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CENTRE D'ÉTUDE SUR L'ÉVALUATION DE LA PROTECTION DANS LE DOMAINE NUCLÉAIRE

OPTIMISATION OF RADIATION PROTECTION

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Content of the presentation

- **Foundation of optimisation of radiation protection**
  - Historical evolution
  - From ICRP 60 to ICRP 103
- **Optimisation in practice**
  - Optimisation process
  - Global and detailed analysis of jobs
  - Elements supporting the ALARA approach

The foundation of the principle of optimisation of radiation protection

Historical evolution of the concept (1)

- **Until the 40's**, radiation protection was based on protection **against the deterministic effects** of ionising radiation
  - The individual dose limit, set up well below the threshold of deterministic effects was a guaranty that such effects would not appear below the limit.

- **During the 1940s**
  - Recognition of '**stochastic effects**'
  - Impossibility to demonstrate the existence or non-existence of a threshold for such effects
  - Due to this uncertainty, **the limit is no longer a guaranty of the absence of risk**

- => Prudent attitude of the ICRP with the recommendation

  "*That every effort be made to reduce exposures to all types of ionising radiation to the **lowest possible level**" (1955)*

Historical evolution of the concept (2)

To **reduce** exposure	**to the lowest**	**possible** level		
To **keep** exposure	**as low as**	**practicable**		*Pub 1 - 1959*
To keep exposure	as low as	**readily achievable**	**economic** and **social consideration** being taken into account	*Pub 9 - 1966*
To keep exposure	as low as	**reasonably achievable**	economic and social consideration being taken into account	*Pub 22 - 1973*
To keep exposure	as low as	reasonably achievable	economic and social **factors** being taken into account	*Pub 26 - 1977*

Historical evolution of the concept (3)

- **ICRP 60 (1990)**
  - Need to consider in the optimisation process :

    "the magnitude of individual exposures, the number of people exposed and the likelihood of incurring exposures where these are not certain to be receivers

  - Emphasis on the **equity issue** : optimisation may introduce inequity between one individual and the other (uneven distribution of benefits and detriments through society)

  => Propose the **use of dose constraint** for practices:

    - a **source-related value of individual dose** used to limit the range of options considered into the procedure of optimisation

Historical evolution of the concept (4)

- **ICRP 103 (2007)**

- *'the **likelihood** of incurring exposures, the **number of people** exposed, and the **magnitude** of their **individual doses** should all **be kept as low as reasonably achievable, taking into account economic and societal factors.***

- *This means that the level of protection should be the **best under the prevailing circumstances,** maximising the margin of benefit over harm.*

- *In order to avoid severely inequitable outcomes of this optimisation procedure, there should be **restrictions on the doses or risks to individuals from a particular source (dose or risk constraints and reference levels)**'*

From ICRP 60 to ICRP 103 (1)

- **ICRP 60**
  - **Practices**
    - Justification, optimisation, limitation (except for medical exposures)
    - Dose limits
    - Individual dose constraint
  - **Interventions**
    - Justification, optimisation
    - Intervention levels

From ICRP 60 to ICRP 103 (2)

The ICRP 60 approach

Practices

Dose limit

Dose constraint

Optimisation

Interventions

"generic" optimisation

Action/intervention level

From ICRP 60 to ICRP 103 (3)

- **ICRP 103**
  - **Planned exposure situations:** situations involving the deliberate introduction and operation of sources.
    - Justification, optimisation, limitation (except medical exposures)
    - Dose limits, dose constraint
  - **Emergency exposure situations:** situations that may occur during the operation of a planned situation, or from a malicious act, or from any other unexpected situation, and require urgent action in order to avoid or reduce undesirable consequences.
    - Justification, optimisation
    - Reference levels
  - **Existing exposure situations:** exposure situations that already exist when a decision on control has to be taken, including prolonged exposure situations after emergencies
    - Justification, optimisation
    - Reference levels

From ICRP 60 to ICRP 103 (4)

The ICRP 103 approach

Planned exposure situations

Dose limit

Dose constraint

Optimisation

Emergency and existing exposure situations

Reference level

Optimisation

Planned Exposure Situations

- **Occupational exposure**
  - Constraints usually set by operator
  - Small operators may need guidance from regulator
  - Transient/itinerant workers need special attention

- **Public exposure**
  - Constraints usually set by regulator
  - About 0.3 mSv in a year appropriate

Optimisation in practice

Optimisation process

- **A source related process** to keep the magnitude of individual exposures, the number of people exposed and the likelihood of potential exposure As Low As Reasonably Achievable, taking into account economic and societal factors

- **An on-going, cyclical process**
  - Evaluate exposure situation to identify the need for action
  - Set up appropriate individual dose constraint or reference level
  - Identify possible protection options to obtain exposures below the dose constraint
  - Select best option(s) under prevailing circumstances
  - Implement the selected option(s)
  - Regular review of the exposure situation

Optimisation process (2)

- ALARA is a **predictive** approach:

- **Overall evaluation of levels of exposure at stake**
  - Generic overview of the situation and its evolution
  - Identification of major areas of improvement
  - Check the effectiveness of the optimisation programme

- **Detailed analysis of specific jobs**
  - Identification of factors contributing to exposures
  - Determination of the most appropriate means to reduce exposures

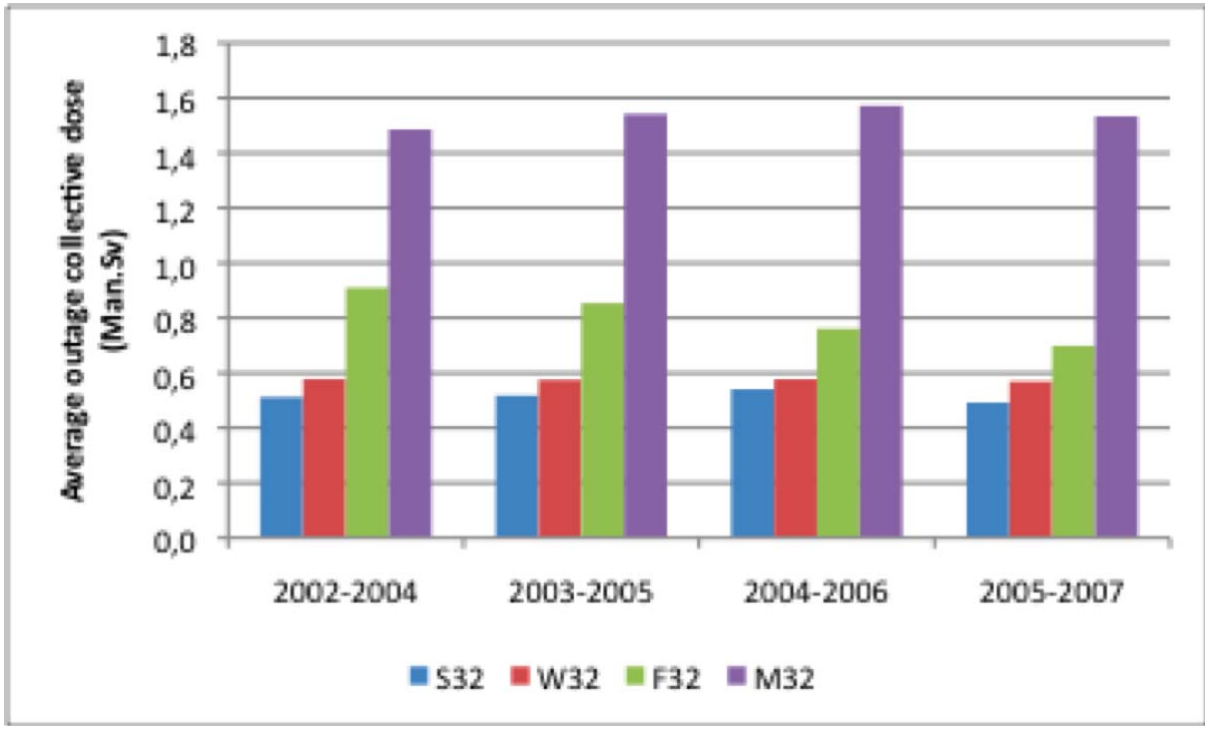
Overall evaluation of levels of exposure (1)

First stage: design of equipments, facilities or new operation

- **Main indicators** (usually on an annual basis)
  - Collective exposures (source related)
  - Distribution of individual exposures
  - Potential exposures (if any)
- **Based on**
  - First, a ‘rough’ estimate of jobs frequency, duration, dose rates, number of workers involved
  - In more complex situations (like design of NPPs), specific modelling tools may be required
- **Objective**
  - Comparison with individual dose constraints and collective dose targets
  - Identify as earlier as possible any design modification needed
  - Start, if the exposure situation is significant, a more detailed optimisation process, task by task

Setting dose targets according to feed-back experience – comparison of design performances

- Outage collective dose in various sister unit group

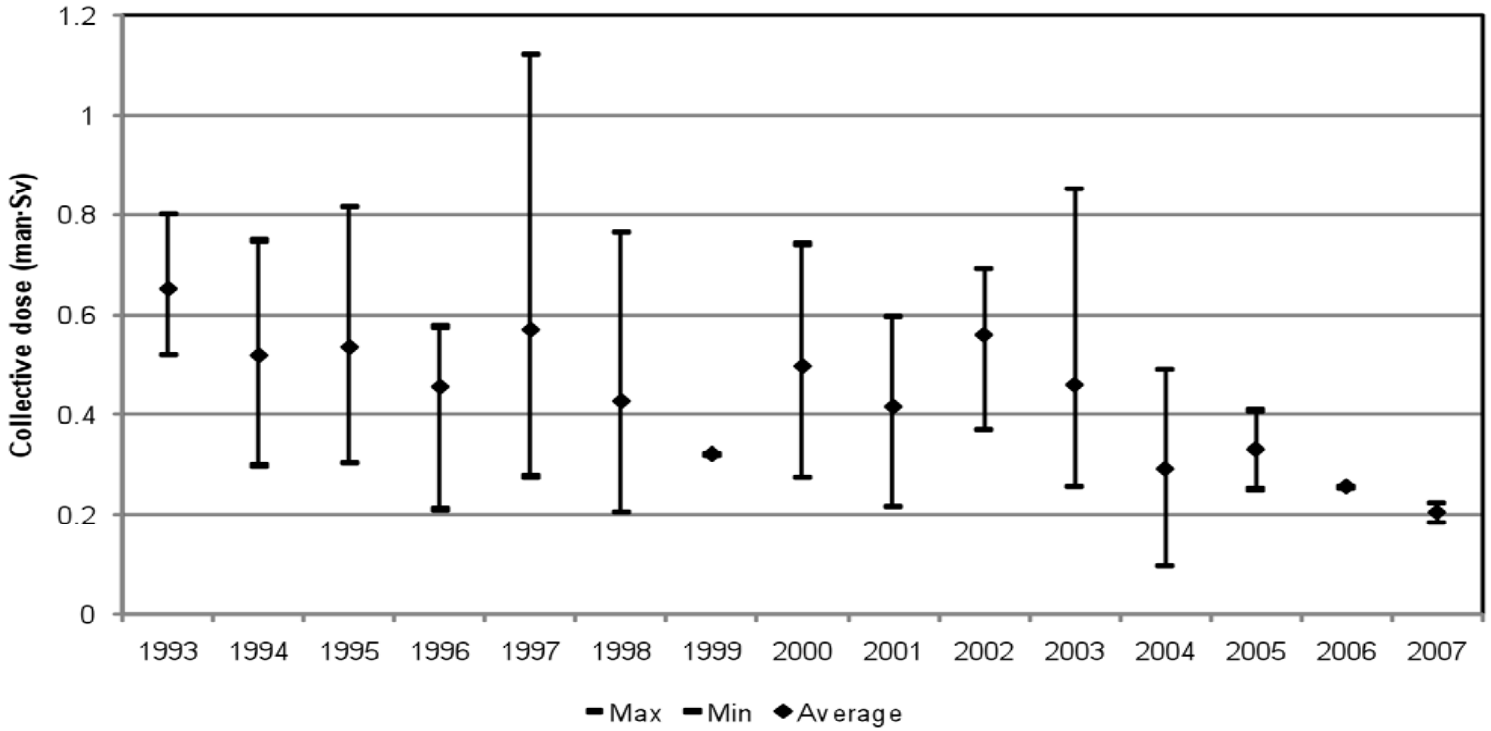


Sister unit goup	Reactor name	Country	2005-2007 Average Outage collective dose (man.Sv)
F32	Tricastin 2	France	0.33*
W32	Doel 4	Belgium	0.24**
M32	Takahama 3	Japan	1.30
S32	Trillo 1	Spain	0.30***

Setting dose targets according to feed-back experience – comparison of task performances

- Steam generators replacement

Figure 21: Average collective dose per steam generator replaced since 1993 (average, minimum and maximum dose)



Overall evaluation of levels of exposure (2)

2nd stage: operation

1. Periodic evaluation by senior management

- **Main indicators**
  - Annual trends in total collective dose and distribution of individual doses
  - Eventually, same indicators, expressed by category of workers, per type of job

- **Objectives**
  - 'Internal' evaluation of trends
  - Comparison with dosimetric goals
  - Check any possible deviation, areas for improvement
  - Control the effectiveness of the RP Programme
  - Give orientation for future dosimetric goals
  - Comparison with 'outside' facilities (national or international)

Global evaluation of levels of exposure (3)

2nd stage: operation

1. ***Periodic evaluation by senior management***

- **Other indicators to be used in a work management perspective**
  - Commitment of all persons (directly or indirectly involved with the management of exposed jobs)
  - Level of knowledge of these persons concerned with dosimetric goals
  - Involvement in the optimisation studies
  - Quality of information system
  - …

Overall evaluation of levels of exposure (3)

2nd stage: operation

2. Systematic evaluation of all radiation jobs

- Broad evaluation of collective and individual doses at the planning stage of jobs
- To be done under the responsibility of HP senior management, in close cooperation with other working groups who might have access to the information
- Based on technical description of jobs, associated with a description of radiological conditions

Global evaluation of levels of exposure (4)

2nd stage: operation

2. Systematic evaluation of all radiation jobs

- **Objectives / benefits of such evaluation**
  - An efficient way of involving the HP staff in the preparation of jobs
  - Allow to obtain the elements needed to elaborate job-related dosimetric goals
  - Allow a systematic evaluation of exposure conditions (where, when and how are the workers exposed)
  - Allow to select which job should be further analysed

Detailed analysis of specific jobs (1)

- **Objectives**
  - Identification of all possible factors (task related) contributing to the exposures
  - Identification of areas of improvement

- **Main data to be collected**
  - Job description
  - Duration of exposure
  - Number of workers involved
  - Dose rate maps
  - Working procedures
  - Protective suits
  - Description of work area (work space, light, position of materials,…)
  - Available tools
  - …

Detailed analysis of specific jobs (2)

- Main questions to be asked
  - **When** are doses integrated ?
    - Look at the detailed schedule of tasks
    - Identify the main job phases contributing to exposures
  - **Where** are doses integrated ?
    - Identify the working areas and specific work places contributing to exposure
  - **Who** is exposed ?
    - Identify doses by working category
    - Identify individual dose distribution
  - **How** are dose integrated ?
    - Identify working conditions and parameters influencing the duration of work
      - Light, protective suit, environment, audio/video links,…

Detailed analysis of jobs (3)

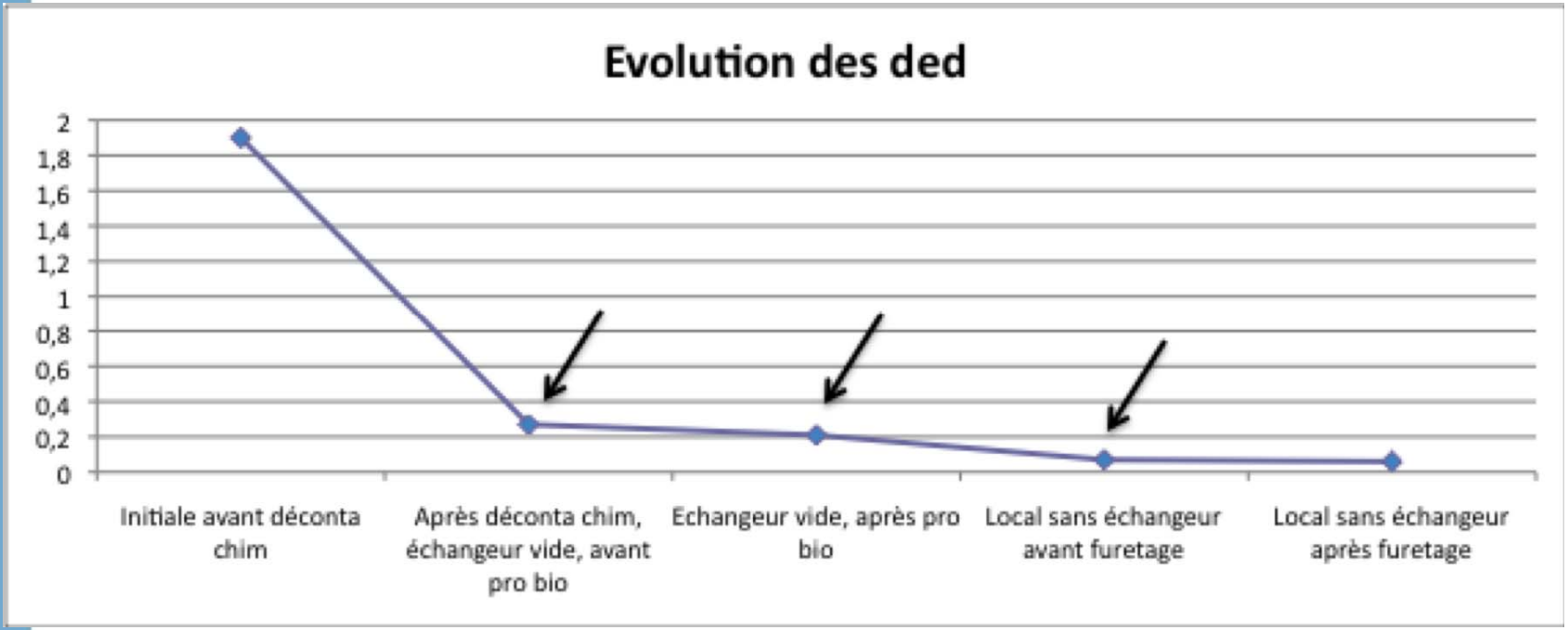
- Example: replacement of RCV heat exchanger – **when** …

Tasks	Collective dose (man.mSv)
Chemical decontamination	**10,03**
Pipes works	**19,42**
Heat exchanger works	**30,56**
- Scaffolding	1,40
- Insulation	12,74
- Handling	9,95
- Other decontamination	6,47
Total	**60,01**

Detailed analysis of jobs (4)

- Example: replacement of RCV heat exchanger – **when** …

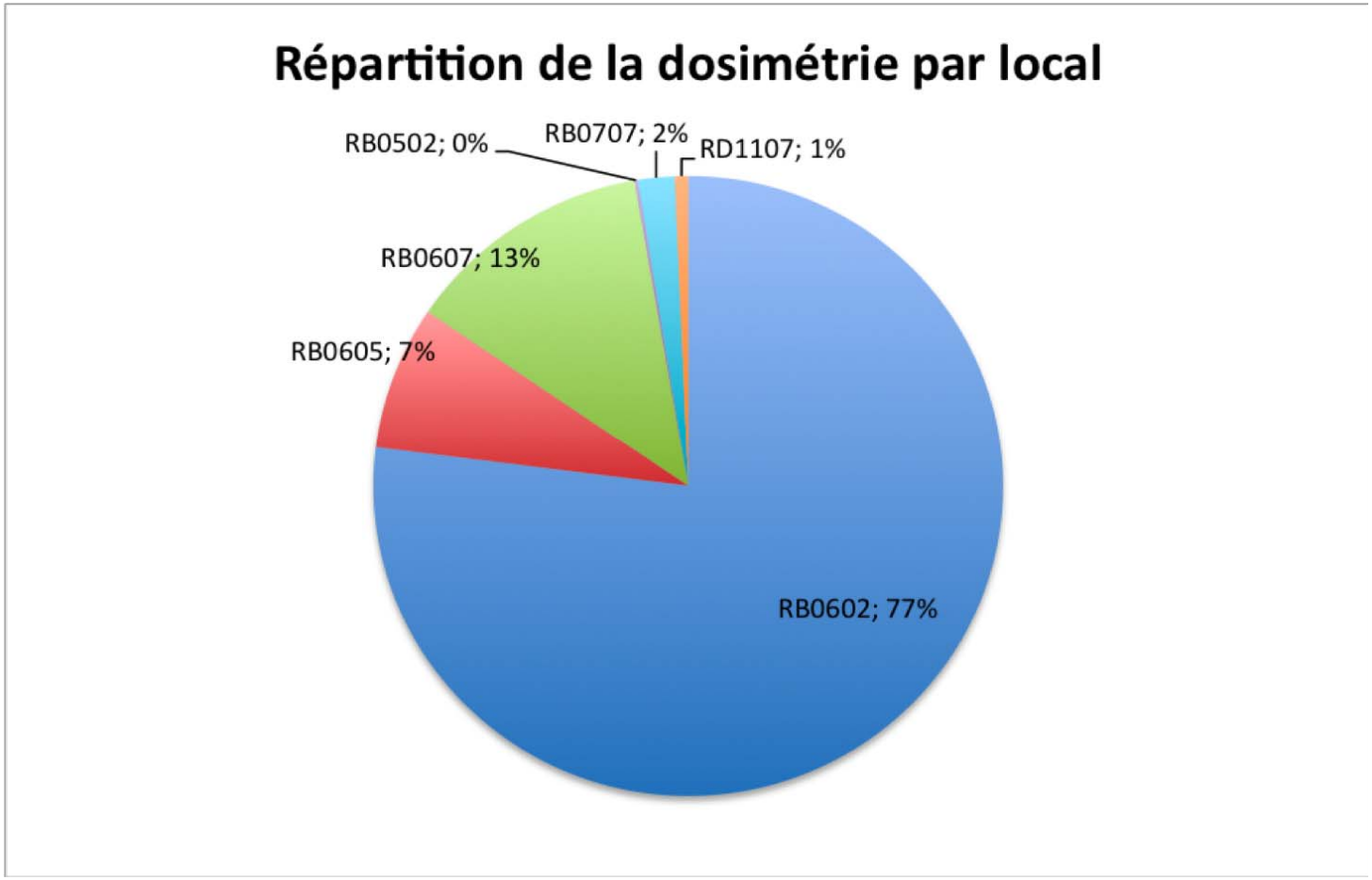
Evolution of dose rates



Detailed analysis of jobs (5)

- Example: replacement of RCV heat exchanger – **Where**…

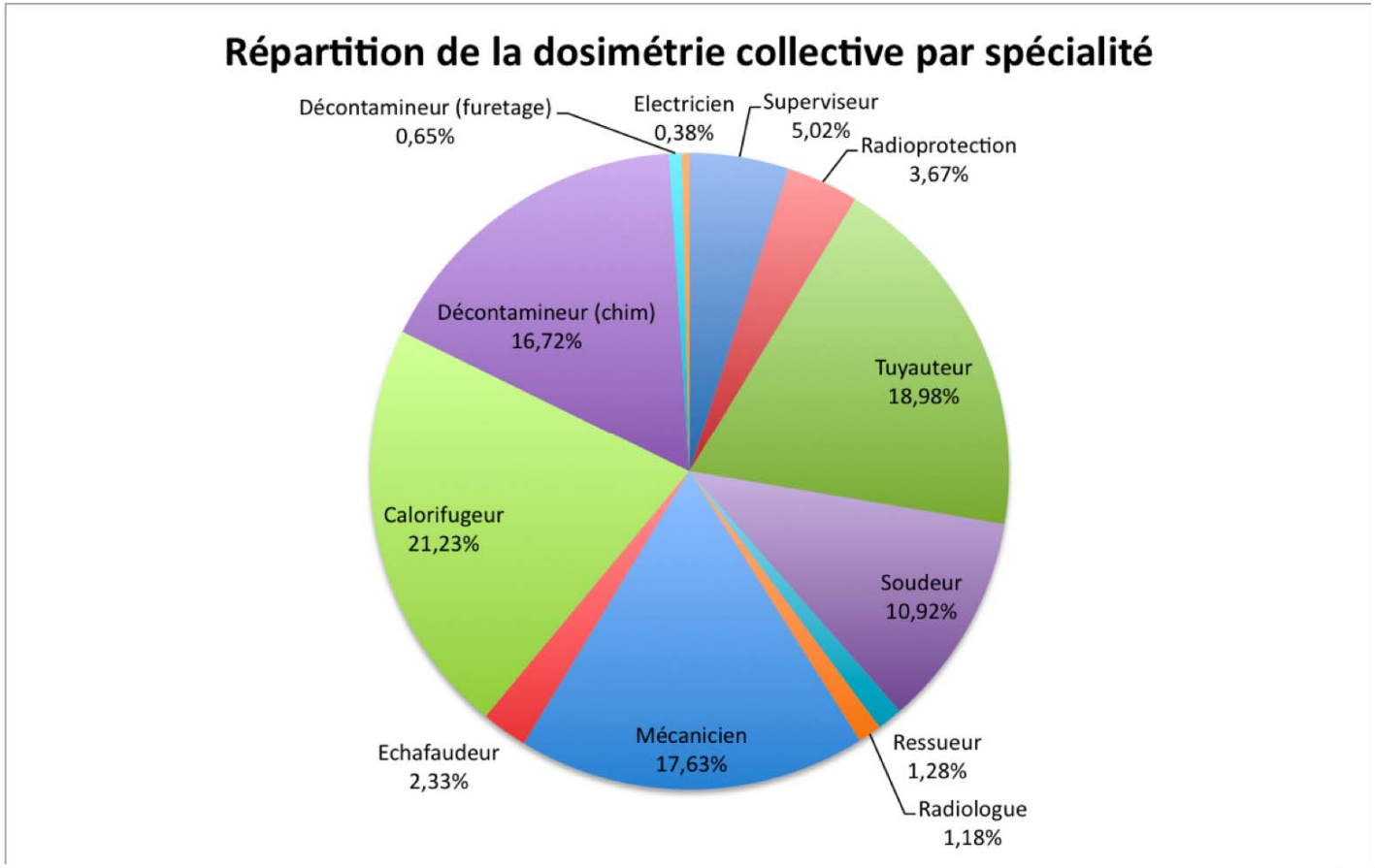
Distribution of doses per working area



Detailed analysis of jobs (6)

- Example: replacement of RCV heat exchanger – **Who**…

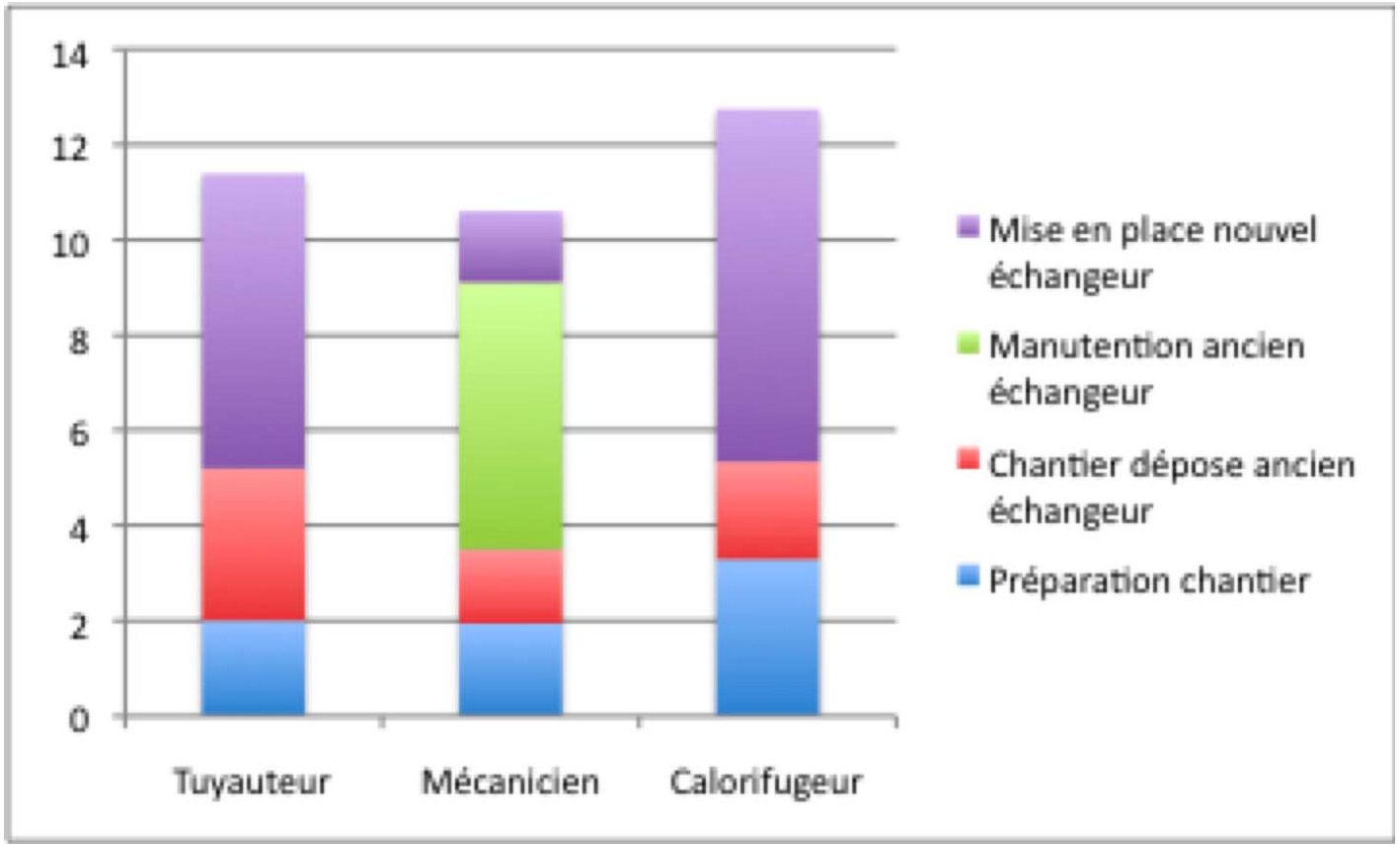
Distribution of doses per worker's category



Detailed analysis of jobs (7)

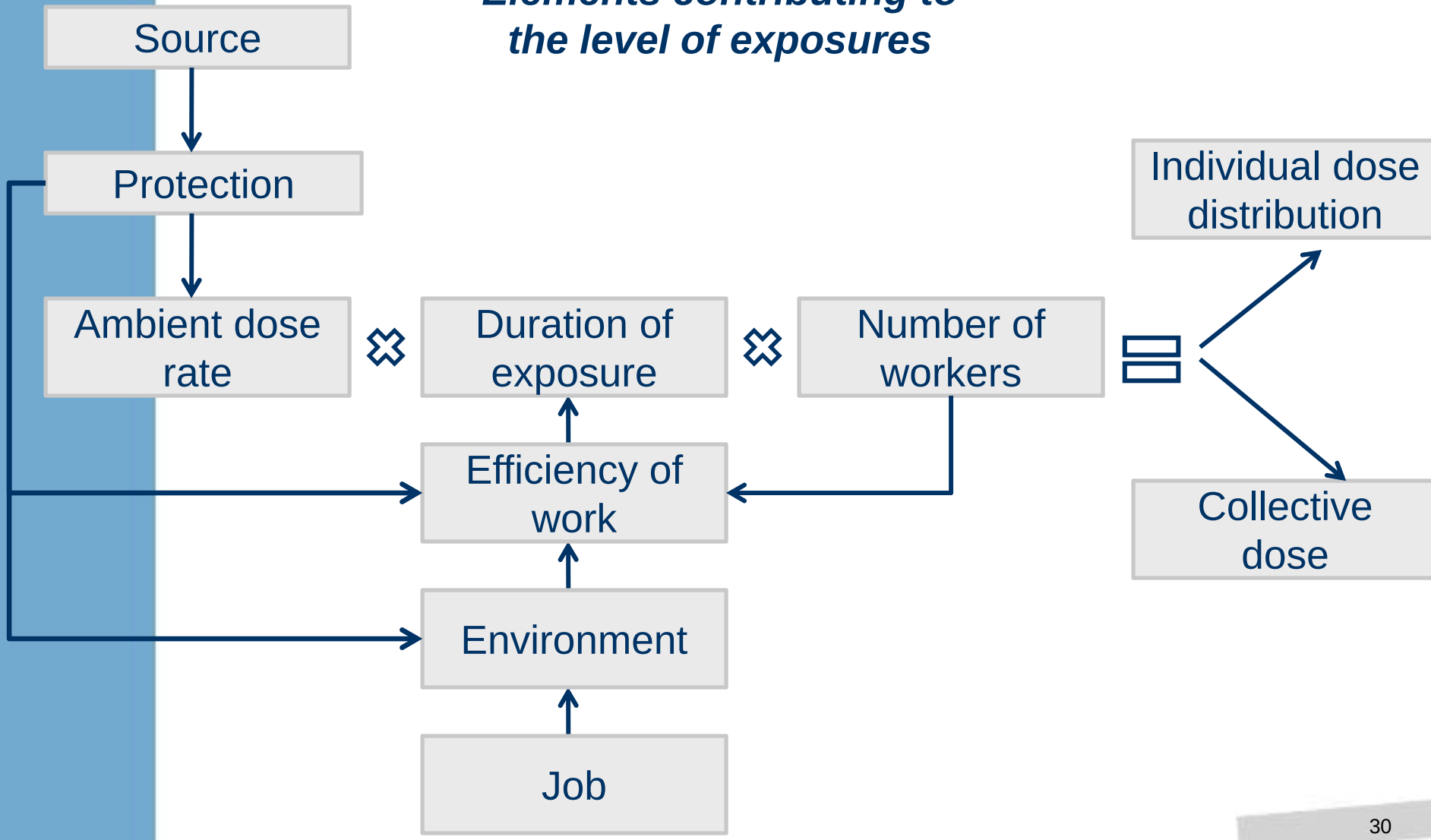
- Example: replacement of RCV heat exchanger – **Who & When**…

Distribution of doses per worker's category



Detailed analysis of specific jobs (8)

Elements contributing to the level of exposures



Detailed analysis of specific jobs (8)

Identification of protection actions

- **Actions to reduce/control dose rate**
  - Decontamination
  - Biological shielding
  - Keeping water in pipes
  - Water flushing of pipes
  - Changes in the work procedure to perform part of the work outside the radiation area or in a lower radiation area
  - …
- **Actions to reduce/control workload**
  - Technical improvements (robotics, tools, …)
  - Preparation of tools
  - Preparation of the area
  - Workers' skill improvement (mock-up training, pre-job briefing,…)
  - Teledosimetry,
  - …

Synthesis of the ALARA process

1. Preparation
- Evaluation of collective and individual exposures predictions
- Comparison and selection of optimal actions
- Setting up of detailed dosimetric objectives

ALARA process

2. Implementation
- Real time follow up
- Comparison of forecasted and actual doses
- Implementation of corrective actions
- Feed back experience data base input

3. Feedback experience
- Performance analysis
- Evaluation of new development and processes
- New organisations

Formalisation of the optimisation process

- Level of effort and formalisation has to be commensurate with the level of individual and collective exposures (level of risk)

- Useful to define formalized levels in order to fix up the optimization analysis and the decision-making procedures which fit with the issue at stake

- 3 or 4 levels for each criteria:
  - Collective dose
  - Maximal individual dose
  - Dose rate at the workstation
  - Others regarding the context (airborne activity…)

- Formalized documents should reflect the level of stake:
  - Radiological work permit
  - ALARA survey

Formalisation of the optimisation process (2)

Example of criteria

Level of stake for the job	0	1	2	3
Collective dose (man.mSv)		1	10	20
Dose rate ($mSv.h^{-1}$)		0,1	2	40
Mean individual dose			1,5	3
Radiological risk of contamination	To be set up by the ALARA Committee			

The elements supporting an ALARA approach (1)

- **A commitment of all stakeholders, eg:**
  - Authorities
  - Operating managers
  - All non-exposed individuals whose action can impact the level of exposure of other individuals
  - The exposed individuals…

- All stakeholders involved have to know and agree with the basic assumption of radiation protection (any level of exposure can induce a risk)

The elements supporting an ALARA approach (2)

- **Commitment of Authorities**
  - Regulations and willingness to enforce it
  - Guidelines: balance between dialogue and control.

- **Commitment of operating management**
  - Definition of Radiation Protection policy
    - Set general goals,
    - Attribute responsibilities in ALARA implementation
    - Maintain independence of RP professionals from operation
    - Allocate means and resources for ALARA implementation,
    - Motivate (acknowledgment of efforts).
  - To set up a confident ambiance between all involved parties (stakeholders).

The elements supporting an ALARA approach (3)

- **Commitment of individuals**
  - Individual empowerment
  - Produce and share information
  - Vigilant attitude
  - Adapted training to functions and responsibilities
  - Retraining for keeping motivation
  - Self-education and training

- **Commitment of Contractors**
  - Shared responsibility between utility and contractor,
  - Integration of ALARA in the contracts (call for proposals, orders, analysis of proposals, feedback analysis),
  - Partnership,
  - Contractors evaluation.

The elements supporting an ALARA approach (4)

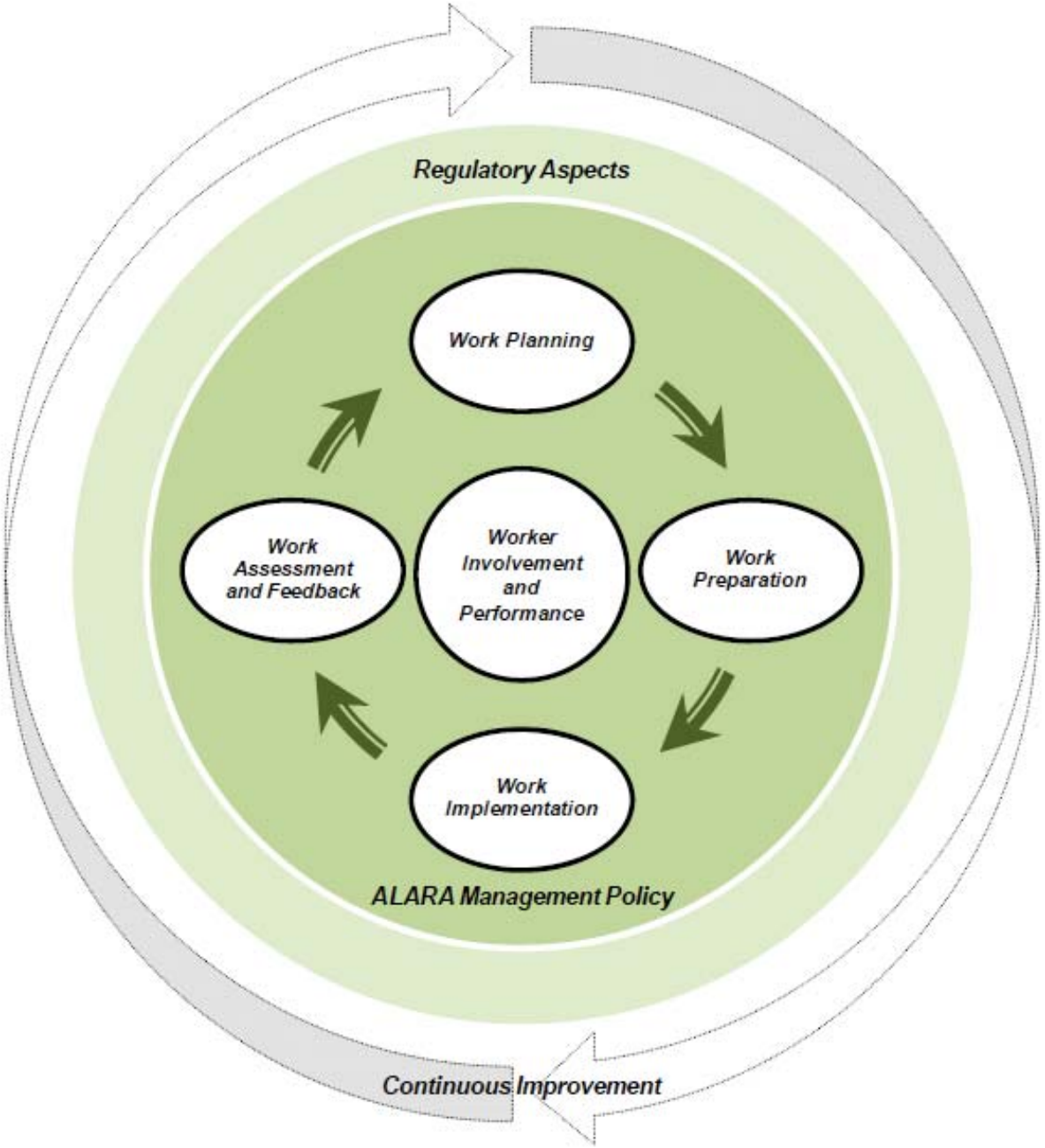
- **Decision-making and coordination structures**
  - Organise dialogue between the professional disciplines involved in an operation
  - Favour the transparency of the optimisation process
    - Identification of decision criteria
    - Traceability of the decision making process
- **Procedures, rules**
  - Clarify the responsibilities for the implementation of the optimisation process
- **Tools**
  - Software (prediction of exposure, dose rate modelisation,…)
  - Feed-back experience databases…
  - ALARA check-list (design, preparation, operation, feedback,..)
  - Decision-aiding tools

Conclusion 1:
Evolution of the optimisation process

- From a strict consideration of "cost-benefit" decision making processes (the 'economic and social factors' being integrated in the so-called 'alpha value - monetary unit of collective exposure)

- To more flexible processes, integrating other considerations and based on quantitative as well as qualitative judgements

Conclusion 2: towards a comprehensive work management approach



Conclusion 3: ALARA in summary

- A behaviour and a frame of mind for all stakeholders
- A predictive approach, which should start as earlier as possible (design of facilities, planning of new operation, planning of outage jobs,…)
- A questioning attitude of 'individuals':
  - **Have I done all I reasonably can to reduce individual doses and the number of people exposed ?**
- A necessity to work collectively to be able to answer to that question => individual commitment to be supported by specific organisation aiming at involving RP as a “professional” component of concerned work categories.