Optimisation of protection,
the cornerstone of radiation protection

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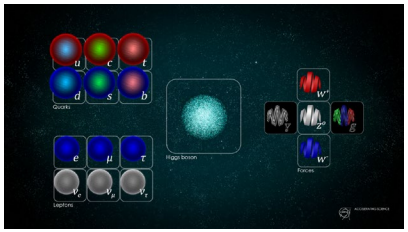
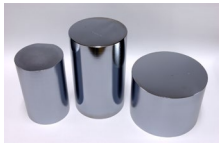
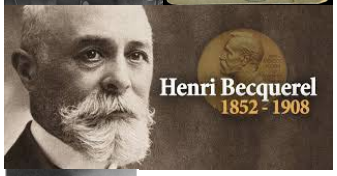
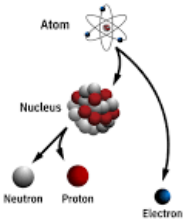
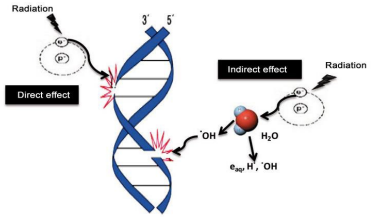
Ionising radiation

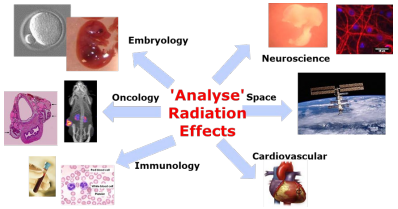


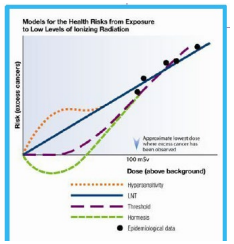












1895 1928 ICRP 2007 ICRP (103) 2022

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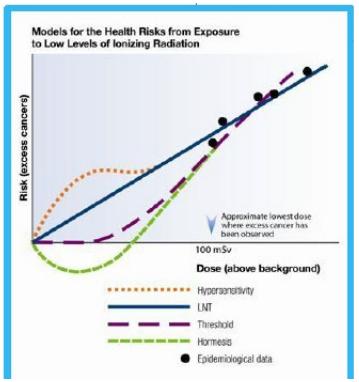
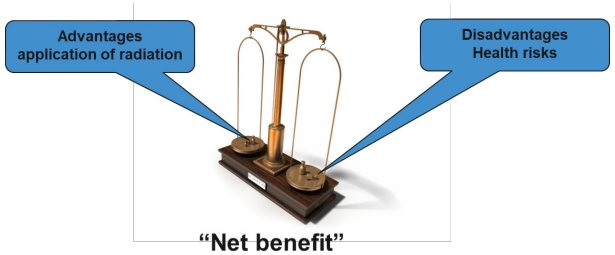
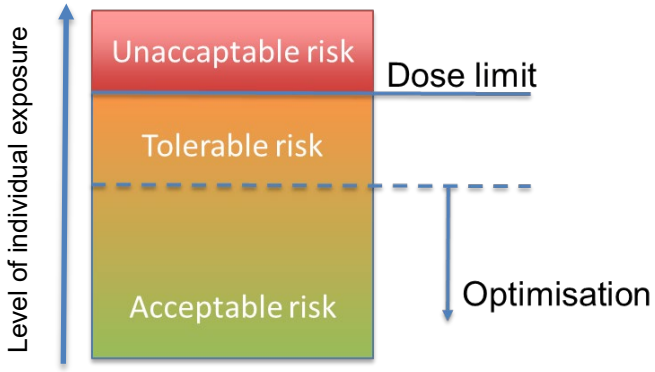
Basic principles

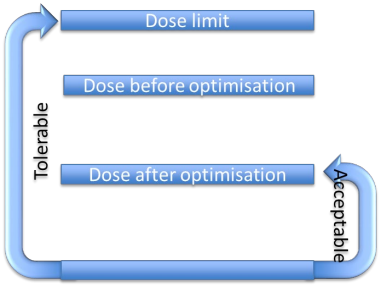
- Linear dose-effect with no threshold (stochastic health effects)
- Basic principles of radiation protection
  - Justification
  - Optimisation → ALARA
  - Dose limits



INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

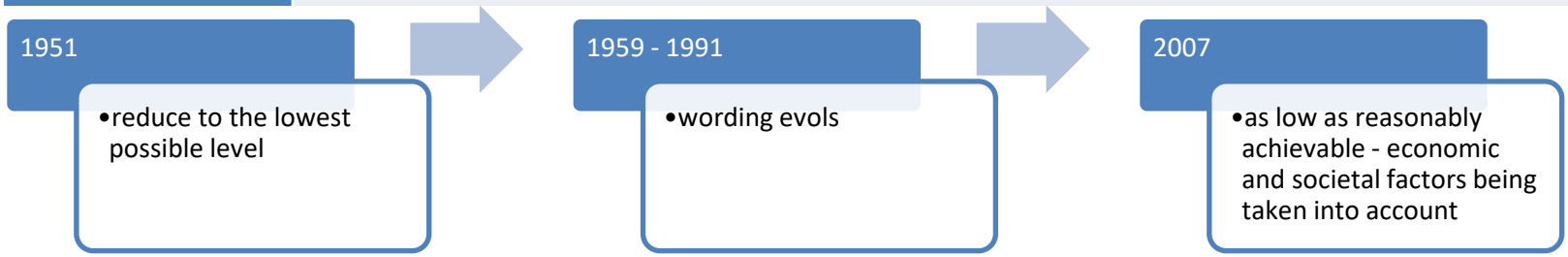






Evolution of ALARA

(ICRP, 1951)	To reduce exposures to the lowest possible level
ICRP Publ. 1 (ICRP, 1959)	To keep the exposure of large population as low as practicable
ICRP Publ. 9 (ICRP, 1966)	All doses (should) be kept as low as is readily achievable economic and social consideration being taken into account
ICRP Publ. 22 (ICRP, 1973)	All doses (should) be kept as low as reasonably achievable economic and social consideration being taken into account
ICRP Publ. 26 (ICRP, 1977)	All exposures shall be kept as low as reasonably achievable economic and social factors being taken into account
ICRP Publ. 60 (ICRP, 1991)	The magnitude of individual doses, the number of people exposed and the likelihood of incurring uncertain exposures shall all be kept as low as reasonably achievable economic and social factors being taken into account
ICRP Publ. 103 (ICRP, 2007)	The likelihood of incurring exposures, the number of people exposed, and the magnitude of individual doses should all be kept as low as reasonably achievable economic and societal factors being taken into account



Adapted from: Optimisation of radiation protection: a practical handbook, ISBN:978-2-9569796-0-9, 2019.

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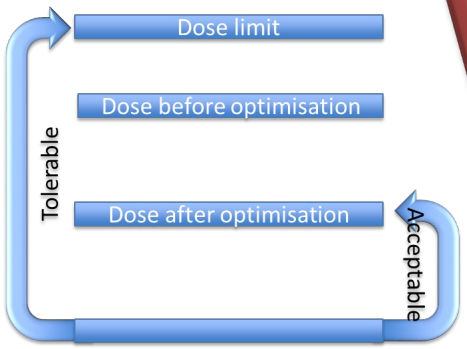
Acceptable level of risk



The ALARA PROCESS

Description of Exposure Situation

Review of Input Data Needed for Dose Assessment

Initial Dose Assessment

ALARA Analysis

ALARA Synthesis
- *Operational follow-up*
- *Check Procedure*

Follow-up & Feedback Experience
- *Performance Analysis*
- *Gap & Mishaps Analysis*
- *Proposal for corrective actions*

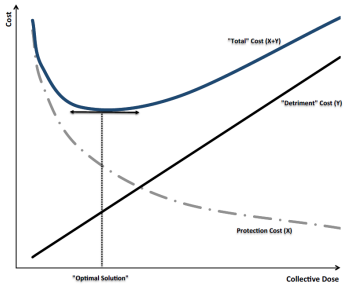
Analysis of Doses
- *Where ? When? Who? How?*

Identification of Protective Actions which Can (or Cannot) be Implemented

Evaluation of Protective Actions Efficiency
- *Impact on Doses*
- *Other Impacts*

Selection of Protective Actions
- *Identification of Decision Criteria*
- *Ranking of Actions*

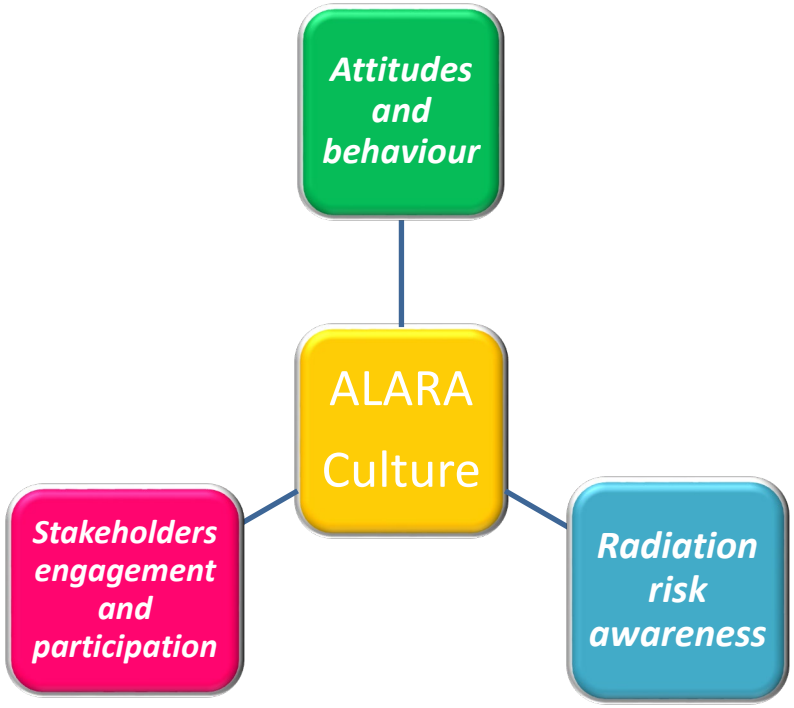
Sensitivity Analysis



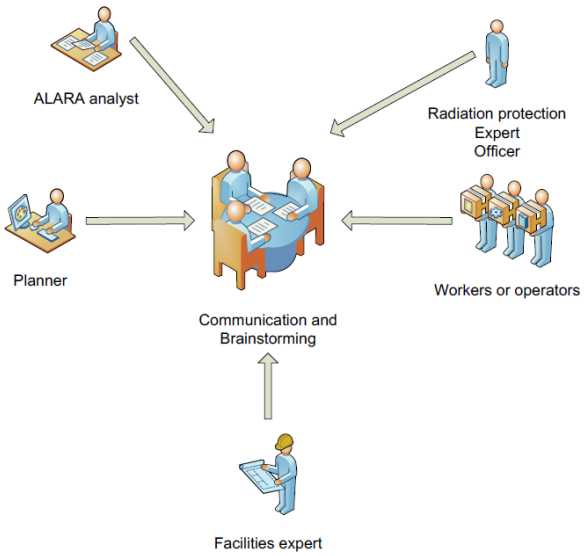
- Industrial risk
- Environmental risk
- Security risk
- Socio economic aspects

$$U_i = \sum_j k_j u_{ij}$$

Safety culture ALARA Culture



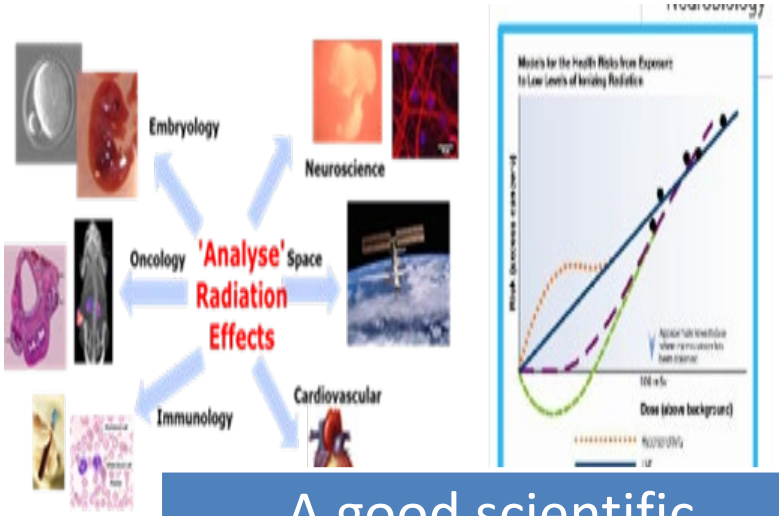
Stakeholders



Stakeholders engagement and participation

- *Competent authorities*
- *Licensees*
- *Manufacturers, suppliers and designers*
- *Radiation protection professionals*
- *Professional associations*
- *Exposed workers*
- *The public*

Education and training



A good scientific understanding of the risk

A good understanding on risk perception

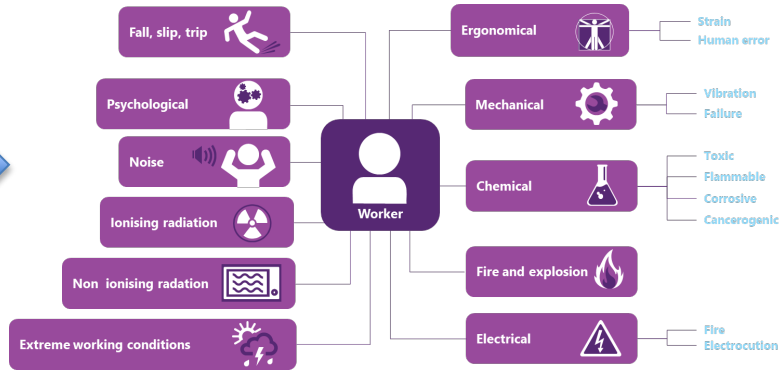
Reasonableness

ICRP 138 (2018)

- The pursuit of reasonableness as “the permanent quest depending on the prevailing circumstances in order to act on knowledge and experience, to do more good than harm (beneficence/non-maleficence), to avoid unnecessary exposure (prudence), to seek fair distribution of exposure (justice), and to treat people with respect (dignity).

IRPA: IRPA perspective on “reasonableness” in the optimisation of radiation protection (2021)

- Judgement call
- Proportionality
- Stakeholder engagement
- Holistic approach
- Avoid over conservatism
- Optimal use of societal resources
- Radiation safety culture
- Auditability, transparency



NEA/CRPPH: Optimisation: rethinking the art of reasonable (2020)

- Broadly in line with the current recommendation in ICRP 103(2007), but emphasis on the multidisciplinary, multi-dimensional nature of the complex circumstances to consider. Consider the whole risk-vector.

Benefits of optimisation

In fact the optimisation approach can be seen as a reference framework, a state of mind and attitude

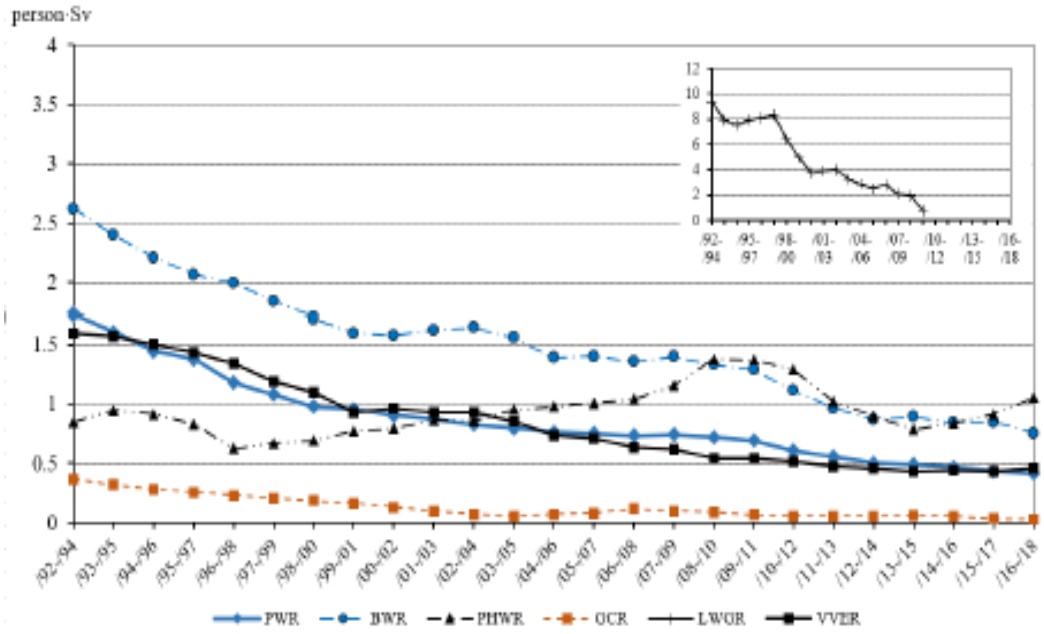
- Allowing an individual and/or an organization to act in a **responsible way** in order to **manage risks** and **giving safety the priority it should have**
- Characterized by **risk awareness**, **balanced judgement of risk and benefits**, and the capability to develop and use required skills and tools for risk assessment and management
- Realized through transdisciplinary **education and training** tailored at each level
- Supported by **management commitment** and management system
- Support feedback from the field and **continuous improvement**

Benefits of optimisation

- Already considerable feedback and literature on optimisation and ALARA
- Feedback from different organizations from practice EAN, ISEMIR, EMAN, ISOE, UNSCEAR, EFOMP, ….
  - that confirm reductions in individual dose
    - A few examples to illustrate

Nuclear industry

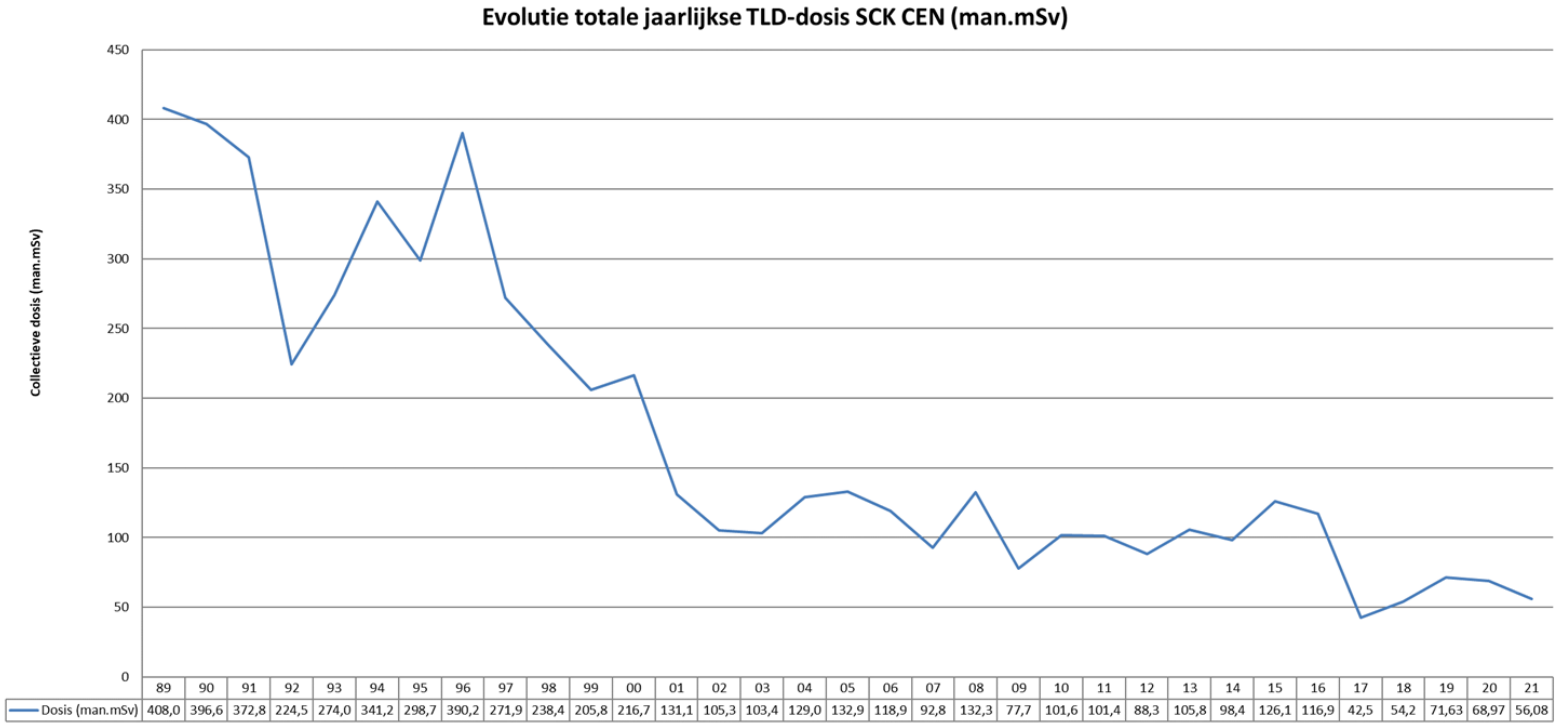
- **UNSCEAR, Report of the United Nations Scientific Committee on the Effects of Atomic Radiation, sixty-seventh and sixty-eighth sessions (2-6 November 2020 and 21-25 June 2021)**
  - *The estimated worldwide annual number of monitored workers exposed to human-made sources increased to over 11.4 million in 2010-2014 compared with about 10 million in the period 1995-1999. The medical sector dominated the workforce exposed to human-made sources, accounting for about 80 per cent of the total. The average annual effective dose for the period* ***2010-2014 for all human-made sources was about 0.5 mSv, a substantial decrease from 1.7 mSv some 40 years ago****, and the average annual collective effective dose was about 5,500 man Sv*
- **ISOE**
  - Occupational Exposures at Nuclear Power Plants, Twenty-Eighth Annual Report of the ISOE Programme 2018



Three-year rolling average collective dose per reactor for all operating reactors included in ISOE by reactor type, 1992-2018 (person·Sv/reactor)

Research

- Evolution of collective dose in a research centre applying the ALARA process
- ALARA committee, ALARA procedure



	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21
Dosis (man.mSv)	408,0	396,6	372,8	224,5	274,0	341,2	298,7	390,2	271,9	238,4	205,8	216,7	131,1	105,3	103,4	129,0	132,9	118,9	92,8	132,3	77,7	101,6	101,4	88,3	105,8	98,4	126,1	116,9	42,5	54,2	71,63	68,97	56,08

Medical

- Medical sector
  - Important improvements have been identified
    - Exposures of workers in conventional radiology, both radiodiagnosis and radiotherapy, are generally well controlled
    - Risk awareness, RP culture, DRL, …
  - Ex. “after analysing the dose results that although there is an increase in medical imagery there is a reduction of dose to the patients” (FANC Belgium)
- However ALARA needs to keep pace with recent developments in the use of new imaging techniques and radiopharmaceuticals
    - Interventional radiology
    - New imaging techniques
    - The production and safe use of new radiopharmaceuticals (theragnostics)
    - Ensuring that sufficient attention is paid to the control and optimisation of exposures

Conclusion

- Do we benefit by using the optimization approach?
  - Dose reductions are achieved in different field applying ionizing radiation
  - Promotes the risk-awareness supporting safety, safety culture and stakeholder involvement
  - Promotes good governance, balanced judgement and allows optimal use of resources
- Optimisation is a cornerstone of protection and radiation protection

Thank you

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