3.0 Introduction to Optimization Procedure: a few questions

Plan of the introduction to optimization procedure

Introduction : the optimization procedure

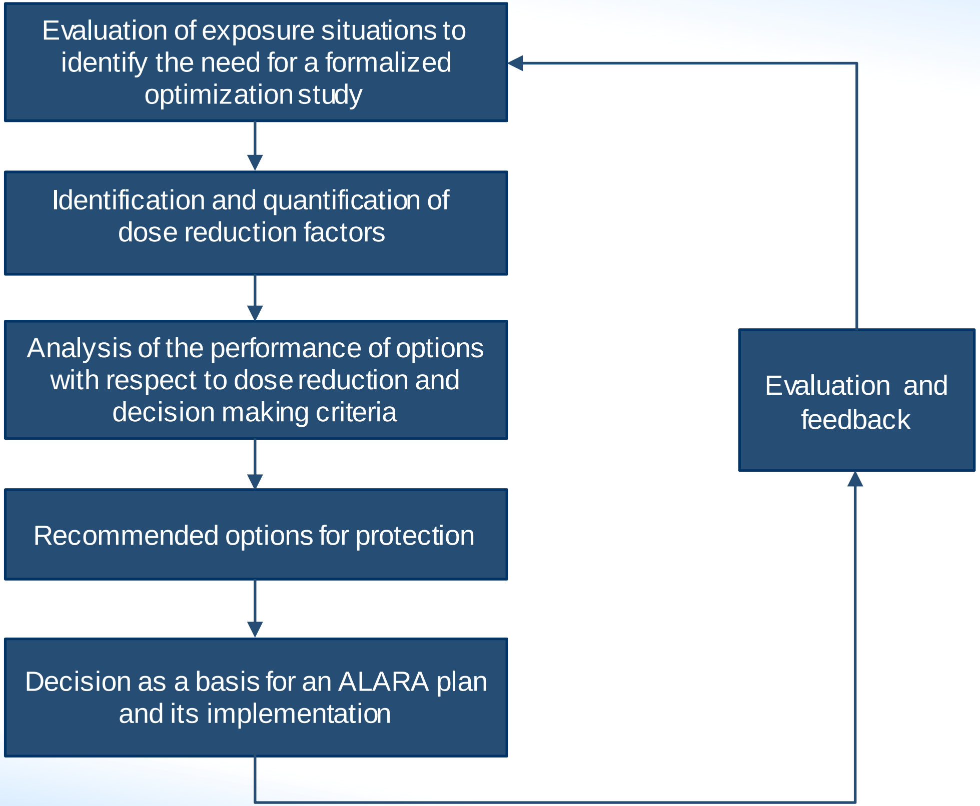
Part one: reminders on a few quantities

- Reducing doses means we are able to quantify occupational doses
- What are the quantities we will quantify both for external and internal doses?

Part two: some questions to be answered

- Your questions
- Some first answers
- What will be developed during the week?

Introduction:
The optimization procedure



Part 1 Quantities : References

International Commission on Radiation Units and Measurements, Inc.

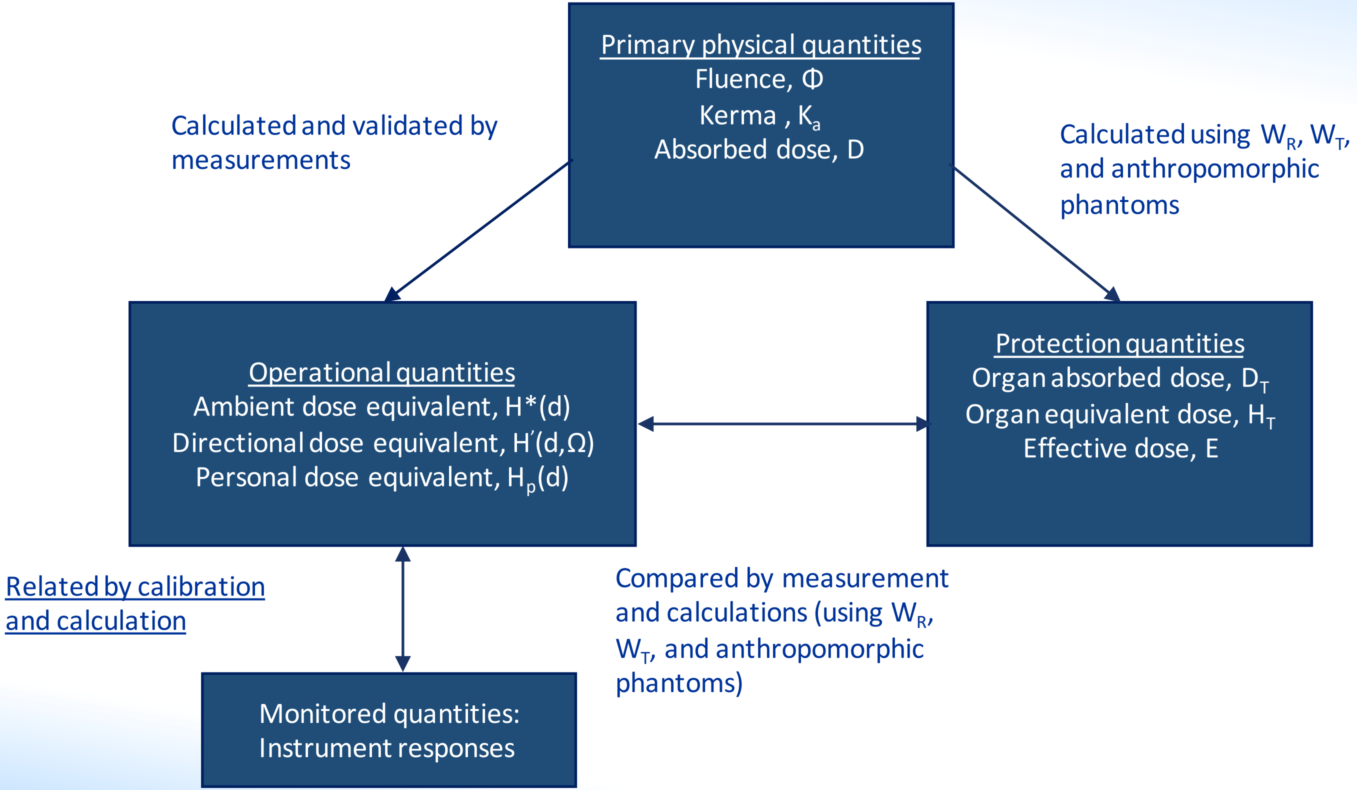
- http://www.icru.org/

ICRU Report 51, *Quantities and Units in Radiation Protection Dosimetry, 1993.*

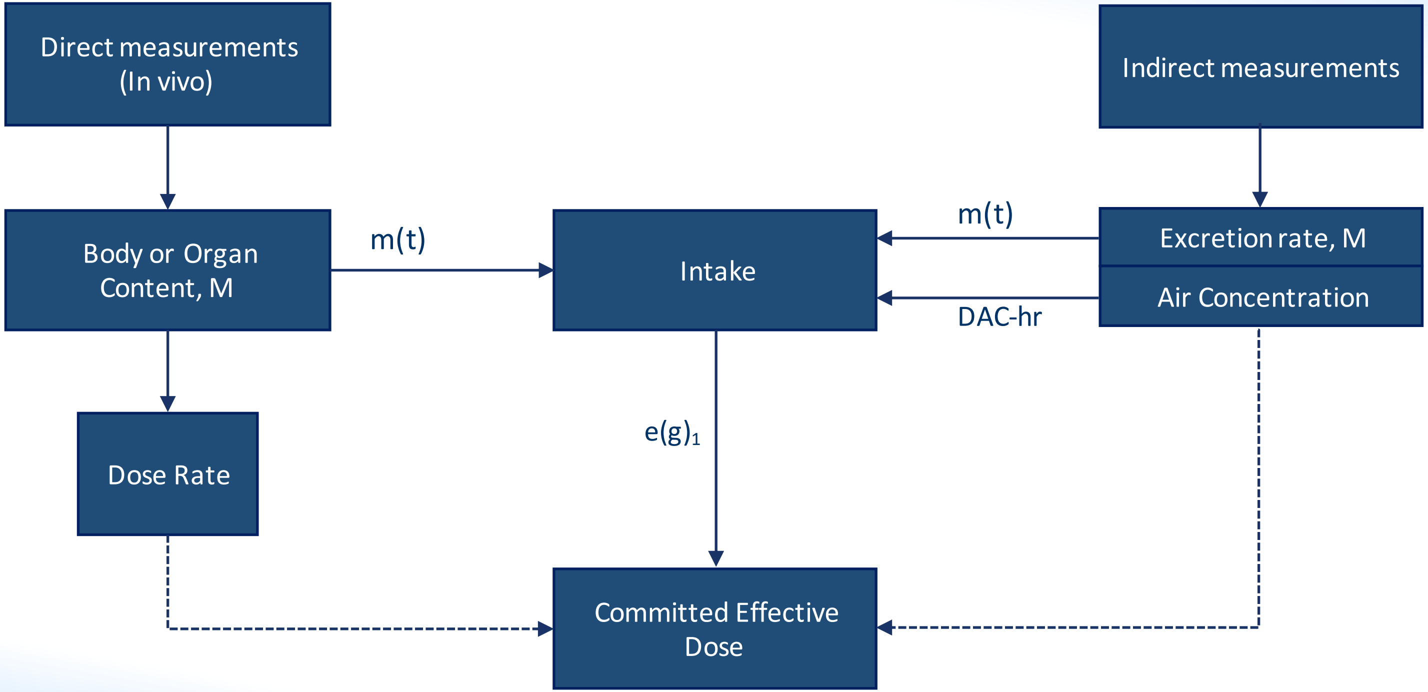
ICRU Report 57, *Conversion Coefficients for use in Radiological Protection against External Radiation, 1998.*

ICRU report 85 "Fundamental Quantities and Units for Ionizing Radiation, 2011

External exposures



Internal exposures



Activity

Activity defines the number of nuclear transformations (disintegrations) per second.

Unit: Bq (Becquerel) $1\ Bq = 1\ s^{-1}$

Former unit: Ci (Curie) $1\ Ci = 3.7 \times 10^{10}\ Bq$

1 Ci ~ Activity of 1g of radium

Activity – Derived Quantities

- Specific activity : activity / mass of source (Bq/g)
- Surface contamination: activity / area (Bq/cm^2)
- Air contamination: activity / volume (Bq/m^3)

Quantities for Internal Dosimetry

D = Energy absorbed per unit of mass

Absorbed dose is proportional to the particle fluence

- Φ = Number of particles / cm^2
- $D = \frac{d\varepsilon}{dm}$
- D = Energy imparted (J) / mass (kg)
- Name: gray, Gy

Quantities for Internal Dosimetry

There are nevertheless other factors to be considered:

1) Different radiation types cause different levels of harm to tissues and organs for the same absorbed dose.
2) The radio-sensitivity (risk of induction of a stochastic effect) of organs and tissues are different for the same absorbed dose.

Equivalent Dose, $H_{T,R}$

$$H_{T,R} = W_R . D_{T,R}$$

W_R is radiation weighting factor for radiation type R, to reflect the amount of harm caused by that type of radiation.

$D_{T,R}$ is absorbed dose (energy imparted per unit of mass) of radiation type R averaged over a tissue or organ T.

Equivalent Dose Unit: J/kg, expressed in Sievert (Sv).

- 1 Sv = 100 rem (the previous unit).

Radiation Weighting Factor, w_R

Radiation Type	w_R
Photons, betas	1
Neutrons of energy:	
< 10 keV	5
10 keV to 100 keV	10
> 100 keV to 2 MeV	20
> 2 MeV to 20 MeV	10
> 20 MeV	5
Alpha particles	20

Radiosensitivities of organs and tissues

The incidence of health effects due to radiation exposure is known to depend on the exposed organ or tissue.

Some organs or tissues are more susceptible to radiation damage than others and some may have greater risk of producing cancer or other effects.

Therefore the effective dose, derived from equivalent dose, reflects the different risks in various organs or tissues per unit of equivalent dose.

Effective Dose

- Is a quantity that estimates the risk of health detriment (stochastic effects) at low doses.
- It permits comparison of risk due to different exposure conditions.

$$E = \sum_T w_T \cdot H_T$$

w_T is the tissue weighting factor for tissue T.

Effective Dose Unit: J/kg, expressed in Sievert (Sv).

1 Sv = 100 rem (the previous unit)

ICRP tissue weighting factors, w_T

ICRP 103 (2007)

TISSUE	w_T	Total
Bone marrow, colon, lung, stomach, breast, **reminder***	0,12 (each)	0,72
Gonads	0,08	0,08
Bladder, oesophagus, liver, thyroid,	0,04 (each)	0,16
Bone surface, brain, salivary glands, skin	0,01 (each)	0,04
***reminder** : Adrenals, extrathoracic region, gall blader, heart, kidneys, lymphatic nodes, muscles, oral muscosa, pancreas, prostate, small intestine, spleen, thymus, uterus		

Quantities for Internal Dosimetry

Intake

- Activity of a radionuclide taken into the body.
- Unit: Bq

Committed Effective dose

- Effective dose delivered in the course of time due to a previous intake of radioactive material.
- Time period integrated over 50 years following intake; E(50)
- Unit : Sv

Assessment of Occupational Exposure

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The following equation is used for assessment of occupational exposure <u>and</u> demonstration of compliance with dose limits:

$$E_t = H_P(10) + \sum_j e(g)_{j,ing} I_{j,ing} + \sum_j e(g)_{j,inh} I_{j,inh}$$

Where,

$H_P(10)$	is the personal dose equivalent,
$e(g)_{j,\ ing}$	is the dose coefficient for ingestion,
$I_{j,ing}$	is the intake from ingestion,
$e(g)_{j,inh}$	is the dose coefficient for inhalation,
$I_{j,inh}$	is the intake from inhalation

Part 2 :What are your “a priori” questions?

What are YOUR questions dealing with optimization?

Having listen to the lectures dealing with why optimizing exposures, reminding you the scientific and regulatory contexts;

Having your professional experience, with successes and problems

A few possible questions?

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When is it mandatory to start implementing optimization of protection and safety

- Is there a schedule? At design stage ? Operation stage? First time? Every time?
- A minimum level of individual dose above which?
- A minimum level of dose rate above which?

Is optimization restricted to external exposures?

Is optimization restricted to effective dose? What about extremity doses?

Why not as low as possible?

What does “reasonable” mean?

How to decide what is reasonable?

When is it mandatory to start implementing optimization?

It is always mandatory to implement optimization, whatever the time in the schedule of an installation life, of an operation, of an examination performance…the analysis has to be done in accordance with the stakes.

There is no threshold of dose neither individual nor collective, or of dose rate beyond which optimization dose not have to be implemented.

There is no type of exposure to be kept out of the scope of optimization (external, internal, occupational, public, patient…)

IAEA BSS GSR Part 3 (1/4)

Requirements on Optimisation of protection and safety and the three exposures situations

GSR-Part 3, Req.1 on Application of the principles of radiation protection says that "Parties with responsibilities for protection and safety shall ensure that the principles of radiation protection are applied for **all exposure situations**".

Definition of the three exposure situations (planned, emergency, existing) are provided in the IAEA Glossary Edition 2018, pp.90-91.

The scope of the each exposure situation is provided in Chapters 3 (planned), 4 (Emergency) and 5 (existing) of the BSS.

IAEA BSS GSR Part 3 (2/4)

Generic	Occupational	Public	Medical
Requirement 11	Requirements 19 and 21	Requirements 29 and 30 (3.126,3.127)	Requirements 34 (3.149) and 38

IAEA BSS GSR Part 3 (3/4)

Generic	Emergency workers	Public
Requirement 43 (4.5 g)	Requirement 45 (4.13)	Requirement 44 (4.7-4.8)

IAEA BSS GSR Part 3 (4/4)

Occupational	Public
Requirement 52 (5.27, 5.28, 5.29, 5.33)	Requirement 48 (5.8) and 50 (5.20 b)

The meaning of “reasonable”?

This is, may be, the most difficult question to answer to

We will try to do it through examples all along the course

Anyway trying to reduce as much as possible, means minimisation and this cannot be considered as a reasonable approach; sometimes it is but some other times it can lead to very expensive actions for small efficiency, which should a misallocation of resources.

Is there a link between ALARA/optimization and safety culture?

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As said in the first lecture implementing optimization means implementing

a predictive approach

- To predict and optimize
- To implement and to follow up
- To analyse and to take care from lessons learned

Does it exist then an ALARA culture?

- With shared values and behaviour?
- With commitment of all stakeholders?

If yes, what is the difference with a safety or even a quality culture?