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# STAR

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## DELIVERABLE (D-N°2.4)

### Virtual Laboratory Description

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(D-N°2.4) –Virtual laboratory description

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<b>PU</b>	Public	
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## **Executive Summary**

The virtual laboratory will be developed from information collated as part of Deliverable 2.2 (joint infrastructure description) and will have a dedicated area on the Radioecology Exchange website.

It will focus on providing information related to each of the following four categories:

- Methodological: descriptions of analytical methods (including problems likely to be encountered); video clips of methods; protocols and manuals used in WP4/5;
- Informative: fact and datasheets, databases, sample archives and examples of sources of environmental dose
- How to use models: CROM and ERICA
- Training: lectures and videos and links to other websites related to training activities

The aim is to provide openly available information which will encourage integration through joint research and joint use of infrastructure. It will also begin to establish the integrated use of data and sample materials within the network and also by the wider community. At the end of the STAR project it will form the basis for an expanded virtual laboratory for the ALLIANCE into the future.

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## **Introduction**

In STAR Deliverable 2.2 an inventory of infrastructure among the STAR partners was created using an on-line wiki pages. This infrastructure inventory contains information on radioanalytical equipment and methods, bioinformatic equipment and methods, sample archives, models, expertise and facilities for radioecological research. Within STAR, partners have more than 170 experts studying radioecology, encompassing the atmospheric dispersion, dosimetry, ecology, ecotoxicology, environmental radiation protection, environmental surveillance, foodstuffs, terrestrial, freshwater and marine radioecology, modelling, radiobiology and radionuclide analytics, emergency preparedness, education and training. Wide-ranging expertise is also available within STAR partners for many accredited radioanalytical methods. There are also many different holistic bioinformatic equipment and platforms for molecular and biochemical analysis to study (radiation) effects endpoints in Europe. The facilities within STAR partners comprise different kinds of laboratories, such as rooms for: pretreatment of samples, specially constructed experimental systems for radioecological and biological studies and measurement, specialized equipment for radioactivity measurements, radiochemical and biological treatment of samples. This information will be utilised and expanded upon by work package 2 with significant contributions from all other STAR partners to develop the STAR virtual laboratory.

## **Virtual Laboratory Plan**

The virtual laboratory will have a dedicated area on the Radioecology Exchange website. Following a number of meetings and discussions it was agreed it would contain information about the facilities held at each partner laboratory (collated as part of Deliverable 2.2); describe a number of analytical methods and best practices; provide access to the protocols and manuals used within work packages 4 and 5; give information on the basic radioecology of a number of radionuclides; provide access to key databases; give instructions on how to use common 'radiological' models and provide access to a wide range of training materials including on-line demonstrations.

## **Virtual Laboratory Description**

The STAR Virtual Laboratory will focus on providing information related to each of the following four categories:

- Methodological: descriptions of analytical methods (including problems likely to be encountered); video clips of methods; protocols and manuals used in WP4/5;
- Informative: fact and datasheets, databases, sample archives and examples of sources of environmental dose;
- How to use models: CROM and ERICA
- Training: Lectures and videos, links to websites related to training activities

The content of each of these categories is described in more detail below.

## **Methodological**

### **Analytical Methods**

The laboratory survey (Deliverable 2.2) indicated that a wide-ranging expertise in the area of radionuclide determination methods can be found within the STAR partners. Expertise covers analysis methods for natural radionuclides like U-238 and Th-232 series radionuclides, artificial radionuclides like Pu, Am, Sr, Tc, as well as methods for nutrient and ion concentration determinations. Most of the analysis methods are either evaluated or accredited by an external evaluator, which shows the remarkably high quality of the laboratories. The general descriptions of the analyses used within STAR partners are described in Deliverable 2.2 and can be accessed through on-line wiki pages. More detailed descriptions of the selected analyses will be included in the virtual laboratory. Detailed descriptions have already been written for the following radiochemical methods:

- Americium analysis Am-241 (see Appendix 1)  
<https://wiki.ceh.ac.uk/display/smi/Americium+from+urine+sample>
- Strontium analysis Sr-90, Sr-89  
<https://wiki.ceh.ac.uk/display/smi/Strontium+analysis+of+plant+samples>
- Plutonium analysis Pu-238, Pu-239+240  
<https://wiki.ceh.ac.uk/display/smi/Plutonium+and+americium+analysis+from+soil%2C+vegetation+and+sediment>
- Pre-treatment of the seawater sample for plutonium analysis:  
<https://wiki.ceh.ac.uk/display/smi/Pretreatment+of+seawater+for+transuranic+analysis>
- Uranium analysis U-234, U-235, U-238  
<https://wiki.ceh.ac.uk/display/smi/Uranium+from+water+sample>
- Polonium analysis Po-210  
<https://wiki.ceh.ac.uk/display/smi/Polonium+from+water+sample>

The other radiochemical analyses, which will be added to the virtual laboratory, include some of the following: advanced gamma spectrometric analysis, tritium analysis H-3, lead analysis Pb-210, gross alpha analysis, radium analysis Ra-226, Ra-228, radon analysis Rn-222, carbon 14 analysis and technetium analysis Tc-99. Also descriptions of environmental sampling and pre-treatment of samples will be added to the virtual laboratory as appropriate.

Similar information to that being prepared by STUK for the methods above will be prepared by all other partners (see brackets for responsibilities). Each method will state known problems and their solutions, uncertainties and any QA knowledge etc.). They will be available to Alliance members by January 2014.

- ICP-MS measurements (IRSN)
- Nutrient analysis (CEH)
- Gross beta analysis (CIEMAT)
- Neutron activation analysis (UMB)
- Preparation of gamma standards (CEH)

- Element concentration (not ICP-MS) (BFS)
- Ion concentration analysis (BFS)
- Advanced stable isotope analysis (CEH)

### Video clips

STAR partners STUK and SCK.CEN will prepare a number of short videos or power point shows in 2013. Five videos have already been prepared by STUK describing environmental sampling; these are:

- Air filter sampling at STUK, <http://www.dreambroker.fi/w/473d954b4>
- Sampling of suspended matter at STUK, <http://www.dreambroker.fi/w/37256fcea>
- Evaporation of water at STUK, <http://www.dreambroker.fi/w/09da7ab75>
- Sea water sampling at STUK, <http://www.dreambroker.fi/w/49113db04>
- Pre-treatment of fish for NaI at STUK, <http://www.dreambroker.fi/w/3498180ed>

Other videos/powerpoint shows will also be prepared by SCK.CEN; these include:

- General molecular/biochemical analyses
- Biosphere impact studies
- Working in a radiobiology: laboratory (PowerPoint show)
- *Lemna* culture and growth measurement (PowerPoint show)
- *Arabidopsis* culture (PowerPoint shows with audio)

All of the videos/powerpoint shows will be made available to Alliance members by January 2014.

### Protocols and manuals

All the protocols used during experiments conducted in STAR work packages 4 and 5 will be made available on the virtual laboratory by January 2014. Two of the protocols will be described in detail, describing any problems (and their solutions) these are:

- Endoreduplication is a typical response of plants to avoid damage by different abiotic stressors. This is estimated by measuring the ploidy of plants in isolated nuclei. Here the isolation and staining of nuclei for ploidy estimation in plants (e.g. *Arabidopsis*, *Lemna*) after exposure to radiation or radionuclides is given (SCK•CEN).
- Exposure of the nematode worm *Caenorhabditis elegans* during its whole life cycle to radionuclides (e.g. uranium, americium, external gamma) for the study of toxic effects on growth and reproduction kinetic (IRSN).

### Informative

#### Radioecology factsheets and associated datasheets

STAR milestone 7.5 requires the production of 'targeted briefing documents on basic radioecology'. To address this factsheets which will summarise the radioecological information for a twenty elements will be produced. Each factsheet (see Appendix 2), which is aimed at a readership of age 16+, will contain:

- Elemental information e.g. typical concentrations in soil and water
- Why the element is of interest

- Number of and key sources of radioisotopes
- Behavior of the radioisotopes in the environment
- Radionuclides of particular interest to radioecology
- Links to more in-depth information
- Reference list (containing references used in both fact and datasheets)

Associated with each of the factsheets a number of datasheets will also be created for those radionuclides highlighted as of particular interest. Each datasheet (see Appendix 2) will contain:

- Commonly used parameters e.g. half-life, origin, decay mode and decay chain
- Parameters useful for human assessments e.g. concentration ratios, transfer factors and EU food intervention limits
- Parameters useful for wildlife assessments e.g. concentration ratios, EMCLs, dose coefficients.

Fifteen fact and data sheets are currently at various stages of preparation and a further five were added to the list in April 2013; they are all listed in the table below together with information on their current status. Complementing the fact and data sheets a document will be produced which will describe in a little more detail the information held within them and provide links to where further in-depth information can be found. If no suitable descriptive material can be identified the text will be prepared by STAR. All the information will be available on the Radioecology Exchange by January 2014.



<b>Factsheet title</b>	<b>Underlying datasheet(s)</b>	<b>Partner Creating</b>	<b>Stage of preparation</b>	<b>Factsheet reviewed?</b>	<b>Factsheet reviewer</b>	<b>Datasheets reviewed?</b>	<b>Datasheets reviewer</b>	<b>Current status</b>
Caesium	<sup>134</sup> Cs, <sup>135</sup> Cs, <sup>137</sup> Cs	CEH	<b>Factsheet:</b> Final draft <b>Datasheets:</b> Final drafts <b>References:</b> Not prepared	Yes	Tom Hinton	Yes	CIEMAT	<b>Factsheet:</b> Address comments <b>Datasheets:</b> Address comments <b>References:</b> To prepare
Iodine	<sup>129</sup> I, <sup>131</sup> I	CEH	<b>Factsheet:</b> First draft <b>Datasheets:</b> Final draft <b>References:</b> Not prepared	Ready to review	Tom Hinton	Yes	CIEMAT	<b>Factsheet:</b> Ready for review <b>Datasheets:</b> Address comments <b>References:</b> To prepare
Technetium	<sup>99</sup> Tc, <sup>99m</sup> Tc	CEH	<b>Factsheet:</b> First draft <b>Datasheets:</b> Not prepared <b>References:</b> Not prepared	Ready for internal review	Tom Hinton	No	CIEMAT	<b>Factsheet:</b> Internal review <b>Datasheets:</b> To prepare <b>References:</b> To prepare
Strontium	<sup>89</sup> Sr, <sup>90</sup> Sr	CEH	<b>Factsheet:</b> Not prepared <b>Datasheets:</b> Not prepared <b>References:</b> Not prepared	No	Tom Hinton	No	CIEMAT	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare
Tritium	<sup>3</sup> H	IRSN	<b>Factsheet:</b> Completed <b>Datasheets:</b> Final draft <b>References:</b> Completed	Yes	Tom Hinton	Ready to review	BFS	<b>Factsheet:</b> Completed <b>Datasheets:</b> Ready for review <b>References:</b> Completed
Carbon	<sup>14</sup> C	IRSN	<b>Factsheet:</b> First Draft <b>Datasheets:</b> First Draft <b>References:</b> First Draft	Ready for internal review	Tom Hinton	Ready to review	BFS	<b>Factsheet:</b> Internal review <b>Datasheets:</b> Ready for review <b>References:</b> Ready for review
Chlorine	<sup>36</sup> Cl	IRSN	<b>Factsheet:</b> First Draft <b>Datasheets:</b> First Draft <b>References:</b> First Draft	Ready to review	Tom Hinton	Ready to review	BFS	<b>Factsheet:</b> Ready for review <b>Datasheets:</b> Ready for review <b>References:</b> Ready for review
Polonium	<sup>210</sup> Po	CIEMAT	<b>Factsheet:</b> Completed <b>Datasheets:</b> Final draft <b>References:</b> First Draft	Yes	Tom Hinton	Yes	CEH	<b>Factsheet:</b> Completed <b>Datasheets:</b> Completed <b>References:</b> Ready for review
Lead	<sup>210</sup> Pb	CIEMAT	<b>Factsheet:</b> First Draft <b>Datasheets:</b> First Draft <b>References:</b> First Draft	Ready to review	Tom Hinton	No	CEH	<b>Factsheet:</b> Ready for review <b>Datasheets:</b> To prepare <b>References:</b> To prepare
Radon	<sup>222</sup> Rn (considering <sup>119</sup> Rn, <sup>220</sup> Rn)	CIEMAT	<b>Factsheet:</b> In preparation <b>Datasheets:</b> Not prepared <b>References:</b> Not prepared	No	Tom Hinton	No	CEH	<b>Factsheet:</b> To complete <b>Datasheets:</b> To prepare <b>References:</b> To prepare
Uranium	<sup>234</sup> U, <sup>235</sup> U, <sup>238</sup> U	UMB	<b>Factsheet:</b> Final draft <b>Datasheets:</b> First draft <sup>238</sup> U <b>References:</b> To prepare	Ready to review	Tom Hinton	<sup>238</sup> U only completed so far	IRSN	<b>Factsheet:</b> Ready for review <b>Datasheets:</b> To prepare <b>References:</b> To prepare
Americium	<sup>241</sup> Am	UMB	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare	No	Tom Hinton	No	IRSN	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare

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(D-N°2.4) –Virtual laboratory description

Dissemination level: RE

Date of issue of this report: 29/05/2013

Plutonium	$^{238}\text{Pu}$ , $^{239}\text{Pu}$ , $^{240}\text{Pu}$	UMB	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare	No	Tom Hinton	No	IRSN	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare
Radium	Isotopes to be confirmed	UMB	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare	No	Tom Hinton	No	IRSN	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare
Thorium	$\text{Th}^{230}$ , $\text{Th}^{232}$ , $^{234}\text{Th}$	UMB	<b>Factsheet:</b> Final draft <b>Datasheets:</b> Some first drafts <b>References:</b> To prepare	Ready to review	Tom Hinton	No	IRSN	<b>Factsheet:</b> Ready for review <b>Datasheets:</b> To complete <b>References:</b> To prepare
Cobalt	$^{57}\text{Co}$ , $^{60}\text{Co}$ (will consider others)	BFS	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare	No	Tom Hinton	No	SU	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare
Silver	$^{110\text{m}}\text{Ag}$	CEH	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare	No	Tom Hinton	No	CIEMAT	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare
Tellurium	$^{129\text{m}}\text{Te}$ , $^{132}\text{Te}$	SU	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare	No	Tom Hinton	No	UMB	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare
Neptunium	$^{237}\text{Np}$	SU	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare	No	Tom Hinton	No	UMB	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare
Potassium	$^{40}\text{K}$	BFS	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare	No	Tom Hinton	No	SU	<b>Factsheet:</b> To prepare <b>Datasheets:</b> To prepare <b>References:</b> To prepare
Descriptive document		CEH to draft with all partners					IRSN to review	Final version to be prepared by December 2013

The fact and associated data sheets will be completed and quality checked in 2013 and made accessible from a dedicated web page via the virtual laboratory by December 2013.

## Key databases & samples archives

STAR partners hold of some of the key databases used to define parameter values for human foodchain and environmental assessment models. Star partner NERC-CEH has made their [INSPIRE](http://gateway.ceh.ac.uk) compatible 'Information Gateway' (<http://gateway.ceh.ac.uk>) open to all STAR partners so data and metadata can be safely stored. Below is a list of data/metadata STAR partners have agreed to make available on the Radioecology Exchange (some information is already currently accessible). The remaining data/metadata will be added in 2013/14 and where possible photographs, figures or short videos will be linked to it.

- BFS Fungi monitoring data
- CEH ICRP terrestrial RAPs
- CEH Exposure of burrowing mammals to Rn-222
- CEH Observations of Fukushima Fallout in Great Britain
- CEH England & Wales natural radionuclide concentrations in soil, water & sediments
- CEH Post-Chernobyl soil and vegetation surveys
- IRSN Milk monitoring
- IRSN OPERA observatories of environmental radioactivity
- IRSN Rivers monitoring Hydroteleray
- IRSN Teleray
- IRSN Waste water monitoring
- NRPA Freshwater fish data
- NRPA Human monitoring data
- NRPA Large predators data
- NRPA Lichen and plant data
- NRPA Marine data
- NRPA Milk monitoring in grazing animals
- NRPA Moose, red deer and roe deer data
- NRPA Mushroom monitoring data
- NRPA wild reindeer data
- SCK.CEN Monitoring of radiological situation of Belgian territory
- STUK Monitoring of airborne radioactive substances in Finland
- STUK Monitoring of radioactive substances in the Baltic Sea
- STUK Radioactivity of Finnish cereals
- STUK Radionuclide deposition data in Finland
- STUK Monitoring of radioactive substances in foodstuffs in Finland
- STUK Cs-137 in freshwater fish in Finland after Chernobyl accident
- STUK Fukushima monitoring data
- STUK Groundwater monitoring data
- STUK Milk monitoring data
- STUK Radiocesium in Finnish moose
- STUK Cs-137 in Finnish mushrooms
- STUK Cs-137 concentrations in Finnish reindeer meat

- STUK Monitoring of Cs-137 and Sr-90 in river water in Finland
- STUK Radioactivity of timber in Finland
- SU Element composition of biota, water & sediment in the Forsmark area, Baltic Sea

### Sample archives

The STAR NoE holds a large variety of samples from the terrestrial and aquatic environment, and samples from a variety of air samplers collected by a various methods. Deliverable 2.2, the joint infrastructure description has previously collated all this information. STAR partners are in the process of investigating (as of May 2013) if they have any sample archives they wish to make available to Alliance members. If so they will expand the information currently held on infrastructure wiki by June 2013.

### Sources of dose in the environment – ‘topical descriptions’

Complementary to factsheets which will summarise the radioecological information element by element, two ‘topical descriptions’ will show absorbed doses estimations, for humans and wildlife species and for typical environmental exposure scenarios. The objective is to allow a non-specialist audience to understand the link between environmental contamination with radionuclides (Bq) and the doses (absorbed, equivalent or effective) to humans and wildlife species. These examples will illustrate some of the factors that affect the estimation of the dose to a target organism: types of radionuclides, internal and external doses, exposure pathways and diet, life stages and lifecycle.

IRSN and SU, with the help of CIEMAT for the dose calculations in human, will prepare a description of the following two examples by January 2014 meeting (Finland), in order to be discussed and completed with other STAR partners.

- **Example scenario 1: Relative importance of internal vs. external dose and exposure routes, for both humans and a wildlife species, when exposed radionuclides in the environment (IRSN):** This scenario will show the doses calculated for a reference man/woman and for wildlife species, when exposed to radionuclides in contrasting ecosystems (e.g. Marine ecosystem versus freshwater ecosystem; Forest ecosystem versus agricultural/prairie ecosystem). It will show results for a theoretical initial release or from existing contamination (e.g.  $1 \text{ Bq m}^2$  deposit, or  $1 \text{ Bq l}^{-1}$  concentration) of different types of radionuclides or/and exposure situations (e.g. chronic exposure following an accident; discharges from normal operation). The dispersion calculations in the environmental compartments and the dose calculation in humans and wildlife will be done with the default models and recommended data for human and biota impact assessment (see below CROM and ERICA below). Common input parameters will be agreed prior to the calculations to the chosen scenarios (food categories, annual rates of intake, occupancy factors, dose conversion coefficients etc).
- **Example scenario 2: Life stages of frogs (SU):** This scenario could illustrate how external and internal doses can change for different life stages over a lifecycle. Doses from the same kind of deposition as in scenario 1 will be calculated for the reference

frog with a complex lifecycle with life stages such as egg, tadpole, recently metamorphosed juvenile, adult. This scenario will illustrate how exposure pathways and diet can change over a lifecycle and how they affect dose.

### ***How to use models***

Amongst the STAR partners, expertise covers at least 40 different models for radioecological purposes including radionuclides atmospheric dispersion, deposition and transport of radioactivity in the aquatic and terrestrial environment. In radioecology, models are used for a wide variety of applications; examples include the prediction of dose rates and activity concentrations and the associated risk from ionizing radiation.

Models are used for a variety of purposes, these include: calculating stability diagrams, equilibrium states, for transport of multiple components, mixed equilibrium or kinetic biogeochemical reactions, both, in surface ecosystems or associated groundwater flow systems. In radioecology the focus of the models is on human and biota impact assessment. STAR partners are often both users and developers of the models.

As there are many models currently in use, STAR partners CIEMAT and CEH have agreed to briefly describe two of them, these are:

- **CROM (CIEMAT)**

CROM is a generic environmental model code developed by the CIEMAT in collaboration with the Polytechnic University of Madrid based on Safety Report Series 19<sup>1</sup> with some variations from RP 72<sup>2</sup>. It was designed to automate the calculation of radionuclide concentrations in different compartments of the environment and their impact in the food chain, as well as the effective dose calculation in humans, allowing the researcher to concentrate on the analysis of the model results. The models implemented in CROM and the associated user's manual has been published by CIEMAT<sup>3</sup>. A quality control analysis of the code was performed by CIEMAT and RPD-HPA (formally NRPB), for its worldwide distribution by the IAEA as the reference for those models. CROM 6 is available and freely distributed by contacting the IAEA or downloading it from: <ftp://ftp.ciemat.es/pub/CROM>.

CROM uses generic models for dispersion and dilution, and is flexible enough to be used for different degrees of realism. In order to estimate the radionuclide concentrations in environmental media, the quantities and types of radionuclides to be discharged (the source term), the mode and characteristics of the discharge and the receptor points (up to five), should be specified.

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<sup>1</sup> IAEA. "Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment". Safety Report Series SRS 19, Vienna, International Atomic Energy Agency, 2001.

<sup>2</sup> Simmonds, J.R., Lawson, G., Mayall, A. "Methodology for assessing the radiological consequences of routine releases of radionuclides to the environment". Radiation Protection 72, Report EUR 15760; European Commission, Luxembourg. 1995.

<sup>3</sup> Robles, B., Suañez, A., Mora J.C., Cancio. D., "Modelos implementados en el código CROM". Colección Documentos CIEMAT, Madrid. CIEMAT. 2007.

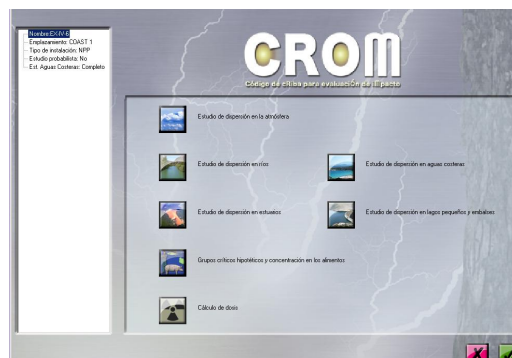


Figure 1. Main screen of the CROM showing the main dispersion modules.

The atmospheric dispersion model is a Gaussian plume model designed to assess annual averaged radionuclide concentrations in air (this model was validated for distances <20 km) used for the calculation of the rate of deposition at various points in the region of interest from long-term releases, provided that a 30 years continuous emission and a neutral atmospheric condition are deemed. The model accounts for the effects of any buildings in the vicinity of the release and the effect of the roughness of the ground in the winds profile. The basic meteorological variables required for each individual air concentration calculation are the wind direction and the geometric mean of the wind speed at the physical height of the release point. The code allows the use of other diffusion factors, for different stability categories than neutral (D), and also the introduction of effective heights but does not calculate them.

Surface water models account for dispersion in rivers, small and large lakes, estuaries and along the coast of seas and oceans. These models are based on analytical solutions to advection-diffusion equations describing radionuclide transport in surface water with steady state uniform flow conditions. The contamination of surface water from routine discharges to the atmosphere is considered for small lakes. All the models contain a great quantity of default values that can be used in absence of local specific information. The models can also be easily used for great lakes and sewerage systems with some considerations of the pathways involved.

The terrestrial food chain models accept inputs of radionuclides from both the atmosphere and the hydrosphere and they take account of the build-up of radionuclides on surface soil over a 30 year period. The process of radioactivity decay and build-up is taken into account in the estimation of the retention of radionuclides on the surfaces of vegetation and on soil, and in the assessment of the losses owing to decay that may occur during the time between collection and consumption. The food categories considered are milk, meat and vegetables. The uptake and retention of radionuclides by aquatic biota uses selected element specific bioaccumulation factors that describe an equilibrium state between the concentration of the radionuclide in biota and water. The types of aquatic food considered are freshwater fish, marine fish and marine shellfish.

The estimated radionuclide concentrations in air, soil, sediment, food and water (representative of 30 years of discharge) are combined with the annual rates of intake and

the occupational factors and the appropriate dose conversion coefficients to obtain the maximum effective dose in one year for the combined external and internal exposure. The dose conversion coefficients for internal exposure are taken from Safety Series No 115<sup>4</sup> while for external exposure have been calculated in base of the coefficients and equations given in the Federal Guidance Report No 12<sup>5</sup>. The model takes into account external gamma dose rates from radionuclides due to cloud immersion, contaminated soil and sediments and water submersion (for gamma and beta exposure). The effective doses from external exposure and radionuclide intakes are calculated for the six age categories recommended by IAEA<sup>4</sup> and ICRP<sup>6</sup>.

The software implements a default database with data for 152 radionuclides and also 8 examples of application based on examples included in SRS19.

- **ERICA (CEH)**

ERICA will be briefly described for the virtual laboratory by January 2014. Information is currently available from: <http://www.eric-tool.com/>

### ***Training***

As part of the STAR WP6 Education and Training, some interactive tools will be provided for student interaction and learning. Below, some examples of e-learning and student interaction tools are given.

### **Lectures and videos**

The following information will be made available on the Radioecology Exchange:

- Training videos and lectures from the first STAR course in Environmental Radiobiology to be held in June 2013 in Norway
- Presentations and summary notes from the ERICA-Tool training course
- Presentations and summary notes etc. (similar to those done for ERICA training course) from PhD and MSc courses.

Other information will be reviewed during 2013 and suitable items will be created and made available on the Radioecology Exchange, these might include:

- Whiteboard presentations (clickable/with voice over)
- Lectures (streamed live or recorded)
- Interviews (streamed live or recorded)
- Audio visual demonstrations

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<sup>4</sup> IAEA "International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources". Safety Series No 115. Vienna IAEA. 1996.

<sup>5</sup> Eckerman, K.F., Ryman, J.C. "External exposure to radionuclides in air, water and soil." Federal Guidance Report n° 12. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 1993.

<sup>6</sup> ICRP "Recommendations of the International Commission on Radiological Protection, 1991". International Commission on Radiological Protection. Publication 60. 1990.

- Mini films/podcasts etc. (see YouTube, or [www.microdocs.org](http://www.microdocs.org))
- Powerpoint presentations (clickable/with voice over)
- Interactive tools (e.g. virtual reality simulations (e.g., walking through a contaminated area))
- Animated tools; interactive equipment e.g. <http://www2.plymouth.ac.uk/science/radiationexperiments/radiationsimulations.swf>
- Dynamic visual models showing radionuclide movement through the environment (e.g. comparison of I and Cs)

### **Websites related to training activities**

Links will be provided to other websites which contain information relevant to radioecology students; currently these include (more will be collated during 2013):

- <http://www.nucleonica.com> (Interactive periodic table, periodic table type applications/add-ons (e.g. element or nuclide specific information such as Kd, environmental half life, transfer factors, important foodstuffs, dose conversion factors, source terms, etc.))
- <http://www2.plymouth.ac.uk/science/radiationexperiments/radiationsimulations.swf> (interactive equipment)
- [www.periodictable.com](http://www.periodictable.com)
- [www.webelements.com](http://www.webelements.com)
- <http://www.periodicvideos.com/>

The majority of training materials listed below will be made available on the Radioecology Exchange by December 2013.

### **Discussion area**

A discussion area e.g. blog (similar to the current news page on the Radioecology Exchange) will be created by March 2014. It was agreed to limit the discussion area to a limited number of topics based on the expertise of the STAR consortium. The topics will be discussed and finalised amongst STAR partners in January 2014 and each partner will be allocated responsibilities for responding to any queries related to a specific topic.

### **FAQ section**

It has recently been agreed that a FAQ section would be useful; in preparation for this STAR partners will during 2013:

- Collate potentially useful FAQ web pages currently available
- Check their own institutes to see if they have any FAQs suitable for use
- Consider what questions would be included within the FAQ section



## Options to be considered if time/resources allow

The following options may be considered for inclusion within the virtual laboratory if time/resources are available towards the end of the project:

- Video tours of STAR partners laboratories
- Company movie (SCK•CEN and CIEMAT already have one)
- Q&A - For example see here: <https://wiki.ceh.ac.uk/x/tlJBg>

## Future of the virtual laboratory

At the end of the STAR project the information provided above will form the basis for an expanded virtual laboratory supported by the ALLIANCE.

## Appendix 1 - Example analytical method

### Americium from urine sample

#### Determination of Am from urine sample

1. Take 200 – 3000 ml of urine in decanter (figure 1)

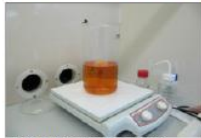


Figure 1. Urine sample in decanter

2. Add tracer, Am-243, typically between 0.02 – 0.05 Bq.
3. Put the decanter onto the double-boiler or heating plate.
4. Add 2 – 3 drops octanol and 1 ml 1.25M Ca(NO<sub>3</sub>)<sub>2</sub>. The urine need to mixed using magnetic stirrer. If you are analysing blank samples, then add 5 ml 1.25 M Ca(NO<sub>3</sub>)<sub>2</sub>.
5. Add 65 % HNO<sub>3</sub>. The amount of acid is 10% of the sample volume e.g. 100ml of HNO<sub>3</sub> is added for one liter sample.
6. Heat the sample in double-boiler at 90 °C for 2 - 3 hours. Cover the sample during heating.
7. Take sample off the boiler.
8. Add 0.2 ml 3.2 M (NH<sub>4</sub>)<sub>2</sub>PO<sub>4</sub> into the warm solution mixing all time.
9. Mix the sample all along using magnetic stirrer, add 25 % NH<sub>4</sub>OH until the pH of the solution is around 9 and Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> precipitation is composed (video 1, figures 2 and 3).



Figure 2. Formation of precipitation, at the beginning.



Figure 3. Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> precipitation at the end.

10. Remove the magnetic stirrer.
11. Heat the sample about 30 minutes. Turn off the heating and let the precipitation to settle down at least two hours, gladly over the night (Figure 4).



Figure 4. Precipitation settling down.

12. Decant the solution. Abandon the solution (video 2).

13. Move the precipitation and remaining solution into the centrifuge tubes (figure 5). Centrifuge samples 10 minutes using 2000 rpm.

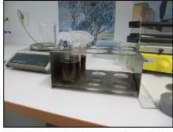


Figure 5. Sample in the centrifuge tube.

14. Move the solution, wash the the precipitation using distilled water and centrifuge samples again.

15. Abandon the solution (video 3, figures 6 and 7.).



Figure 6. Samples after centrifugation



Video 3. Removing the liquid from the sample.



Figure 7. Precipitation.

16. Dissolve the precipitation into 5 ml conc.  $\text{HNO}_3$  and remove the solution into the 100 ml decanter. Wash the centrifuge tubes using 2 x 5 ml conc.  $\text{HNO}_3$ . Add the washing solutions into the original solutions.
17. Wash the decanter using 5 ml conc.  $\text{HNO}_3$  and put washing solutions together with original solution.
18. Add 1 ml 30 %  $\text{H}_2\text{O}_2$ . Evaporate the solution into dryness using heating plate (150 - 200 °C). Add 2 - 3 drops 30 %  $\text{H}_2\text{O}_2$  into the warm sample. This oxidate the remaining organic matter.
19. Cool the sample, add 5 ml  $\text{H}_2\text{O}_2$  and evaporate the sample into dryness.
20. Cool the sample, add 5 ml  $\text{HNO}_3$  and evaporate the sample into dryness.
21. Repeat the steps 19 and 20 until the precipitate is white (figure 7.)



Figure 7. Not yet ready precipitation on the left and final white precipitation on the right.

22. Dissolve the residual into 20 ml 3M  $\text{HNO}_3$  - 1.0M  $\text{Al}(\text{NO}_3)_3$  solution.
23. Prepare the TRU column. Put 2ml TRU resin into the column.
24. Let 5ml 2M  $\text{HNO}_3$  acid to run through the column (conditioning)
25. Load the sample into the column (figure 8). This takes about 1,5 hours.

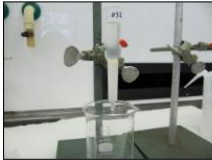


Figure 8. Separation of Am using TRU column. See the yellow colour at the top of the column.

26. Rinse the decanter and put the solution into the TRU column.
27. Add 5ml 0.5M  $\text{HNO}_3$ .
28. Take a new decanter under the column and add 3ml 9M  $\text{HCl}$  into the column. Collect all solutions into the decanter.
29. Add 20ml 4M  $\text{HCl}$  into the column. Collect solutions into the same decanter.
30. Evaporate all solutions nearly dry, takes about 1,5 hours.
31. Add carefully 3ml conc.  $\text{HCl}$  and 1ml conc.  $\text{HNO}_3$ . Evaporate.
32. Repeat the step 31 twice.
33. Add 2ml conc.  $\text{HCl}$  and evaporate nearly dry.
34. Add 2ml conc.  $\text{HCl}$  and heat the decanter for 2 minutes.
35. Dilute the solution using 8ml of ultra pure water and heat the sample for 2 minutes.
36. Remove the sample into the 50ml plastic centrifuge tube.
37. Rinse the decanter using 2ml of ultra pure water and add the water into the 50ml plastic centrifuge tube.

## Appendix 2 - Example Factsheet and Datasheet



Radioisotopes of  
significance to  
environmental  
radioactivity

$^3\text{H}$

### Hydrogen

**Element classification:** not classified

**No. of isotopes:** 7 ( $^1\text{H}$  and  $^2\text{H}$  stables)

**Typical elemental concentrations:**

- Soil (dry): not relevant
- Sea water: about 100 g/l
- Fresh water: about 110 g/l



### Behaviour in the Environment

- ♦ Three chemical forms: tritiated water (HTO), gaseous tritium (HT), organically bound tritium (OBT)
- ♦ HTO follows the water fluxes and biogeochemical cycle
- ♦ Easy atmosphere-water exchanges (evaporation, fog, etc.)
- ♦ HTO very easily absorbed by plants and animals
- ♦ Equilibrium quickly achieved in aquatic environment (HTO)
- ♦ No bioconcentration with HTO
- ♦ Much less known about OBT

# Tritium

radioecology

### Key sources

- ♦ **Nuclear cycle:** [Nuclear power plants](#), [reprocessing](#), waste
- ♦ **Fallout:** Nuclear weapons testing
- ♦ **Nuclear accidents:** e.g. Windscale, [Chernobyl](#), [Fukushima Daiichi](#)
- ♦ **Others:** military, medical and research applications
- ♦ **Natural sources:** reactions of high-energy cosmic rays with atmospheric nitrogen and oxygen



### Why is it of interest?

- ♦ Extremely mobile isotope
- ♦ Easily transferred to any biological tissues, as tritiated water
- ♦ Potential for incorporation in DNA
- ♦ Major component of gaseous and liquid releases with  $^{14}\text{C}$

For more  
information ...

[IRSN  \$^3\text{H}\$  factsheet](#)

[ANL tritium factsheet](#)

[Remediation](#)



### Commonly used or illustrative parameters

Generic parameters	Value
Radioactive half-life	
Origin	
Principal decay mode	
Specific activity	
Freshwater $K_d$	
Marine $K_d$	

Parameters useful for human assessments	Value
CR Pasture grass	
CR Freshwater fish	
CR Marine fish	
$F_r$ Cow meat	
$F_m$ Cow milk	
Human fractional absorption ( $f_a$ )	
Inhalation dose coefficient	
Ingestion dose coefficient	
Biological half-life for Human (adult)	
Biological half-life for Cow milk	
EU Food intervention limit- Dairy	
EU Food intervention limit- Baby food	
EU Food intervention limit- Liquid	
EU Food intervention limit- Other food	
EU Food intervention limit- Minor food	

### Decay chain

[www.star-radioecology.org](http://www.star-radioecology.org)



### Commonly used or illustrative parameters

Parameters useful for wildlife assessments	Value
Terrestrial EMCL – Soil	
Freshwater EMCL – Water	
Freshwater EMCL – Sediment	
Marine EMCL – Water	
Marine EMCL – Sediment	
CR Freshwater fish	
CR Freshwater mollusc	
CR Marine fish	
CR Marine mollusc	
Internal DCC Terrestrial mammal (rat) on soil	
External DCC Terrestrial mammal (rat) in soil	
External DCC Terrestrial mammal (rat) on soil	
Internal DCC Marine fish (benthic)	
External DCC Marine fish (benthic) in water	
External DCC Marine fish (benthic) at sediment interface	
Internal DCC Freshwater fish (pelagic)	
External DCC Freshwater fish in water	

*All terms used in these tables are described and discussed in underlying documents accessed via the hyperlinks provided*

Sources of data  
Data compiled:  
Data updated :

[www.star-radiocology.org](http://www.star-radiocology.org)

## Appendix 3 - Minutes from WP2 meeting in Paris (related to virtual Laboratory)

During the meeting it was agreed that:

Method descriptions; videos; protocols and manuals; sample archive information: access restricted to Alliance members only (location to be agreed).

Fact/data sheets, 'topical descriptions'; model descriptions; majority of training materials: open access on Radioecology Exchange.

The group felt that a discussion area was needed and it would be best hosted on Alliance website (although subsequent discussion that the Radioecology Exchange should become a combined site for ALLIANCE, COMET and STAR).

### Review of outstanding milestones and deliverables

Deliverable 2.4 'Description of the virtual laboratory' is due month 26 (May 2013, on target).

Action list	Deadline	Action
Deliverable 2.4 'Description of Virtual Laboratory': <ul style="list-style-type: none"> <li>Expand 'factsheets' table in D2.4 to include additional information - inc. 'new' sheets (K (Bfs), Te (SU), Co (Bfs), Ag (CEH), Np (SU)) and deadlines, responsibilities.</li> <li>Complete sections of D2.4 'Description of Virtual Laboratory' allocated (see email from CLB on 5/4/13) where appropriate. Clearly identify what will be on the Radioecology Exchange v's restricted access and if possible anticipated delivery date.</li> <li>Provide brief text for D2.4 on proposed input on particles (and state where text should be inserted!).</li> <li>Submit deliverable and put on members wiki (as restricted).</li> </ul>	April 2013  17 May 2013  17 May 2013 31 May 2013	CEH  All  UMB CEH
Protocols and Method descriptions: <ul style="list-style-type: none"> <li>Partners to complete/develop descriptions currently on the infrastructure wiki: <a href="https://wiki.ceh.ac.uk/display/smi/Home">https://wiki.ceh.ac.uk/display/smi/Home</a> (as outlined &amp; allocated in D2.4). Please complete them in a similar manner STUK drafts: <a href="https://wiki.ceh.ac.uk/x/8QBFCQ">https://wiki.ceh.ac.uk/x/8QBFCQ</a> <i>Note: EXPAND &amp; INCLUDE PROBLEMS &amp; SOLUTIONS.</i></li> <li>Gather protocols/training materials used in WP4 ready to go on virtual laboratory.</li> <li>Gather protocols/training materials used in WP5 ready to go on virtual laboratory.</li> <li>Provide a list of links to other sources of information available on-line; prioritise those 'useful' to radioecology. CEH collate.</li> <li>Ensure all descriptions are on infrastructure wiki site by Rovaniemi meeting.</li> </ul>	1 Dec. 2013  Dec. 2013 Dec. 2013 Dec. 2013 Jan. 2014	All  IRSN SCK.CEN ALL, CEH CEH

<p>Facilities:</p> <ul style="list-style-type: none"> <li>Partners to check the information they currently have on the infrastructure wiki and update as appropriate (focus on those facilities open for use by other partners)</li> <li>Prepare a short presentation of the facilities available for other partners to use for Rovaniemi meeting 2014.</li> </ul>	<p>Dec. 2013</p> <p>Jan. 2014</p>	<p>ALL</p> <p>ALL</p>
<p>Factsheets and Datasheets:</p> <ul style="list-style-type: none"> <li>Finalise which food intervention limits to use in datasheets (EU or WHO) and communicate to other partners.</li> <li>QC checking of all fact/datasheets: allocate responsibilities to partners (see table in Deliverable 2.4).</li> <li>Complete factsheets and datasheets (refer to D2.4 for responsibilities) and place final versions on members wiki. <i>Note: I have now changed the template font to Times new Roman also please remember to complete a 'reference list' and create a word document for any text that you think is required to explain a particular point better (for a hyperlink) if needed.</i></li> <li>Scan the pages of documents used for values in datasheets so it is easier for other partners to QC them.</li> <li>QC new/remaining factsheets.</li> <li>Partners to QC <u>datasheets</u> (see table D2.4 for responsibilities).</li> <li>Create overarching descriptive document for fact and data sheets.</li> <li>Mount all information on Radioecology Exchange with a link back to the training pages (<i>note no longer using periodic table format</i>).</li> <li>Consider creating an APP.</li> <li>Consider publicising fact/data sheets at Barcelona conference.</li> </ul>	<p>30 May 2013</p> <p>30 May 2013</p> <p>Begin now but finalise data sheets post new version of ERICA</p> <p>Sept. 2013</p> <p>As sheets completed</p> <p>Oct. 2013</p> <p>Begin now</p> <p>Dec. 2013</p> <p>Dec. 2013</p> <p>Sept. 2014</p> <p>Jan 2014</p> <p>Jan 2014</p>	<p>CEH</p> <p>CEH</p> <p>CEH, IRSN, CIEMAT, SCK, SU, UMB, STUK</p> <p>As above</p> <p>IRSN (Tom)</p> <p>ALL</p> <p>CEH</p> <p>CEH</p> <p>CEH</p> <p>CEH</p>
<p>'Topical descriptions':</p> <ul style="list-style-type: none"> <li>IRSN &amp; CIEMAT to prepare text on the relative importance of internal vs. external dose and exposure routes, for both humans and a wildlife species, when exposed radionuclides in the environment.</li> <li>SU to prepare text on the life cycle of frogs.</li> <li>All partners brainstorm other topics and discuss at meeting in Rovaniemi.</li> </ul>	<p>Jan. 2014</p> <p>Jan. 2014</p> <p>Jan. 2014</p>	<p>IRSN, CIEMAT</p> <p>SU</p> <p>ALL</p>
<p>Descriptions of models:</p> <ul style="list-style-type: none"> <li>CROM</li> <li>ERICA</li> </ul>	<p>Apr. 2013</p> <p>Jan. 2014</p>	<p>CIEMAT</p> <p>CEH</p>
<p>Training (also see WP7 action list):</p> <ul style="list-style-type: none"> <li>Film practicals conducted during June 2013 training course.</li> </ul>	<p>June 2013</p>	<p>UMB, SU</p>



<ul style="list-style-type: none"> <li>• Collate presentations &amp; summary notes etc. (similar to those done for ERICA training course) from PhD and MSc courses.</li> <li>• Provide a list of ‘training’ links that are currently available on-line; prioritise those ‘useful’ to radioecology.</li> <li>• Consider how to use ‘whiteboard’, podcasts etc.</li> <li>• Create/update links to ERICA tool training materials.</li> <li>• Ensure all information is on wiki site by Rovaniemi meeting.</li> </ul>	<p>Aug. 2013</p> <p>Dec. 2013</p> <p>Sept. 2013 Sept. 2013 Dec. 2013</p>	<p>UMB, SU</p> <p>UMB, SU</p> <p>UMB, SU CEH CEH</p>
<p>Databases (also see WP7 action list):</p> <ul style="list-style-type: none"> <li>• Partners to check to see if they have any more data they wish to make available on the Radioecology exchange. <i>Note: the specifically designed wiki is still available to collate data holdings and we have also created a page <a href="https://wiki.ceh.ac.uk/x/l4GECw">https://wiki.ceh.ac.uk/x/l4GECw</a> where you could put photos, figures or short videos which we could link to the data.</i></li> <li>• Partners to consider creating specific email addresses that can be used as specific contacts for data e.g. STAR@STUK</li> <li>• Provide access to STAR databases (and others as agreed) on the Radioecology Exchange.</li> </ul>	<p>June 2013</p> <p>Aug. 2013</p> <p>Starting Sept. 2013</p>	<p>ALL</p> <p>ALL</p> <p>CEH</p>
<p>Sample archives:</p> <ul style="list-style-type: none"> <li>• Partners to check if they have any sample archives they wish to make available to Alliance members and expand the information currently held on infrastructure wiki.</li> </ul>	<p>June 2013</p>	<p>ALL</p>
<p>FAQ section:</p> <ul style="list-style-type: none"> <li>• Collate potentially useful FAQ web pages we could link to (or use the text from. e.g. US Health Physics Society).</li> <li>• Check own an institute to see if they have any FAQ’s suitable.</li> <li>• Consider what questions we could consider including in FAQ</li> <li>• Prepare information collated for brainstorm in Rovaniemi.</li> </ul>	<p>Jan. 2014</p> <p>Jan. 2014</p> <p>Jan. 2014</p> <p>Jan. 2014</p>	<p>ALL</p> <p>ALL</p> <p>ALL</p> <p>ALL</p>
<p>Discussion area (if required after discussion with Alliance):</p> <ul style="list-style-type: none"> <li>• Consider what topics would be covered.</li> <li>• Finalise topics and allocate responsibilities for answering any questions at Rovaniemi meeting.</li> <li>• Create discussion area.</li> </ul>	<p>Jan. 2014</p> <p>Jan. 2014</p> <p>Mar. 2014</p>	<p>ALL</p> <p>ALL</p> <p>CEH</p>
<p>Videos:</p> <ul style="list-style-type: none"> <li>• STUK to finalise video clips already created. They will be used linked to the methods on restricted area and some will link to datasets on Radioecology Exchange.</li> <li>• SCK.CEN to prepare a powerpoint shows (pps files) on General molecular/biochemical analyses, biosphere impact studies, working in a radiobiology laboratory,</li> </ul>	<p>Dec. 2014</p> <p>Dec. 2014</p>	<p>STUK</p> <p>SCK.CEN</p>

<p><i>Lemna</i> culture and growth measurement and <i>Arabidopsis</i> culture (with audio)</p> <ul style="list-style-type: none"> <li>• Review the videos/pps files created above.</li> <li>• Check to see if own institute has a ‘company’ movie available which could be linked to ‘consortium members’ page on Radioecology Exchange. (SCK.CEN and CIEMAT have one).</li> </ul>	<p>Jan. 2014</p> <p>Jan. 2014</p>	<p>CIEMAT</p> <p>ALL</p>
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