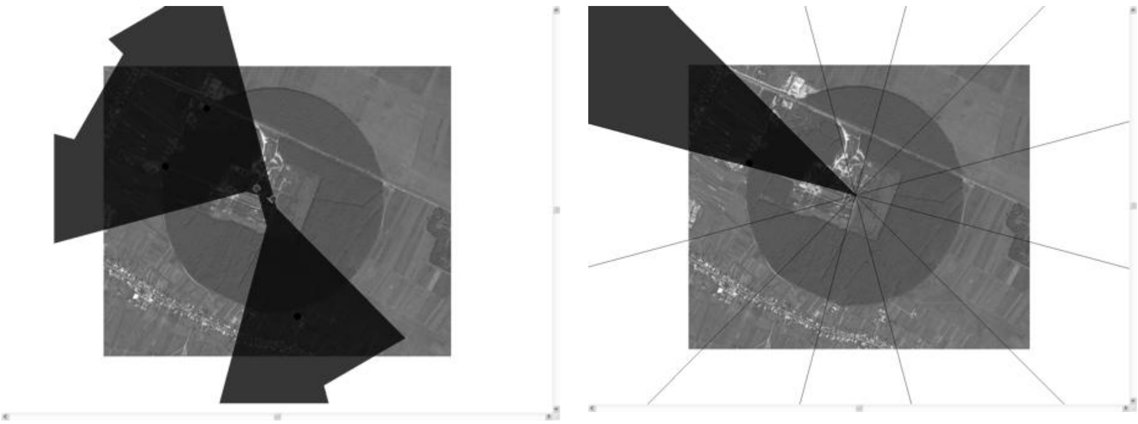


Fig.11 Source to Receptor relationship – code-generated.

The method proposed for computing the DRL in case of a single source, single isotope and single pathway and for a given target group is: step 1 - compute TEDE (Sv in 1a) for a 1Bq/s emission; then – step 2 – compute the DRL as:

$$DRL = \frac{(p * Q_{\max}) * e_1}{Q} = \frac{(p * 1) * 1}{Q} = \frac{p}{Q}$$

$$\left[\frac{Bq}{s}\right]=\frac{([\,]*[mSv])*\left[\frac{Bq}{s}\right]}{[mSv]}$$

where:

*DRL* – the average release rate corresponding to a TEDE of 1mSv in 1y acquired by an individual from the critical group in 1 year;

*p* – the dose constraint – a negotiable fraction of the maximum allowable dose that can be acquired from this specific nuclear facility;

$e_1$ – the 1Bq/s emission rate

$Q_{\max}$ – the maximum allowable dose set by regulations (IAEA threshold: 1mSv in 1 a, *from all sources*)

*Q* – the TEDE corresponding to a 1Bq/s emission rate.

Once the DRL is known, the total activity of a single isotope allowed to be released in 1 year ($DRL_{adm}$) is given as:

$$DRL_{adm} = DRL * 3600 * 24 * 365 \text{ [Sv in 1a]}$$

The dose assessment is performed using the IAEA-recommended set of models and methods [10].

An assessment methodology has been proposed and reflected in the module's architecture and functionality. Accordingly, computing the DRL implies three main phases presented in the sequel, together with tool usage description:

*Phase 1 – Pre-Assessment*

This is dedicated to *creating the theatre of action*. During this phase the following should be performed: *acquire image maps; geo-reference the maps; build source pattern; build receptor pattern.*

The EDAT-integrated GIS is intensively used in this phase. Thus, the sources (points of emission), the receptors (most vulnerable locations, i.e. those likely to feature the highest potential doses) as well as the situation maps are interactively defined by using the GIS. Moreover, the GIS is also called to providing metric input (source-to-receptor distances, wind sector determination, etc.)

*Phase 2- The Assessment*

This phase computes the individual DRLs. Thus, for each critical group, source, nuclide, receptor, and pathway the DRL is computed, obtaining a function DRL{*g*; *r*, *p*, *s*, *n*}, with:

- *g*: critical group identifier;
- *r*: receptor identifier;
- *p*: pathway identifier;
- *s*: source identifier;
- *n*: nuclide

*Phase 2 – Modus Operandi*

There are two manners of assessment: *manual* (using Single File Assessment) or *batch*. The latter has been provided in order to ensure better management and control of the assessment, given the considerable amount of data to be handled in case of detailed evaluations.

*Phase 3 – Wrapping-up the results*

The individual DRLs are wrapped into the conformity criterion, given as:

$$C[g,r] = \sum_{p}\sum_{s}\sum_{n}\frac{L(s,p,n)}{DRL(g;r,s,p,n)} \leq 1, \text{ with}$$

- $L(s,p,n)$: current / planned emission level (Bq/s);

- $g$: critical group identifier;

- $r$: receptor identifier;

- $p$: pathway identifier;

- $s$: source identifier;

- $n$: nuclide

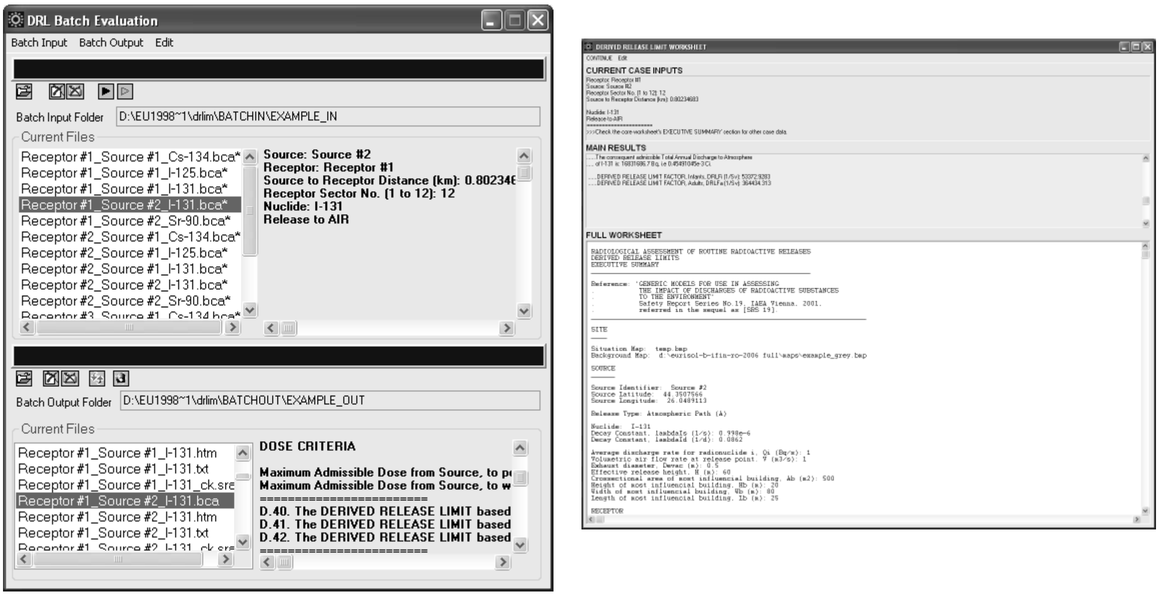



Fig.12. DRL Assessment Phase. Snapshots

As already indicated, ensuring that the conformity criterion is satisfied is, in actual fact, to ensure that the legal dose constraints are duly observed, *all along the overall nuclear compound operation*, thus giving the solution of the problem considered. Aspects of the interface during a DRL session are given in figure 12.

The *conformity criterion schema* for the assessed nuclear facility may be obtained by using the 'DRL Regulatory Constraints' feature, providing the source and receptor patterns characterizing the facility. The schema should be filled in by the user with the appropriate nuclides and values obtained in the individual assessment phase. Other relevant data (maps, etc.) can also be generated in this phase, the EDAT providing the appropriate support for facilitating report generation.

# 3. THE ANCILLARIES

## 3.1. THE RESIDENT GEOGRAPHIC INFORMATION SYSTEM

As it should be evident by now, the EDAT assessment procedures intensively use the resources of the integrated GIS facilities. In an attempt to provide a capability of controlling the scene in the complex process of risk assessment – a standard demand in the trade, the design and implementation of EDAT GIS was guided by the following terms of reference:

- to present a sufficient capability of providing spatial information relevant in the assessment processes (*input-end functionality*);
- to allow visual results rendering (*output-end functionality*);
- to facilitate the assessment process in different phases;
- to provide high versatility in terms of creating the maps;
- to provide the spatial information required in the assessment procedures with no respect to the effective site (localization);
- to provide metric and statistics capabilities, including distance and angle measurements; raster land-scanning for cadastral categories; object-land scanning for identifiable assets; raster-oriented area statistics; object-oriented area statistics.
- to provide a doable solution to terrain elevation monitoring.

Accordingly, the GIS has been developed in order to be used as *data source* for the assessment modules, as *information source* for statistics, and as the support for *visual representation* of the assessment results.

The EDAT GIS system is designed to work with *raster* maps. Virtually any electronic image may be source for a *work map*. The system uses a longitude/latitude rectangular grid for geographic coordinates, in a WGS-84 projection.

The elevations may be gathered either from the USGS GTOPO 30 database or directly from Google Earth™. Supportive to the understanding of the relationship between EDAT assessment modules, native GIS and Google Earth™ is Fig.13.

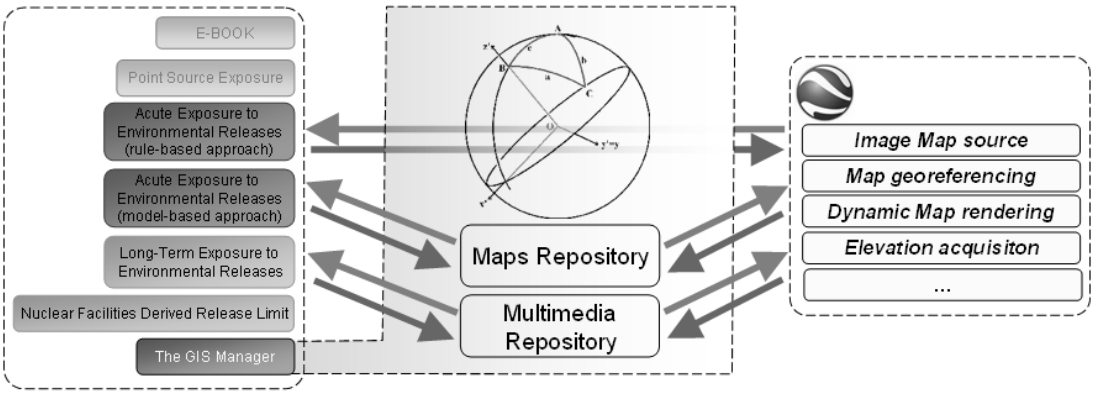



Fig.13. Assessment Modules / Resident GIS / Google Earth™ interaction

## 3.2 THE RESIDENT DATA AND KNOWLEDGE LIBRARIES

The data and knowledge libraries are an essential part of the integrated radiological assessment toolkit. The libraries are both information (educational) sources for the assessor (a 'static' functionality) and input providers for the computational modules of the *Desktop Assistant* (a 'dynamic' functionality).

### 3.2.1. Primary Data Sources

The primary data sources were selected in consideration of the nature of the task at hand, that implies a critical appraisal of the differences and commonalities of the radiological assessment business in the nuclear power fuel cycle, on the one hand, and the accelerator physics, on the other hand.

Appropriate sources emphasizing the commonalities were identified in the knowledge- and data libraries developed in U.S. national laboratories (Oak Ridge, Lawrence Livermore), for the *U.S. Nuclear Regulatory Commission* (NRC), *U.S. Environmental Protection Agency* [9], and the *U.S. Department of Energy* (DOE) [4 - 6].

The formatting and compilation of data and knowledge have taken into account the following aspects:

a) The *data type*, featuring a tight combination of numerical data with text-string type information (knowledge); and

b) The *applications sought* – the radiological assessment of workers and public exposure from the targeted installations, based on projections and diagnoses of radiation doses from occupational and environmental releases, and a consequent evaluation of derived release limits for routine activity, and derived intervention levels and countermeasures in case of accidental (abnormal) releases/exposures.

On these lines, the following type of information is covered:

*b.1. Nuclide-specific information in a cross-reading format*:

- Nuclide lists, with each nuclide displaying a collection of standard features covered; and
- Nuclides features, with each feature specified by all the nuclides covered.

The data come with explanations on the models employed in their acquisition, as well as on the assumptions and validity restrictions, as appropriate.

*b.2. General information*, including emergency-related procedural specifications, various physical correlations (meteorology, countermeasure effectiveness etc.), normative exposure levels by various representative regulations etc.

### 3.2.2. The e-Book

An ‘e-Book’ was also designed (v. Fig.14) in a *vademecum* format, involving a minimum of comments. It is essentially comprised of two data libraries:

A. *The FRMAC Library*, based on primary data source [4], mainly targeting the health and environmental impact of hypothetical, severe accidental releases of radioactivity to the environment; and

B. *The EPA Library*, based on primary data source [9], mainly targeting the health and environmental impact of technological (routine) or long-term/insidious/protracted accidental releases of activity to the environment.

The book is presented in a CHM format, allowing an easy access, moving-around and printing of data (Fig.14).

### 3.2.3. The XData Library

The 'XData' facility manages the bulk of data and info in the *Desktop Assistant*. Unlike the e-BOOK (the 'static' data library), the data in this code-integrated engine are used as such throughout the assessment procedures (computational phases).

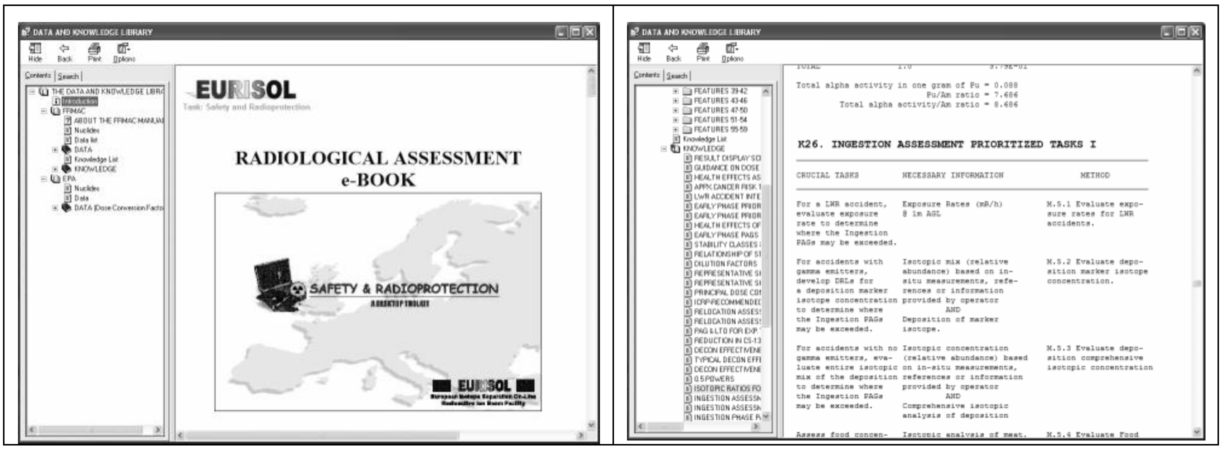



Fig.14 The e-Book – Snapshots.

The default libraries are labeled *FRMAC* and *EPA*, respectively.

The *EPA External Dose Abacus Module* is an interpreted implementation of the short-hand computational procedures drawing upon the data library referred to as [9]. The Data Library contains 64 features for 813 radionuclides, of which 63 features refer to Dose Conversion Factors (DCFs) for deriving dose equivalents (Sv, mrem) from environmental radiometrical quantities, such as units of time-integrated concentrations (Bq.s/m3) and ground depositions (Bq.s/m2) of activity. The dose equivalents bear upon:

a. Tissues or organs, namely *the gonads, breast, lung, red bone marrow, bone surface, thyroid, the skin, and a remainder mixing contributions from the adrenals, brain, the small intestine, kidney, muscle, pancreas, spleen, thymus, and uterus*; and

b. The *whole body*, via the *Effective Dose Equivalent*, obtained as a weighted sum of tissue/organ dose equivalents.

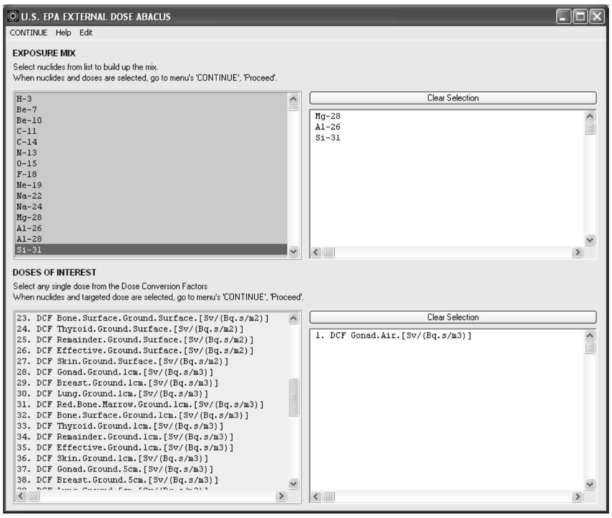



Fig.15 EDAT EPA External Dose Abacus - snaphot.

The form of the time-functions ***ACTIVITY_TIME_FACTOR*** and ***DOSE_TIME_FACTOR*** involved in computations follow from the decay-ingrowth Bateman equations applying to each and every nuclide in the Data Library. The cases on record may involve 1, 2, or 3 daughter-nuclides only.

# 4. FINAL REMARKS

The reactions expressed on various occasions - such as the EURISOL town meetings, working team exchanges etc. seem to converge on the opinion that *EURISOL Desktop Assistant* may constitute a valid radiological assessment toolkit, potentially usable both within the EURISOL scope *and* off this framework – as a decision support facility relating to the health and environmental impact of nuclear activities. Apart from its methodological relevance, the project deliverable was also deemed effective in indicating the amplitude and required technical substance of the challenge posed by the issue of addressing the radioprotection of RIB accelerator installations. The latter aspect will undoubtedly come to attention by the time when issues such as the siting and the authorization requiring a detailed and many-sided environmental statement will in turn come to the forefront of the EURISOL, or any other RIB facility, agenda.

With this in mind, it is important to point out that EDAT's strength should not be seen as primarily relating to the *numbers* (doses, derived limits etc.) it generates. In actual fact, independent benchmarking of EDAT dosimetry against e.g. COSYMA's – a reference, well-established European radiological assessment tool, has taken the co-operating research teams to more than a few debates on 'accuracy' and 'discrepancies', only to re-discover the sensitivities of the computational decision support business to such factors as the aprioric conservatism culture; the rule-based versus the analytic approaches; modeling assumptions; confidence in the static (hard-coded) inputs as well as in the appropriateness and quality of the user input etc. Given what is believed to be the inherent nature of such complexities, EDAT has taken up an open mind on user preferences and beliefs, being articulated *as an open-ended platform*, capable of promptly assimilating alternative models and computing solutions addressing the same problems, or versions of these. A live evidence for this feature was brought in the very process of EDAT growth – when an analytical, less conservative approach to the assessment of offsite-consequential accidents, based on COSYMA's constitutive equations was developed and plugged into the system, in order to balance the more conservative, rule-based approach originally proposed, based essentially on the U.S. technical wisdom and methods.

And, in a way of a final *caveat*: a research-grade product with the confessed vocation of only offering educated opinions on radiological safety issues relating to RIBs, EDAT is *not* meant to rule out, or otherwise substitute for the specific, accepted/recommended tools that will be called upon by the formal national and/or international regulatory procedures to site, erect, and operate a RIB. Rather, it may assist the RIB proponents themselves to get oriented when appointing/hiring the professional consulting engineering entities that would generate the required documentation, and in evaluating the respective results.

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