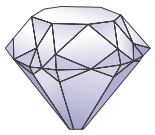

FASSET Project Summary

Background and project organisation

Radiological protection has traditionally focused on the protection of man. For the past decade, the limitation to human health protection has been increasingly questioned and the requirement for an internationally agreed rationale to the protection of the environment to ionising radiation is now recognised, *e.g*. as reflected in the ongoing revision of the Recommendations of the International Commission on Radiological Protection. The FASSET project (contract N°: FIGE-CT-2000-00102) was launched in November 2000 under the EC 5th Framework Programme, to develop a framework for the assessment of environmental impact of ionising radiation in European ecosystems. It involved 15 organisations in seven European countries, and set out to organise radioecological and radiobiological data into a logic structure that would facilitate the assessment of effects on non-human biota resulting from known or postulated presence of radionuclides in the environment.

The FASSET project was divided into four work packages (WP), with the following broad objectives:

- WP1 – Dosimetry. To provide radiation dosimetry models for a set of reference organisms relevant to different exposure situations.
- WP2 – Exposure. To assess transfer, uptake and turnover of radionuclides in European ecosystems and identify components of the ecosystems where exposures (external and internal) may be high.
- WP3 - Effects. To critically examine reported data on biological effects on individual, population and ecosystem levels, as a point of departure for characterising the environmental consequences of, *e.g*., a source releasing radioactive substances into the environment.
- WP4 - Framework. To review existing frameworks for environmental assessment used in different environmental management or protection programmes and to integrate project findings into an assessment framework.

In WP2, seven European ecosystems were considered, four of them terrestrial and three of them aquatic. A list of generic *reference organisms* was drawn up on the basis of expert judgement of exposure situations in the selected ecosystems. A number of novel modelling approaches were applied in the work, and resulted in a Handbook that compiles relevant information for the initial stages of the impact assessment.

The identification of reference organisms served as starting points for the development of dosimetric models in WP 1. For a variety of reference geometries, dosimetric conversion factors were computed, in several cases involving Monte Carlo calculations, and tabulated in the Handbook.

WP3 considered general ‘umbrella’ effects that, when manifested in an individual, may have an impact at population level or at higher levels of the organisational hierarchy. A database was also assembled, compiling data from the literature for a number of wildlife groups for each of these four umbrella effects (FRED – The FASSET Radiation Effects Database).

WP4's main task was to organise the work from the above three work packages into a framework for impact assessments, which would take into account experiences from existing

systems for environmental risk assessment. The formulation of the FASSET assessment context was also part of this WP, which helped define the remit of the framework.

The FASSET project produced a total of six report deliverables, D1-D6. The final deliverable, D6, describes the FASSET framework and draws on information produced under the other five deliverables. Complete documentation on the FASSET project can be found on FASSET's website (www.fasset.org).

The progress and dissemination of results were further carried out by presentations at major international conferences and by publications into the scientific literature. It also help support the development of international initiatives, and lead to the commissioning of further research, *e.g.* under the EC 6th Framework Programme.

The FASSET Framework – an overview

The assessment framework developed under FASSET includes the following fundamental elements: source characterisation; description of seven major European ecosystems; selection of a number of reference organisms on the basis of prior ecosystem and exposure analysis; environmental transfer analysis; dosimetric considerations; effects analysis; and, as an integral part of the aforementioned steps, general guidance on interpretation, including consideration of uncertainties and possibilities to extrapolate from existing data to areas where data are absent or scarce. The project has used existing information, supplemented by the development of models, by Monte Carlo calculations, and by building an effects database (FRED, the FASSET Radiation Effects Database). An overview is given below, with reference to the different FASSET Deliverables (*cf.* also Fig. 1).

Source characterisation

The initial phase of the assessment involves the characterisation of the radionuclide input in the environment. A set of radionuclides from 20 elements was selected for inclusion within the Framework, on the basis of being routinely considered in assessments and emergency planning for accidental releases; representing a range of environmental mobilities and biological uptake rates; being of both anthropogenic and natural radionuclides; and, being representatives of α-, β- and γ-emitters [D1].

Furthermore, a preliminary flowchart for the screening of radionuclides and a description of criteria useful in the process has been described. This guidance was based on a number of criteria used to define the source term, physical characteristics, environmental fate, biological activity and chemical characteristics, as discussed in [D2].

Ecosystem characterisation and selection of 'reference organisms'

The Framework includes information on seven European ecosystems to allow for identification of maximally exposed ecosystem components [D1]. The ecosystems considered were as follows.

- *Forests*: land with tree crown cover of more than 10 %, an area of more than 0.5 ha and with trees, which are able to reach a minimum *in situ* height of 5 m at maturity.
- *Semi-natural pastures and heathlands*: including mountain and upland grasslands, heath and shrub lands, saltmarshes and some Arctic ecosystems.
- *Agricultural ecosystems*: including arable land, intensively managed pastures and areas used for fruit production.
- *Wetlands*: areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt.

- *Freshwaters*: all freshwater systems, including rivers and lakes.
- *Marine*: the North-Eastern section of the Atlantic Ocean and its marginal seas.
- *Brackish waters*: the non-tidal, shallow Baltic Sea; organisms are immigrants from either marine or freshwater systems.

The ecosystems overview enabled identification of a number of reference organisms, based on habitat and feeding habits, as well as bioaccumulation and biomagnification [D1]. The Framework defines the reference organism as: *"a series of entities that provide a basis for the estimation of radiation dose rate to a range of organisms which are typical, or representative, of a contaminated environment. These estimates, in turn, would provide a basis for assessing the likelihood and degree of radiation effects"*. In total, *ca* 30 reference organisms have been chosen. It should be noted that these 'organisms' are not equivalent to specific species – they rather represent biological components of importance for the functioning of each ecosystem, and thus they are suitable targets for impact assessments.

Environmental transfer and dosimetry

A number of radionuclide transfer models developed for the seven major European ecosystems have been used for calculation of external and internal radionuclide concentrations. Furthermore, calculations and tabulations have been made to allow conversion of external and internal concentrations to absorbed dose (rate), including those resulting from natural background radiation for a number of ecosystems. The Conversion factors for estimates of dose rates have involved Monte Carlo calculations and the definition of a number of representative geometries for different reference organisms. Data have been compiled in a Handbook on the initial assessment stages [D5], as well as in a separate report on dosimetry [D3].

Effects analysis

The Framework centres the effects analysis on individuals, accepting that effects must materialise in individuals *before* they can become manifested within the ecosystems. In order to organise the available knowledge on radiation effects, it was decided that the Framework would concentrate on four effects categories, or 'umbrella effects'.

- *Morbidity* (including growth rate, effects on the immune system, and the behavioural consequences of damage to the central nervous system from radiation exposure in the developing embryo).
- *Mortality* (including stochastic effect of somatic mutation and its possible consequence of cancer induction, as well as deterministic effects in particular tissues or organs that would change the age-dependent death rate).
- *Reduced reproductive success* (including fertility and fecundity).
- *Mutation* (induced in germ and somatic cells).

[D4] reviews the current knowledge on radiation effects on biota, grouped under 16 wildlife groups, which are broadly comparable with the chosen reference organisms. The report is supported by the FASSET Radiation Effects Database (FRED). The database contains approximately 25 000 data entries from more than a thousand references. The reviewed effects data give few indications of readily observable effects at chronic dose rates below 100 μGy/h. However, it is advised that using this information for establishing environmentally 'safe' levels of radiation should be done with caution, considering that the database contains large information gaps for environmentally relevant dose rates and ecologically important

wildlife groups. Assessors are encouraged to use the database as a starting point, and seek the original papers to extract more detailed information.

The FRED contains only limited data that enable the derivation – or even discussion – of radiation weighting factors. The recommendation is that assessors, as a part of a sensitivity analysis, make a judgment whether the weighting factor matters in each particular case.

Uncertainties and interpretation

The Framework contains general advice as to the interpretation and handling of uncertainties associated with the assessment. For a number of radionuclides, transfer and effects data are lacking or scarce, necessitating information to be extrapolated from 'known' data, and involving a substantial component of expert judgment.

Outlook

On the basis of the FASSET experience, and other recent projects, it can be concluded that there is substantial agreement in terms of conceptual approaches between different frameworks currently in use or proposed, and that differences in technical approaches can largely be attributed to the differences between ecosystems of concern, or to different national legal requirements. Furthermore, sufficient knowledge appears to be available to support robust, scientifically-based assessments following the FASSET framework structure, although significant data gaps exist, *e.g.* concerning environmental transfer of key nuclides and effects data for key wildlife groups at environmentally relevant dose rates.

Future challenges lie in the development of an integrated approach where decision-making can be guided by sound scientific judgements, which requires, *inter alia*: filling of gaps in basic knowledge of relevance to assessment and protection; development of risk characterisation methodologies; development of user-friendly assessment tools; and stakeholders involvement, including the development of supporting communication strategies.

Some of the above outstanding issues will be addressed within the EC 6th Framework Programme project ERICA (Environmental Risk from Ionising Contaminants: Assessment and Management), which was launched in March 2004 and takes the FASSET framework as its starting point. The objective of ERICA is to provide an integrated approach to scientific, managerial and societal issues concerned with the environmental effects of contaminants emitting ionising radiation, with emphasis on biota and ecosystems. The final outcome has been termed the ERICA integrated approach to assessment and management of environmental risks from ionising radiation. Progress of the ERICA project can be followed on the web-site, www.erica-project.org.

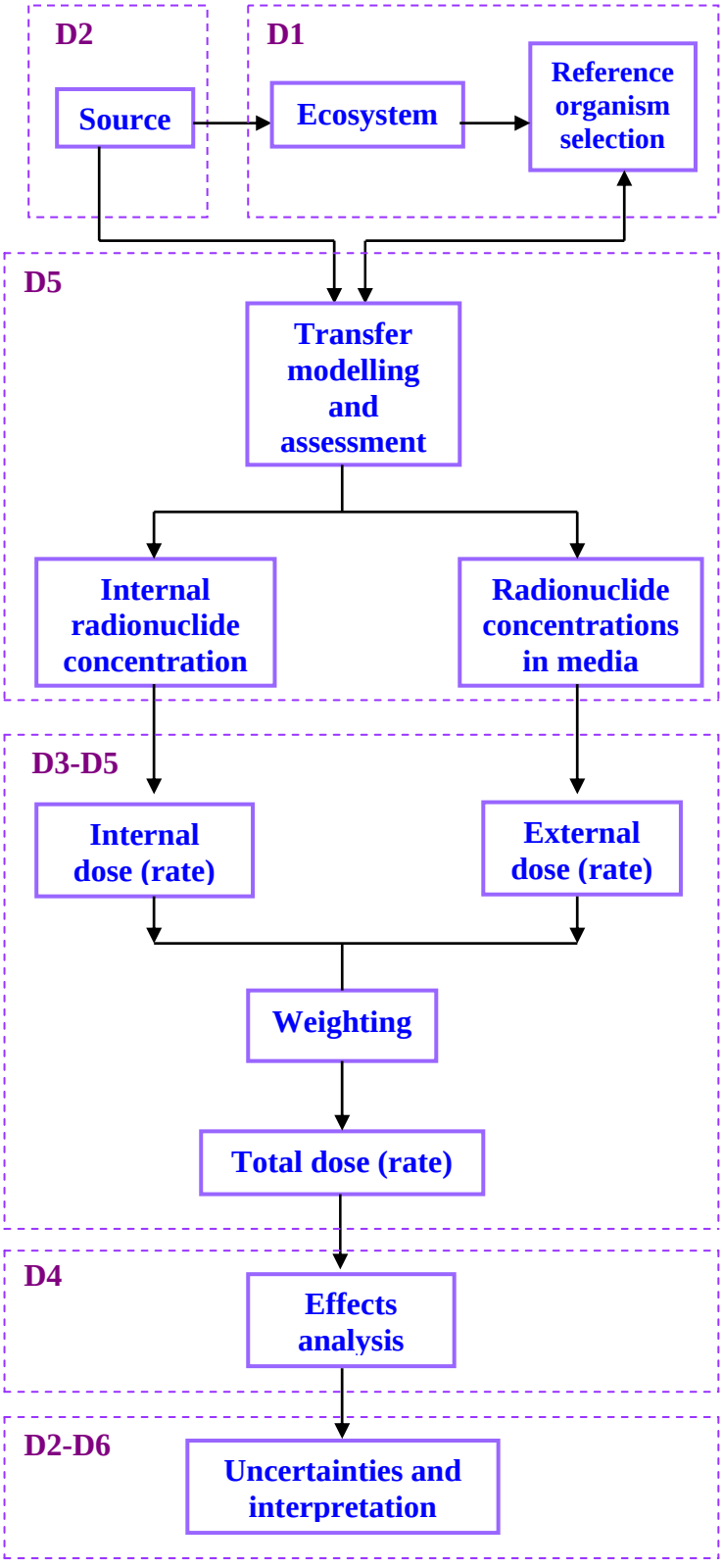

Figure 1 *Sequential organisation of the Framework elements, as developed by the FASSET Project, with reference to the sources of detailed information in the different FASSET Deliverables.*