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CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE

Practical implementation of ALARA and ALARA tools

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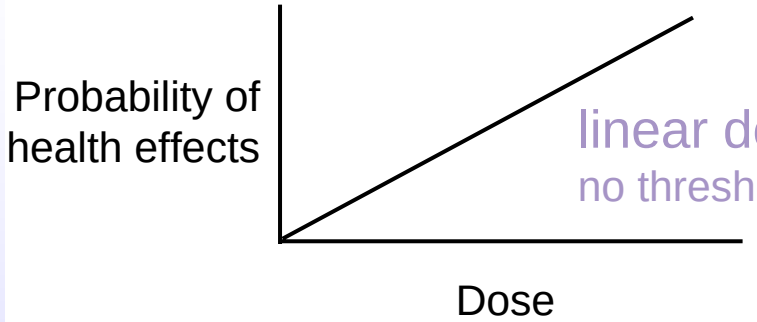
Contents

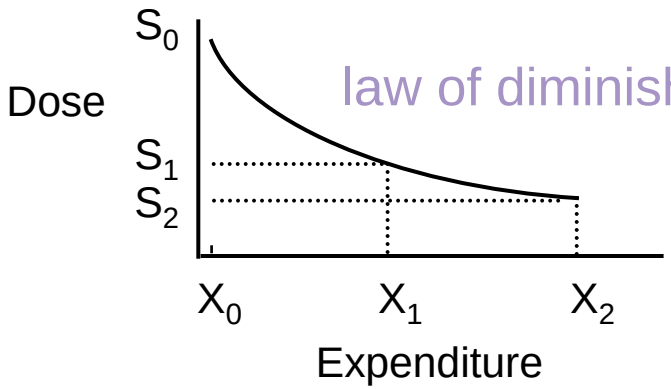
- Background to the ALARA concept
- The ALARA procedure
- Practical implementation
- Communication in ALARA
- Tools
- Organisation

Background to the ALARA concept
Risk and risk reduction

deterministic versus stochastic effects



linear dose-effect relationship
no threshold!



law of diminishing returns (glazing)

$X_1 - X_0 \rightarrow S_0 - S_1$

$X_2 - X_1 = X_1 - X_0 \rightarrow S_2 - S_1$

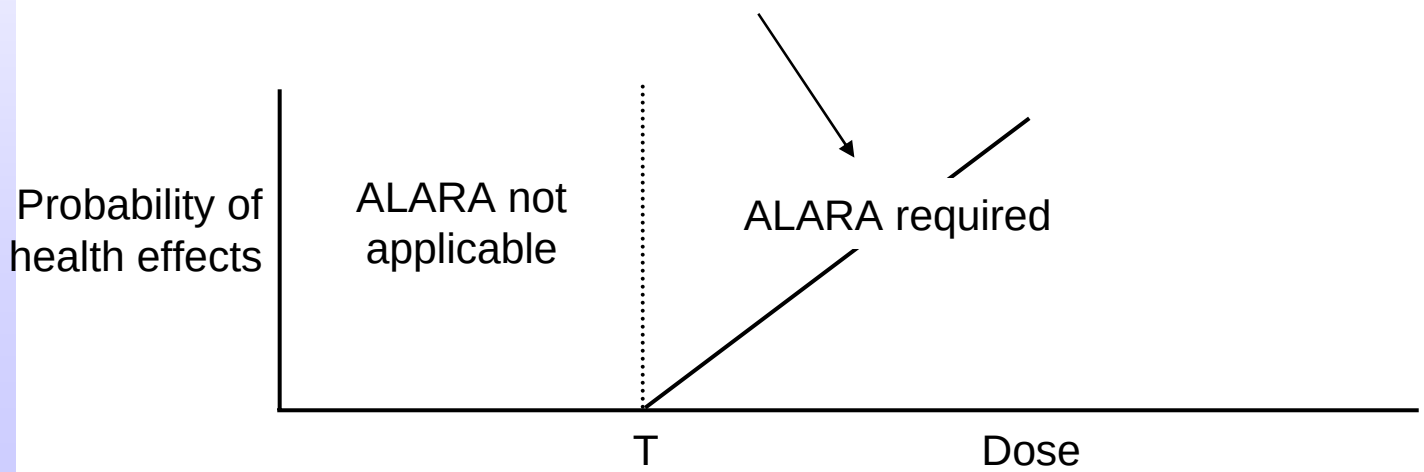
$S_2 - S_1 < S_0 - S_1$

Background to the ALARA concept reasonable risk reduction

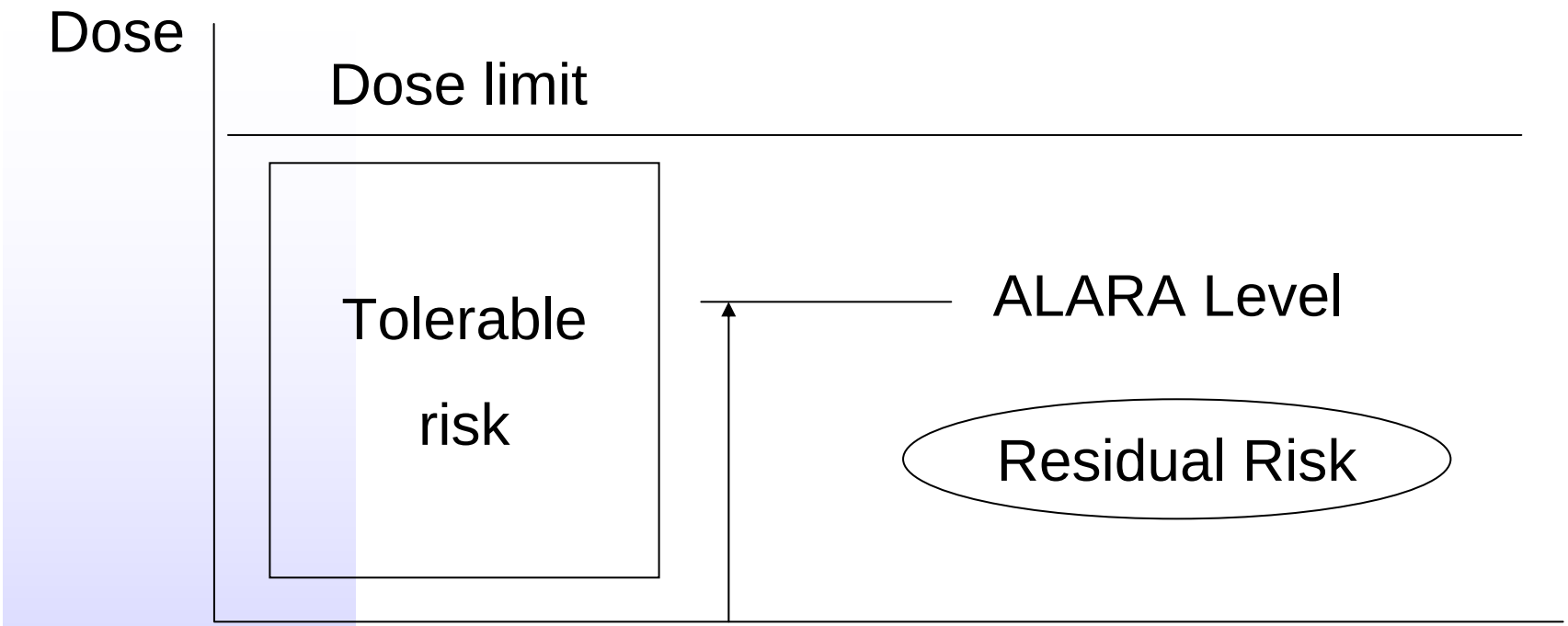
- never infinite resources available!

  → need for optimisation

- two points are worthy to note:
  - it is not the minimisation of doses at all costs
  - even if there is a threshold



Background to the ALARA concept
Tolerable and Residual risk



ALARA stakeholders

→ To reach an agreement on the residual risks

Background to the ALARA concept
Starting points

→ first: everyone safety conscious

→ secondly: guidance on interpreting the ALARA principle

- good practice
- real optimisation

  (= systematic approach = ALARA procedure)

  + use of cost-benefit analysis

- = decision-aiding techniques

Where can I find some guidance

- ALARA from theory towards practice
  - CE, report EUR 13796 EN
- Information System on Occupational Exposure (ISOE)
  - Workshops
  - Publications
- European ALARA network
  - Workshops
  - Recommendations
  - Newsletters
  - Sub networks
- BVS ALARA training day

"I hear and I forget. I see and I remember. I do and I understand."

Confucius

How to we organise the work according to ALARA

Radiation protection

and

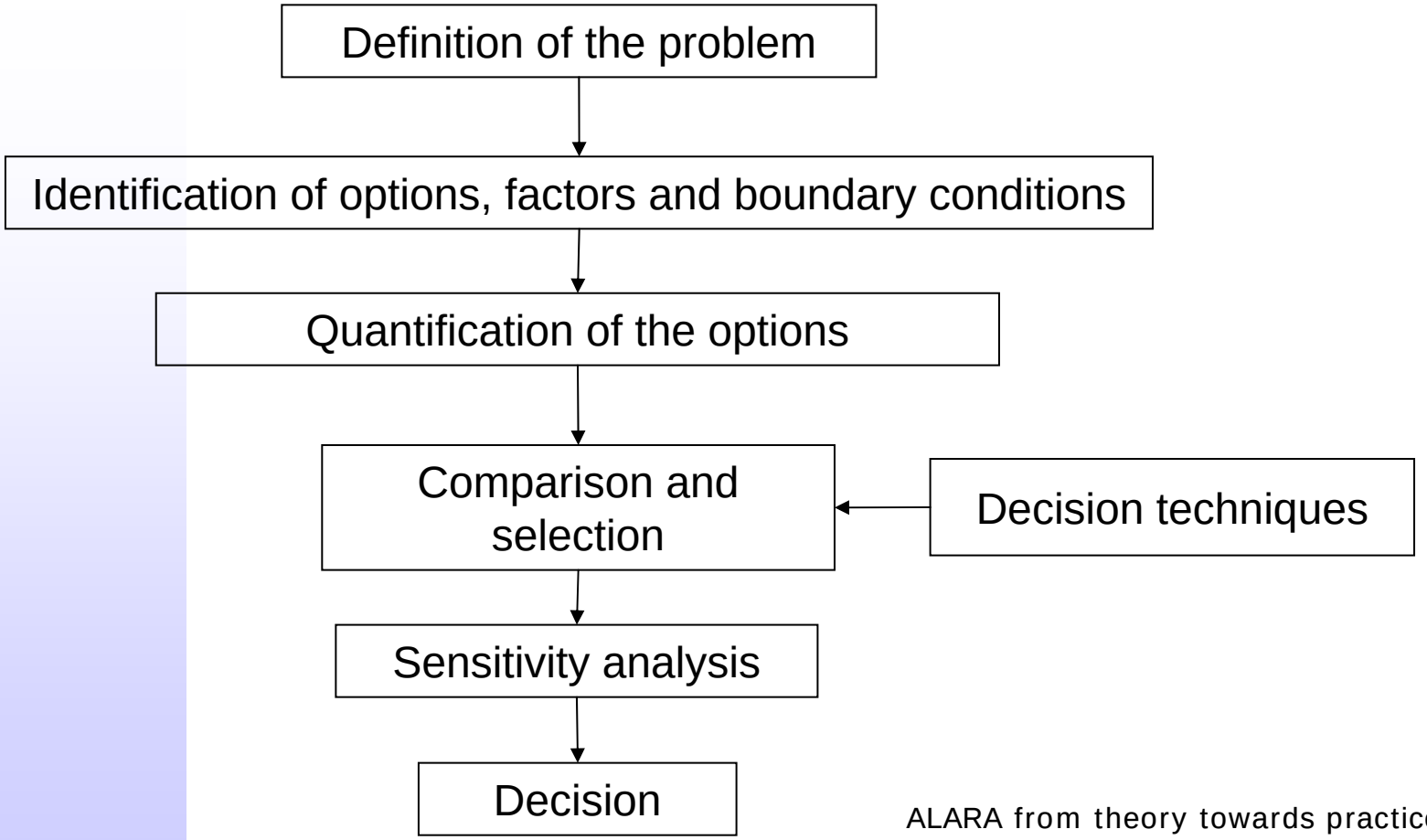
ALARA

The plan

Ideas The decision

The work

The ALARA procedure



ALARA from theory towards practice

EUR 13796 EN

ALARA procedure
Definition of the problem

- Are the actions that we plan justified
- What are the actions that are planned
  - Size of the problem
  - Type of action (inspection, maintenance, decommissioning, installation, outage, ...)
  - Duration of the work
  - Number of people involved
  - Location of the work
  - Frequency of the actions
  - Sequence of the actions
- What are the radiological risks involved
- What are the industrial risks involved

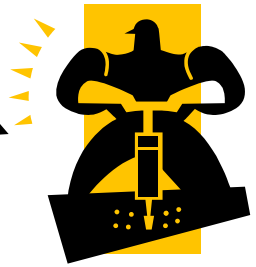
To clearly define your ALARA problem
Communicate !

Radiation protection

- Radiological characterisation of the site

ALARA analyst

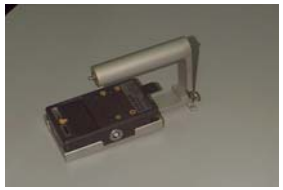
Planner
- Work description
- Site information



Workers and Technicians
- Work duration
- Technical realisation

Radiological characterisation of the workplace

- History of the site, return of experience
  - Information on the use of the site
  - Typical isotopic vectors
- Radiological measurements
  - contamination
  - Air contamination
  - Dose rate measurements (4π)
  - Spectral analysis of sweeps, liquid samples,…
  - Gamma scanning, gamma camera's



Results of the Radiological characterisation

- Dose rates at worker positions
- Dose maps
- Contamination levels
- Isotopic vectors
- Localisation of sources
- Determination of the relative strength of sources

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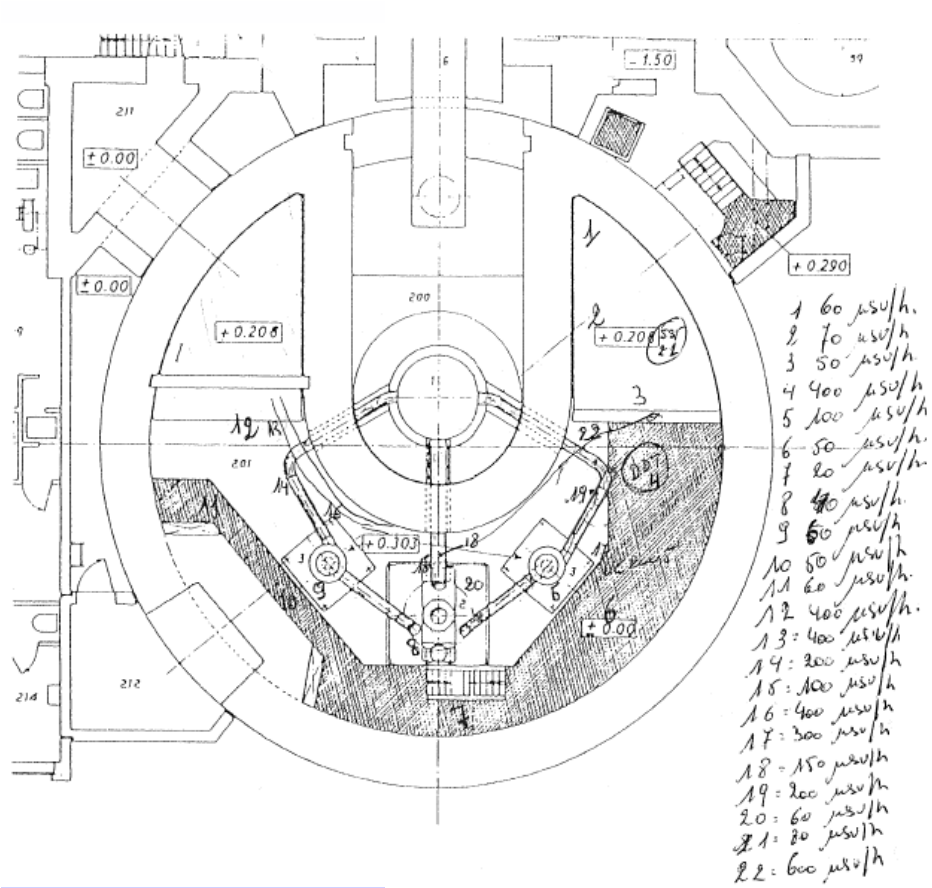
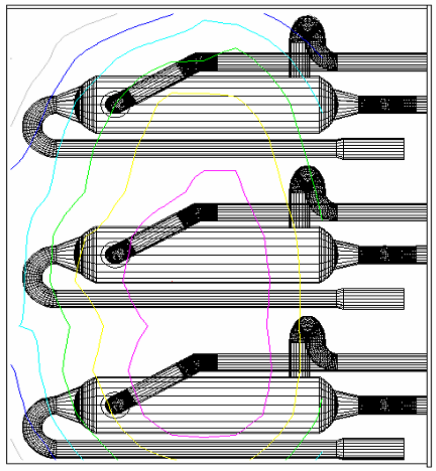
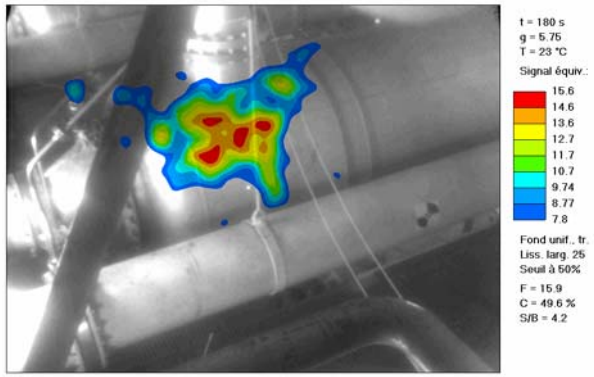
Dose rates
Dose rate maps



Dose rate at worker position



Dose rate maps



Localisation of hotspots

Technical characterisation of the workplace

- Site history
- Geometry
  - Plans of the site
  - Geometric scanning or survey
- Materials
  - Technical description of the site
- Technical limitations
  - Technical description of the site

Work description

- Breakdown of the work description in smaller units
  - Number of people
  - Location
  - Duration
  - Techniques used

"Préparation" du chantier	man	h
obturation des fenêtres de la piscine RC (7)	2	5
Ventilation mobile BR2	3	8
Stand de découpe (installation / check)	3	4
Marquage tuyauteries	2	12
Modifications des circuits		
Eau de service	2	10
Air comprimé		
SOD	3	24
OD (niet)	2	10
Mise en sécurité NST	2	5
vase d'expansion	2	2
Démantèlement points chauds + autres opérations		
Pompe MC n°2	2	2
Herpi's	2	2
Ligne collecte d'effluents	2	3
Déshabillage DDT supérieur	2	4
Déshabillage SPHx	2	4
Spray System	2	5
Déshabillage DDT inférieur (dont L.O. + HDT)	2	3
Piquages tuyauteries primaires	2	3
Déshabillage MBT + évacuation	2	4
Piquages GV	2	3
Démantèlement ligne N²	2	2

Identification of dose reducing options

- What can we do to reduce the dose ?

Reduce exposure time

More efficient tools

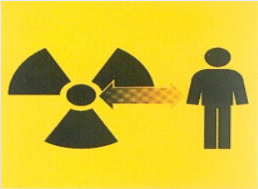
Better work conditions (light)

Better design of components

Optimising work sequences

Training

Increase distance



More efficient long handling tools

Better design of components

Optimising work sequences

Training

Move sources

Decontamination

Shielding

Introduction of shielding

Better design of the installation towards shielding

Multidisciplinary approach

- Brainstorming
  - Dose evaluation and dose reducing options
  - Work planning, organization of the work place
  - Return of Experience
  - Expert of the installation
  - Expert of the specific technological solutions used
  - .....

⇒ Ways to plan the work

Dose reducing options

How efficient are my dose reducing options

- Cost of protection
  - Direct capital cost
  - Indirect capital cost
  - Operational cost
  - Direct gain
- Radiation doses
  - Collective dose
  - Individual dose
  - Occupational versus public dose
  - Dose distribution over time

Dose Factors

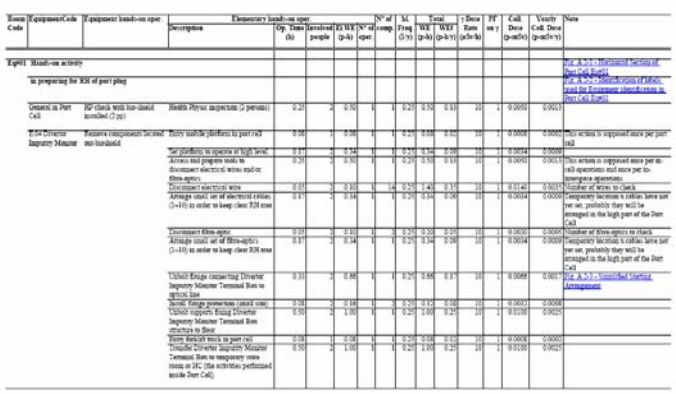
- Collective dose

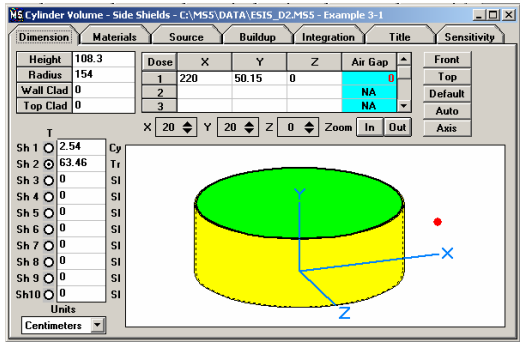
$$S = \sum_i H_i P_i$$

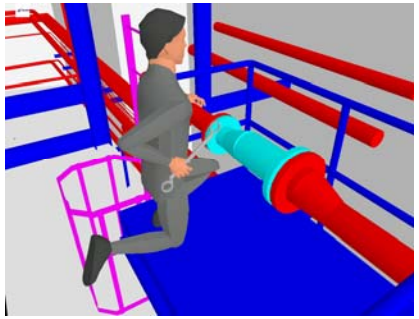
- Individual dose
  - Avoid unequal distribution of the risks
- Avoid dose transfer

Means to assess dose

- Using tables based on the measured dose rates at the worker position
- Dose calculation programs to assess shielding effectiveness
- Work simulation programs







Dose Tables

- Advantage
  - Quick assessment possible
- Disadvantage
  - Static, difficult to examine change in the environment
  - Difficult to investigate dose reducing options, needs a combination with dose calculation programs (MicroShield, MCNP, ...) to reassess the dose rates changes.

$$S = \dot{H} \cdot T \cdot N$$

N number of workers

T task duration

$\dot{H}$ dose rate

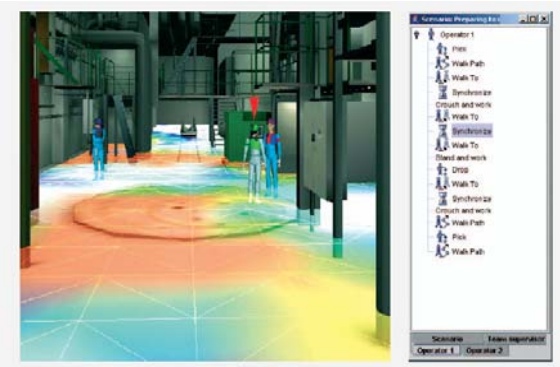
Room Code	EquipmentCode	Equipment hands-on oper.	Elementary hands-on oper.					N° of comp.	M. Freq. (1/y)	Total		γ Dose Rate (µSv/h)	PF on γ	Coll. Dose (p-mSv)	Yearly Coll. Dose (p-mSv/y)	Note
			Description	Op. Time (h)	Involved people	El.WE (p-h)	N° of oper.			WE (p-h)	WEf (p-h/y)					
Eq#01	Hands-on activity															Fig. A.2-1 - Horizontal Section of Port Cell Eq#01
	in preparing for RH of port plug															Fig. A.2-2 - Identification of labels used for Equipment identification in Port Cell Eq#01
	General in Port Cell	HP check with bio-shield installed (2 pp)	Health Physic inspection (2 persons)	0.25	2	0.50	1	1	0.25	0.50	0.13	10	1	0.0050	0.0013	
	E.04 Divertor Impurity Monitor	Remove components located out-bioshield	Entry mobile platform in port cell	0.08	1	0.08	1	1	0.25	0.08	0.02	10	1	0.0008	0.0002	This action is supposed once per port cell
			Set platform to operate at high level	0.17	2	0.34	1	1	0.25	0.34	0.09	10	1	0.0034	0.0009	
			Access and prepare tools to disconnect electrical wires and/or fibre-optics	0.25	2	0.50	1	1	0.25	0.50	0.13	10	1	0.0050	0.0013	This action is supposed once per in-cell operations and once per in-interspace operations
			Disconnect electrical wire	0.05	2	0.10	1	14	0.25	1.40	0.35	10	1	0.0140	0.0035	Number of wires to check
			Arrange small set of electrical cables (1=10) in order to keep clear RH area	0.17	2	0.34	1	1	0.25	0.34	0.09	10	1	0.0034	0.0009	Temporary location: x cables have not yet set, probably they will be arranged in the high part of the Port Cell
			Disconnect fibre-optic	0.05	2	0.10	1	2	0.25	0.20	0.05	10	1	0.0020	0.0005	Number of fibre-optics to check
			Arrange small set of fibre-optics (1=10) in order to keep clear RH area	0.17	2	0.34	1	1	0.25	0.34	0.09	10	1	0.0034	0.0009	Temporary location: x cables have not yet set, probably they will be arranged in the high part of the Port Cell
			Unbolt flange connecting Divertor Impurity Monitor Terminal Box to optical line	0.33	2	0.66	1	1	0.25	0.66	0.17	10	1	0.0066	0.0017	Fig. A.2-3 - Simplified Starting Arrangement
			Install flange protection (small size)	0.08	2	0.16	1	2	0.25	0.32	0.08	10	1	0.0032	0.0008	
			Unbolt supports fixing Divertor Impurity Monitor Terminal Box structure to floor	0.50	2	1.00	1	1	0.25	1.00	0.25	10	1	0.0100	0.0025	
			Entry forklift truck in port cell	0.08	1	0.08	1	1	0.25	0.08	0.02	10	1	0.0008	0.0002	
			Transfer Divertor Impurity Monitor Terminal Box to temporary store room or HC (the activities performed inside Port Cell)	0.50	2	1.00	1	1	0.25	1.00	0.25	10	1	0.0100	0.0025	

Simulation programs

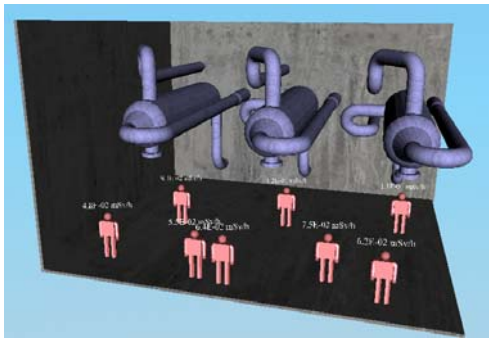
- VR-Domain Rolls Royce Associates
- Virtual radiation field Un. Florida
- VR-dose Halden VR-centre
- HesPi UPM
- ErgoDose NNC
- CHAVIR (Chantier Virtuel)
- VISIPLAN

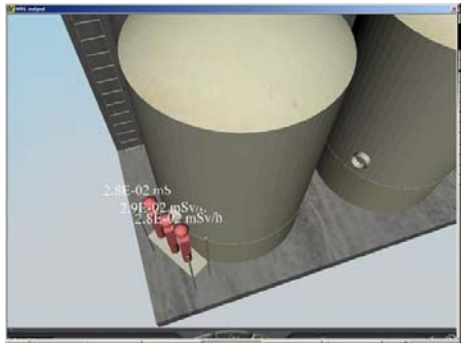
  3D ALARA planning tool (SCK•CEN)

Simulation programs

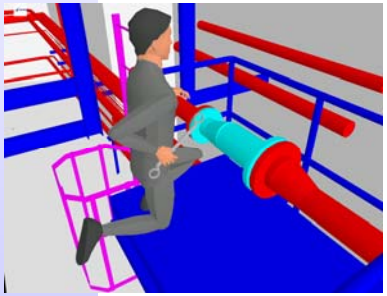


VRDose IFE Halden

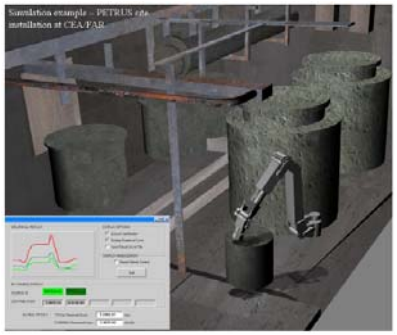




VISIPLAN 3D ALARA planning tool SCK•CEN

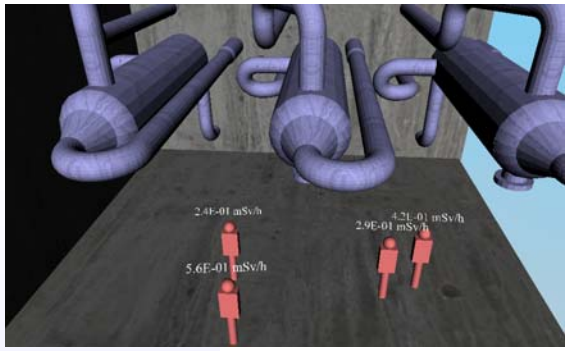


ErgoDose NNC

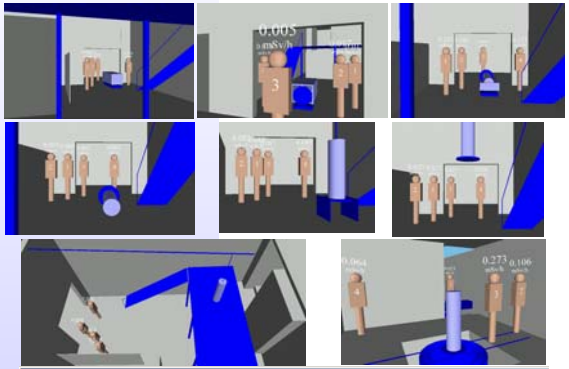


CHAVIR CEA-LIST

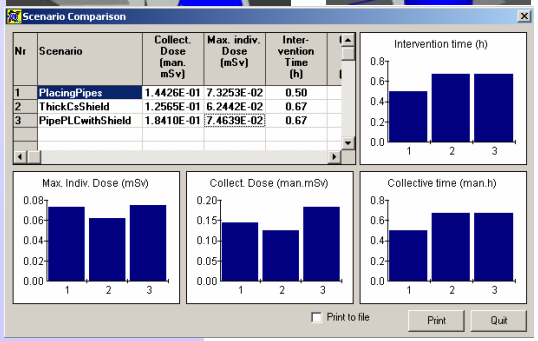
Dose analysis
VISIPLAN 3D ALARA planning tool



Analysis of individual trajectories



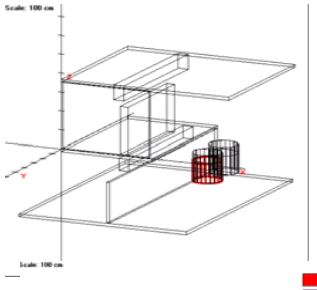
Analysis of scenarios



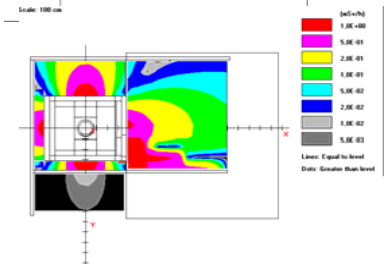
Scenario comparison

Steps in the analysis

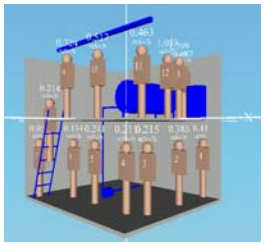
3D Model building



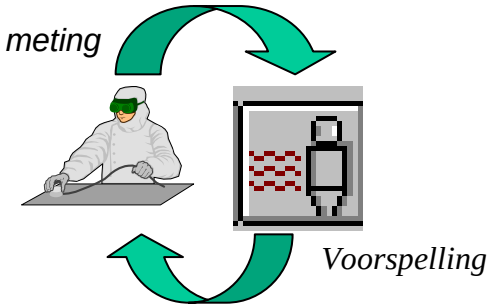
General analysis based on dose maps



Detailed analysis based on trajectory simulation



Follow up of the dose uptake during the work



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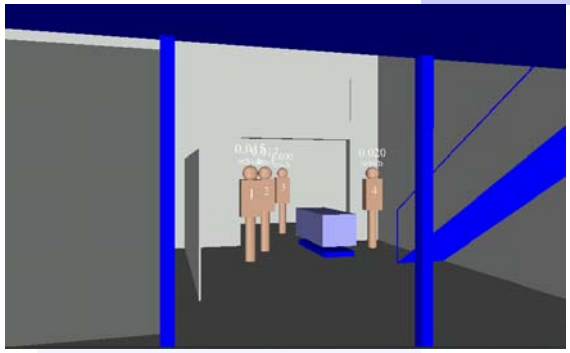
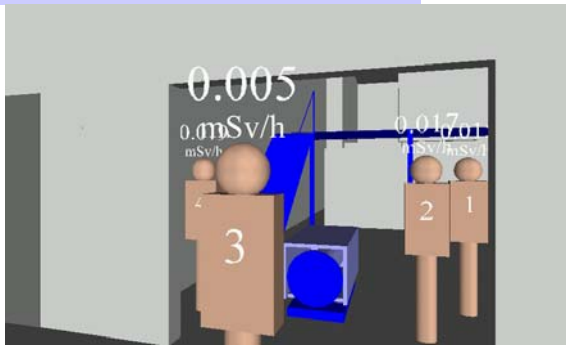
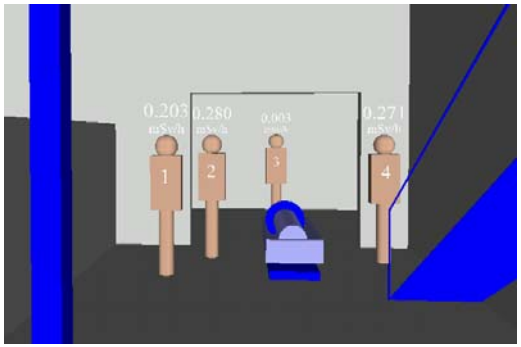
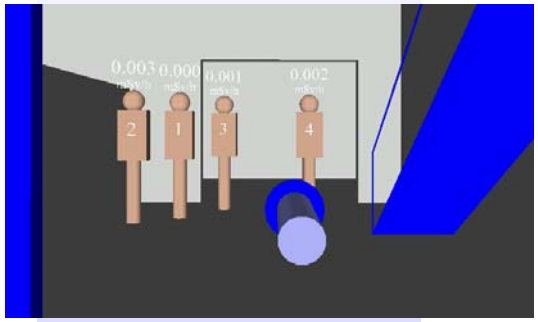
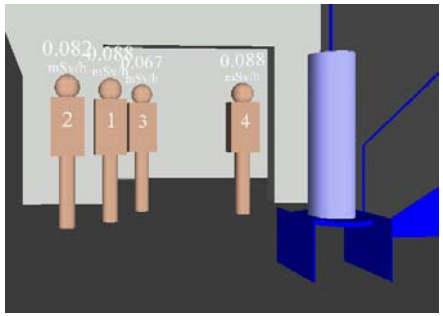
Example Fuel loading

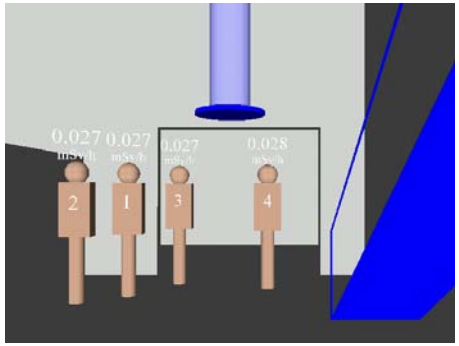


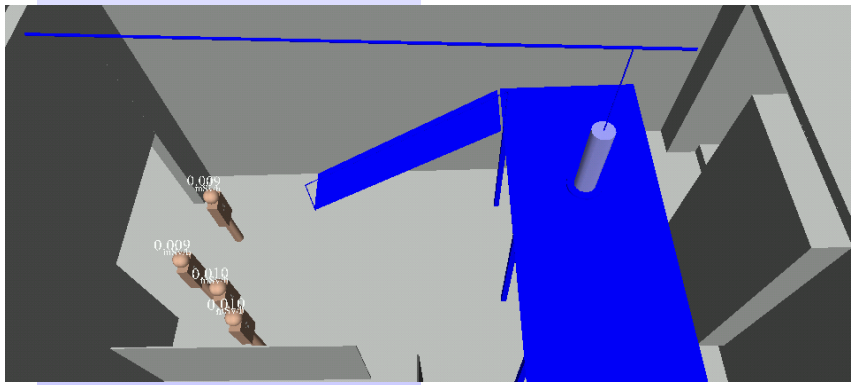


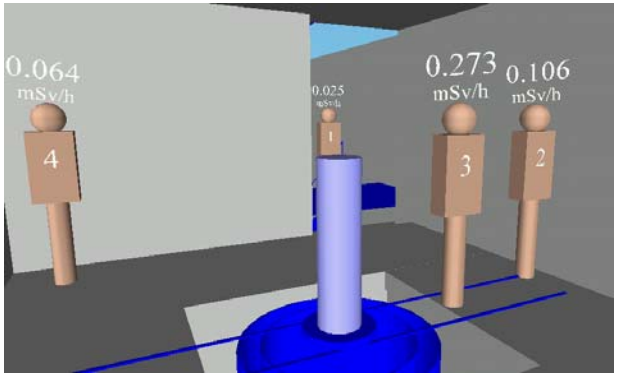




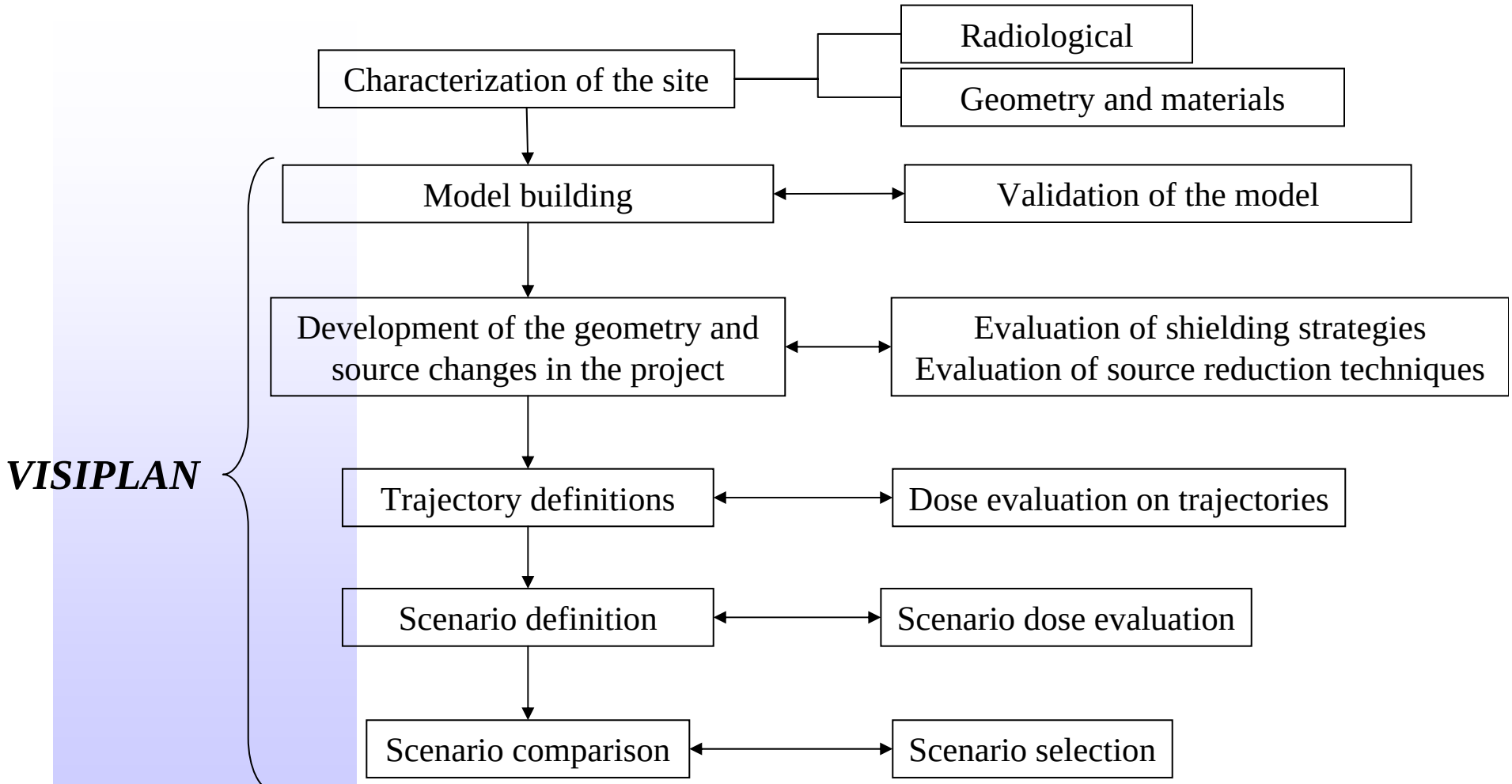








ALARA assessment with VISIPLAN 3D ALARA planning tool



Decision techniques

- Cost benefit
- Cost effectiveness

⇒ De monetary reference value of the avoided unit of exposure man.SV

(More a baseline reference value then an operational tool → no regulatory status)

(Belgium 39-2200 Euro/man.mSv depending on the exposure conditions)

Cost-Benefit

DOSE

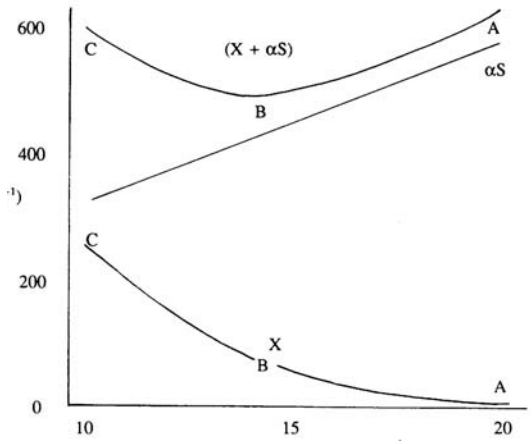
$$Y = \sum_j \alpha_j S_j$$

KOST

C

Total cost of an option = Y + C

Optimisation



Sensitivity analysis

- Is my selection of the final scenario influenced by the uncertainties in my base assumptions
- Take into account the uncertainties in
  - Dose measurements
  - Determination of the source strength
  - Isotopic vector
  - Modelling as a whole
  - Alpha-value
- What if ? analysis

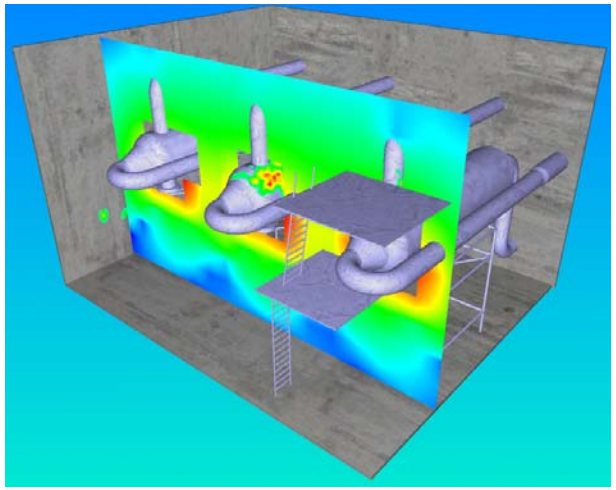
Decision

- ALARA results = support to the decision maker
- Needs a correct representation of
  - assumptions
  - reliability
  - …
  - α-waarde
  - pre-job studies(dose, dose rates,…)
- The decision needs traceability

Is our job done now ?

- No
  - Communicate the strategy or the selected option and the residual risk

"Préparation" du chantier	man	h
obturation des fenêtres de la piscine RC (7)	2	5
Ventilation mobile BR2	3	8
Stand de découpe (installation / check)	3	4
Marquage tuyauteries	2	12
Modifications des circuits		
Eau de service	2	10
Air comprimé		
SOD	3	24
OD (niet)	2	10
Mise en sécurité NST	2	5
vase d'expansion	2	2
Démantèlement points chauds + autres opérations		
Pompe MC n°2	2	2
Herpi's	2	2
Ligne collecte d'effluents	2	3
Déshabillage DDT supérieur	2	4
Déshabillage SPHx	2	4
Spray System	2	5
Déshabillage DDT inférieur (dont L.O. + HDT)	2	3
Piquages tuyauteries primaires	2	3
Déshabillage MBT + évacuation	2	4
Piquages GV	2	3
Démantèlement ligne N²	2	2



Make the workers aware of the residual risk

And now, is our job done ?

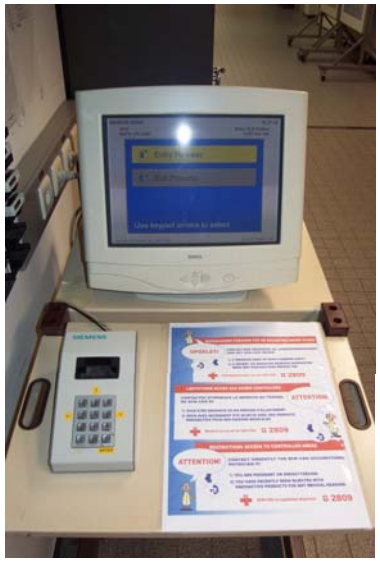
- No
- follow up is needed
  - Are the doses according to the predicted ones ?
  - If their are discrepancies why is this the case ?
  - Are corrective actions needed and can we install them

Follow up tools

- Operational dosimetry
- Feedback reports
- Feedback databases

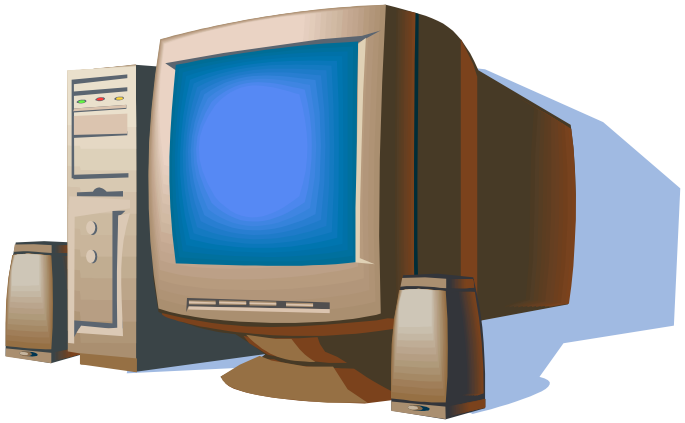
Operational dosimetry

- Close follow up of the dose uptake for the specific actions
- Clear reporting, easier to establish REX



ALARA databases

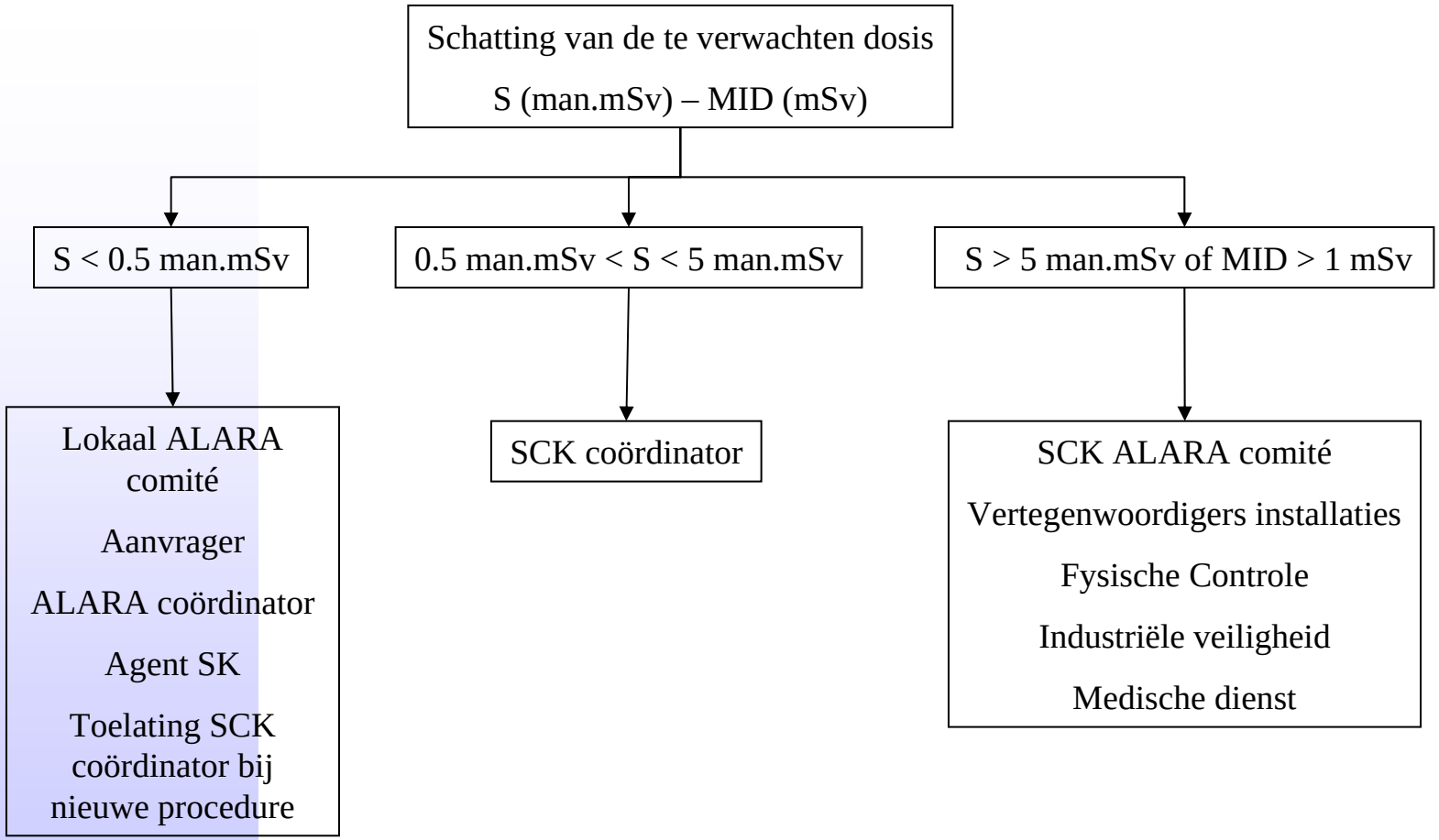
- Allows to organize the information on the practices and their authorisations
- Allows easy consultation for REX



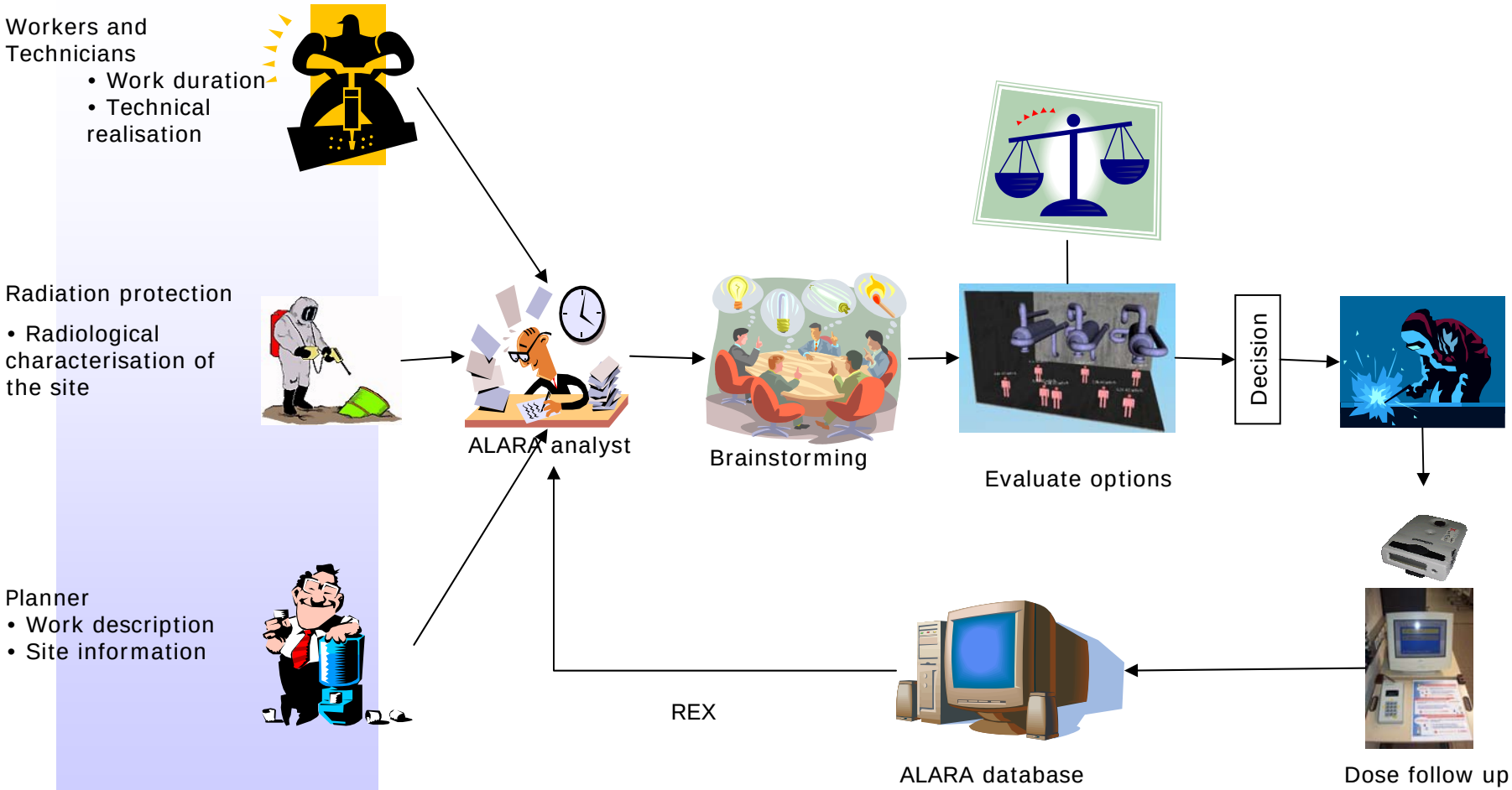
Implementing ALARA

- In order to implement and use ALARA tools you need to establish a set of procedures describing
  - The structures and persons within the organisation that are responsible for the ALARA follow up
  - The extend of the means put into action for a given exposure level
  - The hierarchical level of the final decision

ALARA procedure at the SCK•CEN



ALARA procedure and feedback put into practice



Conclusion ALARA

- Precaution
  - The existing scientific evidence at this moment for exposures to the low doses leads us to adopt the LNT approach
- Responsibility
  - Limited resources
  - Residual risk
- Transparency
  - Decision based on a compromise
  - Clear indication of the exposure levels
  - The applied means put into practice to reduce the dose must be clear and verifiable