ICRP's 2007 Recommendations on Radiological Protection

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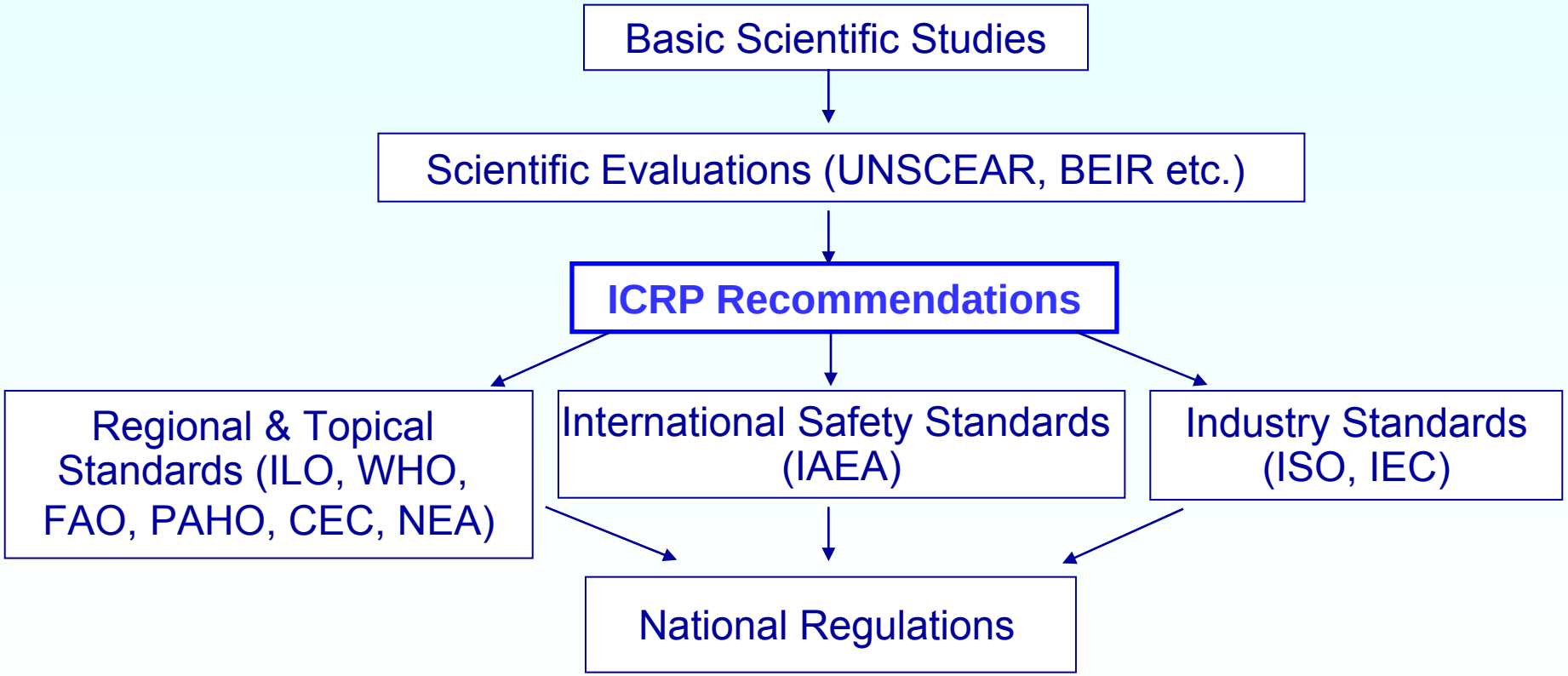
Chairman of ICRP

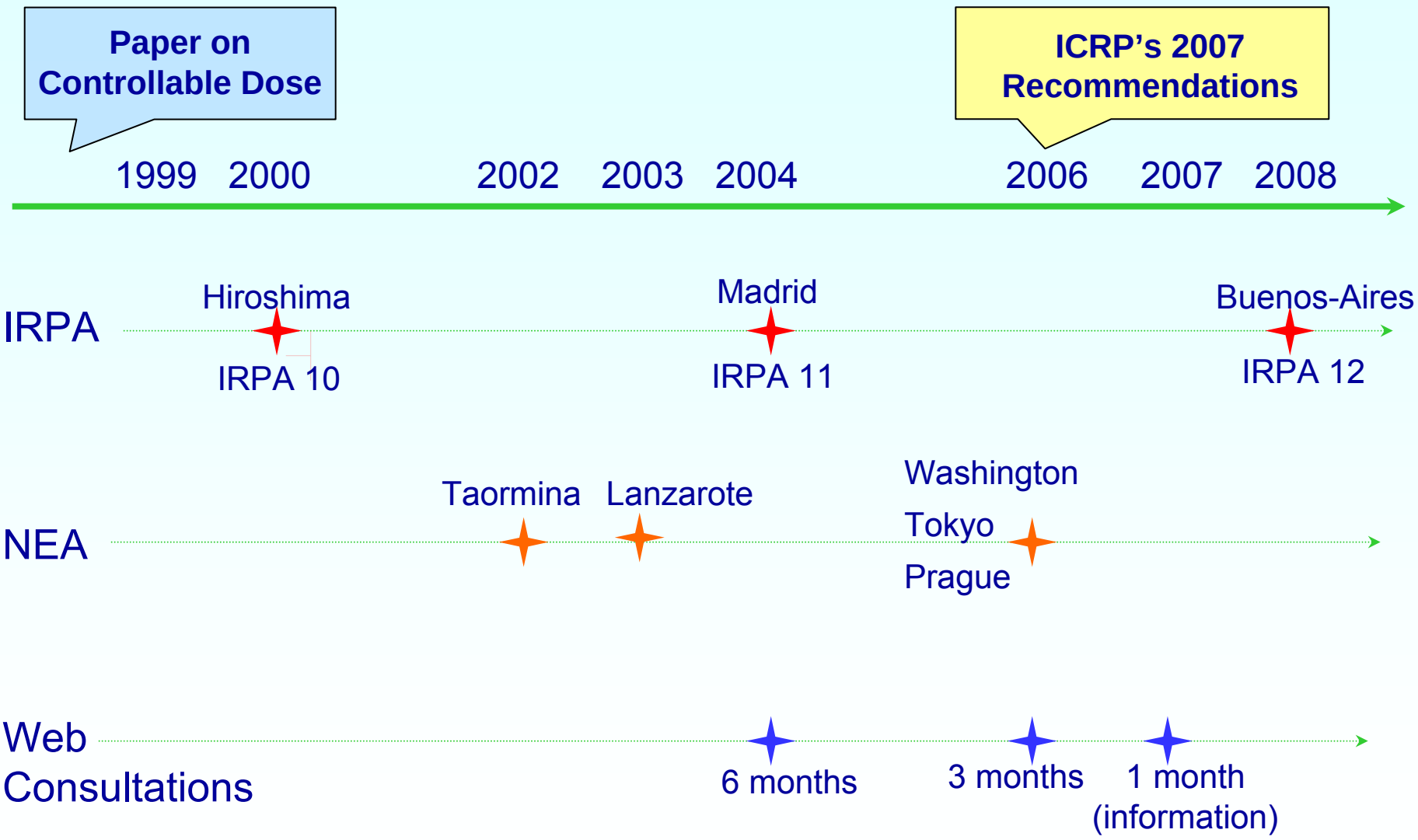
The Role of ICRP



Aims of the Revision

- To take account of new biological and physical information and of trends in the setting of radiation safety standards
- To improve and streamline the presentation of the recommendations
- To maintain as much stability as is consistent with the new scientific information

An Open Process



ICRP's 2007 Recommendations

- The January draft

  …including comments on the 2006 version

- Significant amendments at the final approval meeting in Essen 21 March 2007

- More detailed guidance in forthcoming reports

  User feedback will influence ICRP priorities

The 2007 Recommendations and…

- Annex A on Biology – Updated version
- Annex B on Physics – Updated version
- ICRP Publ. 99 – Low-dose risk extrapolation
- ICRP Publ. 101:1 – Representative person
- ICRP Publ. 101:2 – Optimisation
- ICRP Publ. 91 – Framework, non-human species
- Scope (exclusion, exemption) – draft
- Protection in medicine – draft

Primary Aim of the Recommendations

To contribute to an appropriate level of protection

for people and the environment

without unduly limiting the desirable human actions

that may be associated with radiation exposure

Components of the System

COMPONENT	CHARACTERISTICS
Exposure situations	Planned – Emergency – Existing
Exposures	(Virtually) Certain – Potential
Exposure types	Occupational – Medical / patients – Public
Exposed individuals	Worker – Patient – Public
Assessment types	Source-related – Individual-related
Principles	Justification – Optimise protection – Dose limits
Levels of dose	Limits – Constraints – Ref. levels
Safety of sources	Security and emergency plans

The Basis of the System of Protection

- Reference anatomical and physiological models of man
  - *To assess doses*
- Molecular and cellular studies
  - *To assess hazards*
- Animal experiments; epidemiology
  - *To assess probability of detriment*

Deterministic and Stochastic Effects

These words continue to be the default terms

- **Deterministic**
  - *Mostly due to cell killing above a threshold (100 mGy or more)*
  - *New data on eye will be considered when available*
- **Stochastic**
  - *Cancer and heritable disease*
  - *LNT model: Scientifically plausible but not unambiguous*
  - *DDREF: 2 a broad average judgement*
  - *The paper on LSS by Preston et al. is in press (Radiat. Research)*

Heritable Disease

- Mouse studies of induced mutations still vital because genetic effects not demonstrable in man
  - *Human spontaneous mutation rates are used to estimate Doubling Dose*
- Probability of heritable risk was over-estimated in 1990
  - *Particularly for multifactorial diseases*
- Nominal probability coefficients: 2 generations only
  - *Based on UNSCEAR 2001, agrees with BEIR VII*
  - *Calculation to equilibrium – assumptions not sustainable*
  - *Contribution after 2 generations small and uncertain*
  - *No substantial difference 2 – 10 generations*
  - *Thus, no significant underestimation of genetic risk*

Further Conclusions on Biology

- Genomic instability, bystander effects, adaptive response, non-cancer disease: uncertainties
  - Insufficient knowledge for protection purposes
- Genetic susceptibility: not a major protection issue
  - *Known disorders too rare to distort risk estimates*
  - *Impact of weak genetic determinants cannot be judged*
- In-utero cancer risk: similar to that of young children
  - *Life-time risk a few times higher than that of the population*
- Nominal probability coefficients for cancer
  - *Now incidence-based*

Nominal Probability Coefficients (% Sv^{-1})

Exposed population	Cancer		Heriditary effects		Total	
	1990	2007	1990	2007	1990	2007
Whole	6.0	5.5	1.3	0.2	7.3	5.7
Adult	4.8	4.1	0.8	0.1	5.6	4.2

For practical protection purposes, the approximated overall fatal risk coefficient of 5% per Sv is still appropriate

Changes in Radiation Weighting Factors, w_R

Type and energy range	1990	2007
Protons	5	2
Neutrons	Stepwise function	Continuous function

Tissue Weighting Factors, w_T

Tissue	w_T	$\sum w_T$
Bone-marrow, breast, colon, lung, stomach, remainder tissues *(14)*	0.12	0.72
Gonads	0.08	0.08
Bladder, oesophagus, liver, thyroid	0.04	0.16
Bone surface, brain, salivary glands, skin	0.01	0.04

Females and Males

- The system of protection is sufficiently robust to achieve adequate protection for both sexes

  A value judgement, based on science

- Thus, no need for sex- and age-specific radiological protection criteria

  It precludes discrimination

- Nominal risk estimates for protection

  Individual retrospective assessments require specific information

The Principles of Protection

Source-related, apply in all exposure situations:

- Justification

  Whether introducing new source or reducing old exposure, achieve more benefit than detriment

- Optimisation of protection

  Using dose and risk constraints and reference levels to (a) increase equity, (b) consider multiple sources

Individual-related, applies in planned exposure situations:

- Application of dose limits

  Except medical exposure of patients

The Use of Effective Dose (E)

- For compliance and prospective planning
- Not for detailed retrospective dose and risk assessments after exposure of individuals
- Not for epidemiological studies

Types of Exposure Situation

- Planned exposure situations:
  - *Involve the deliberate introduction and operation of sources*
  - *May also give rise to potential exposures*
  - *It is the situation, not the exposure, that is planned!*
- Emergency exposure situations:
  - *Unexpected development of a planned situation, or a malicious act*
  - *Require urgent action to avoid or reduce undesirable consequences*
- Existing exposure situations:
  - *Pre-existing situations that are found to require action*

Practices and Interventions

The words remain, but with more limited meaning

- Practice
  - *A human activity that increases exposure or the risk of exposure*
  - *Part, but not all, of planned exposure situations*
- Intervention
  - *A protective action that reduces exposure*
  - *Used in emergency and existing exposure situations*

Categories of Exposure

- Occupational exposure

  All radiation exposure of workers incurred as a result of their work, i.e., only what can reasonably be regarded as the responsibility of the operating management

- Public exposure

  All exposures of the public from a source, except medical exposure of patients

  Includes exposure of embryo/fetus of exposed workers

- Medical exposure of patients

  Comforters and carers, and volunteers in research, are discussed in this context

Identification of Exposed Individuals

- Workers

  Any employed person with rights and duties in occupational radiological protection

  Work areas are classified:

  - *Controlled – special procedures needed*
  - *Supervised – monitoring only needed*

  Workers are not classified

- Members of the public

  Anyone receiving exposure that is neither occupational nor medical

- Patients

  Anyone exposed by diagnostic, interventional, or therapeutic procedures

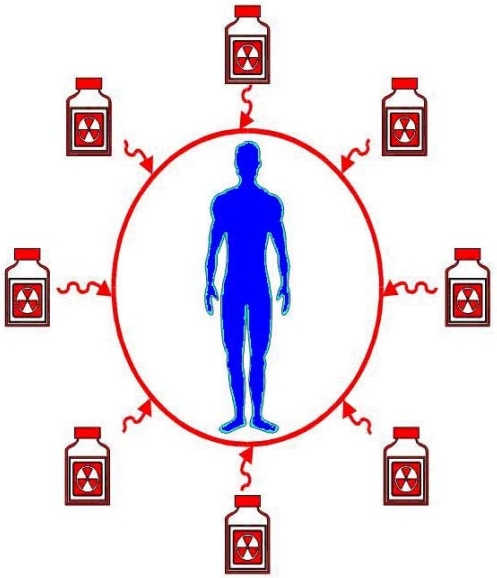
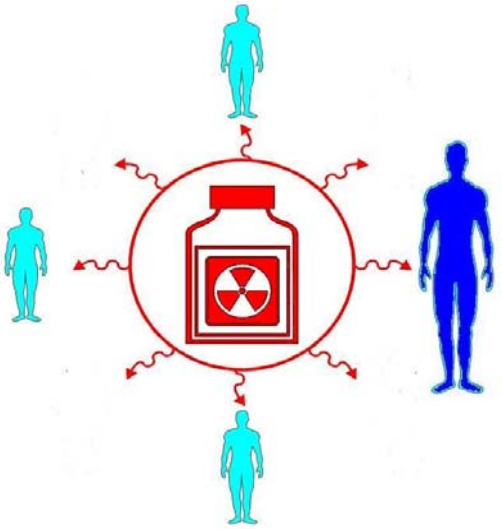
Members of the Public

- The system of protection uses individual dose criteria
- Doses to individual members of the public cannot be measured directly
  … and often, not at all
- Doses depend on age, location, eating habits…
- Thus, we must characterise an exposed individual: the Representative Person
  Dose should be representative of the more highly exposed members of the population

Formerly: 'The Critical Group'

- Dose limits and constraints were applied to the mean dose in a 'critical group'
- Dose assessment methods have evolved
  For instance, probabilistic techniques
- 'Critical' has the connotation of a crisis
  Never intended by ICRP
- 'Group' is confusing in this context
  The assessed dose is the dose to an individual
- The new concept: the Representative Person
  Publication 101

Levels of Protection

Dose Limits	Dose Constraints and Reference Levels
Protect individuals from public **and** occupational **exposure…**	
from **all** regulated sources, in **planned** exposure situations	from **a** source, in **all** exposure situations
	

Justification

- Do more good than harm
- Recognise *distribution of responsibilities*
  Justification, primarily at the political level (can be delegated)
- Radiological considerations are just one input
  Important, but rarely overriding
- Medical radiation requires separate treatment
  Justify: Radiation – Procedure – Application to this patient

Unjustified Exposures

- Deliberate addition of radioactive material to food, toys…
- Radiological examinations for occupational, legal, health insurance, etc, purposes
  - *Unless useful information on individual health is obtained*
  - *Criminal investigations may be justified*
  - *Images should be evaluated clinically*
- Medical screening of asymptomatic population groups
  - *Unless expected benefits exceed societal and health detriment*

Optimisation of Protection

- Maximise net benefit
- Keep exposures as low as reasonably achievable, taking into account economic and societal factors
- Radiation safety culture:

  Have I done all I reasonably can to reduce dose and risk of accidents?
- An on-going, iterative process:

  Evaluate exposure situation

  Select appropriate constraint/reference level

  Identify protection options

  Select best option under prevailing circumstances

The Collective Dose in Optimisation

- Collective Dose: a key parameter, but a single number is insufficient
- Decision-makers usually also need to know
  - *the average dose, the number exposed, the range of doses*
  - *subgroups with different doses*
- *Perhaps* give more weight to
  - *a few large individual doses than many small doses*
  - *doses incurred now than doses in the far future*

The Use of Collective Dose (S)

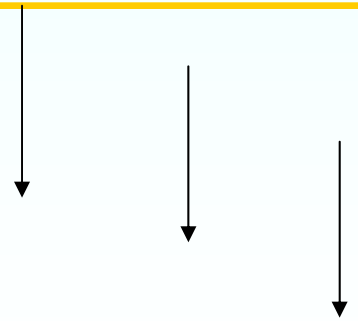
- For optimisation of protection
- For comparing technologies and protection options
- Not for epidemiologic risk assessment
  Inappropriate to use it in risk projections based on epidemiology
- Not for predicting number of cancer deaths due to trivial exposures to large populations
  An unreasonable, unintended, incorrect use of collective dose

Optimisation and Source-related Restrictions

Planned exposure situations

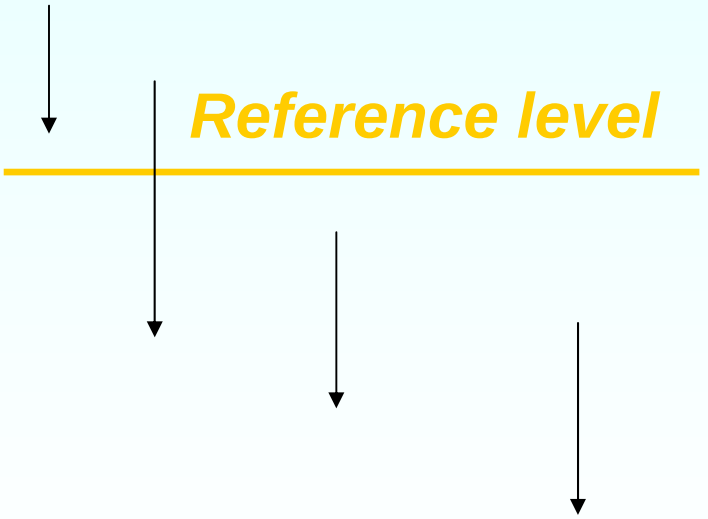
Dose limit

Dose constraint



Optimisation

Existing and emergencies exposure situations



Optimisation

Dose Constraints and Reference Levels

- In a *planned* situation, dose constraints guide optimisation

  Constraints

  (a) increase equity at the expense of total detriment;

  (b) take account of multiple sources

- In *emergency* and *existing exposure* situations, it is not always possible to reduce doses below the reference level

  The optimisation of protection is similar to that in planned situations, but the result may be different

  Reference levels, and not constraints, are used because the conditions, not the chosen dose level, constrain optimisation

Bands of Projected Dose for Constraints and Reference Levels

- 100 – 20 mSv

  <u>Example:</u> Radiological emergencies

- 20 – 1 mSv

  <u>Examples:</u> Occupational exposures in planned situations, Radon in dwellings

- ≤ 1 mSv

  <u>Example:</u> Public exposures in planned situations

Dose Limits

- Apply in planned situations
- Apply to the total dose to an individual from all regulated sources
- Do not apply in emergency exposure situations
  - *Informed volunteers in life-saving actions or preventing catastrophic conditions: no limit*
  - *Informed volunteers in urgent rescue operations: relaxed limits*
  - *Pregnant or breast-feeding women should not be employed as first responders undertaking life-saving actions*

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

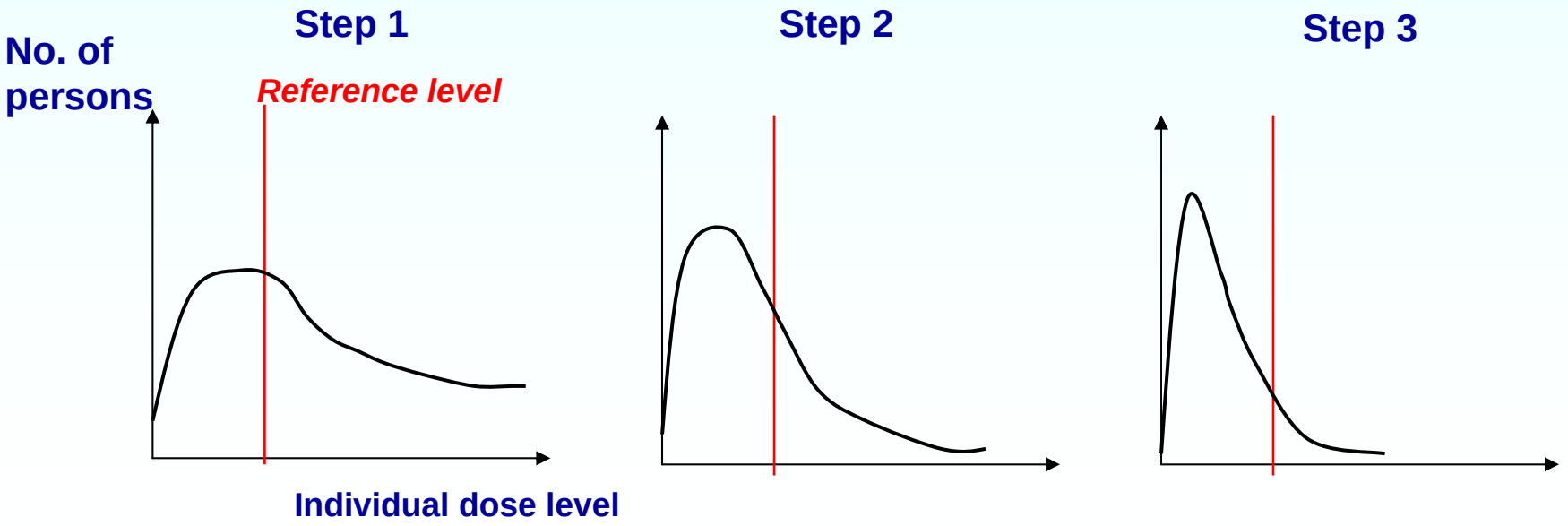
  About 0.3 mSv in a year appropriate

Emergency Exposure Situations

- Optimisation recommended to *and below* Reference Levels
  - *The old intervention system implied optimisation to intervention levels*
- Reference Level: An upper value of projected dose for all pathways combined
  - *The old system implied averted dose for single countermeasures*
- Additional guidance will be provided
  - *Existing guidance in ICRP P63 is extended, not replaced*

Existing Exposure Situations

- Optimisation recommended to *and below* reference levels
  - *The 1990 system implied optimisation to intervention levels*
- Optimisation, an iterative process
  - *This does not mean a moving target – the reference level stays*



Existing Exposure Situations: Radon

- Upper level of dose: 10 mSv
  - *National regulators can set lower constraints*
  - *Range reinstated and radon/progeny equilibrium assumed*

Situation	Reference level
Domestic dwellings	600 Bq m^{-3}
Workplaces	1500 Bq m^{-3}

Special Features of the System of Protection

- Justification in medicine
  - *Radiation as a tool*
  - *Specific procedures*
  - *Individual patients*
- Optimisation in medicine
  - *Diagnostic Reference Levels – not constraints*
  - *Radiotherapy: dose in and outside the target*
- Effective dose
  - *Could be used for comparing clinics etc, not for detriment assessment*

Exclusion and Exemption

- Exclude from legislation:
  Exposure situations unamenable to control
  'Cannot be regulated'

- Exempt from some or all requirements:
  Exposure situations where controls are unwarranted
  'Need not be regulated'

- Reference to the Scope draft - no numbers in Rec.

Potential Exposures

- Workplace accidents
  - *Number of people affected is small*
  - *Detriment is health risk to those directly exposed*
- Large disasters
  - *Number of people affected can be large*
  - *Detriment also includes contaminated land, food restrictions, etc*
- Exposures in the far future, e.g. from waste repositories
  - *Considerable uncertainties*
  - *Dose calculations useful to compare protection options but not to project detriment*

Assessment of Potential Exposures

- Everybody is responsible for safety

  Particularly important to remember outside the nuclear fuel cycle

- Risk constraints: guide optimisation of protection against risk (probability of death) =

  *Probability of accident * Probability of death given accident dose*

- ICRP continues to recommend established generic constraints:

  Potential exposure of workers: 2 10^{-4} per year

  Potential exposure of the public: 1 10^{-5} per year

- Safety of sources includes security

Why Protect Other Species?

- *Not* driven by concerns of existing radiation hazards
- Fills a conceptual gap

  We need scientific evidence that the environment is adequately protected

  - and methods to achieve better protection if required
- Further guidance will be provided

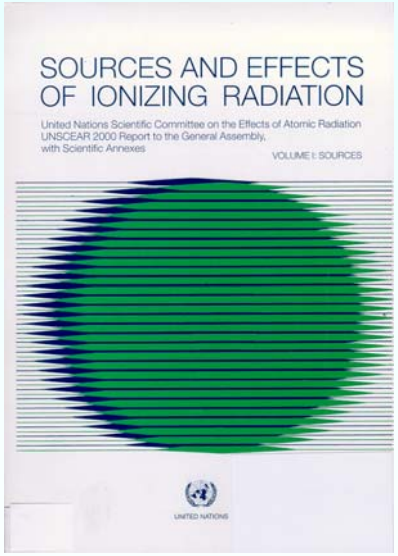
Summary of the 2007 Recommendations

- Updating weighting factors and radiation detriment
- Keeping the three principles of protection and clarifying how they apply to sources and the individual
- Moving to a situation-based approach applying justification and optimisation of protection to all controllable exposure situations (planned, emergency, and existing exposure situations)
- Keeping the dose limits
- Re-enforcing optimisation of protection to be applied in a similar way to all exposure situations, with restrictions on individual doses (dose constraints and reference levels)
- Developing a framework to demonstrate radiological protection of the environment.

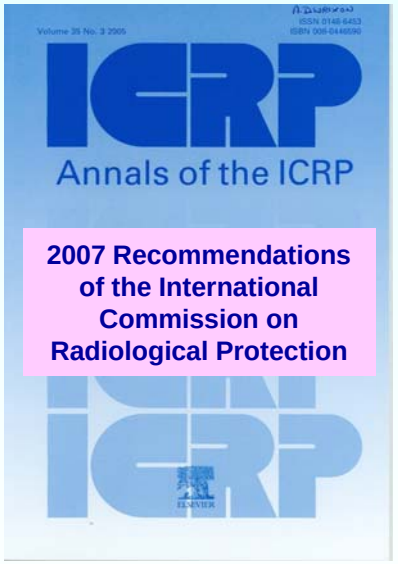
Time Schedule

- Early autumn 2007: Publication of the Recommendations
- International standards: 2010?
- National standards: 2015?

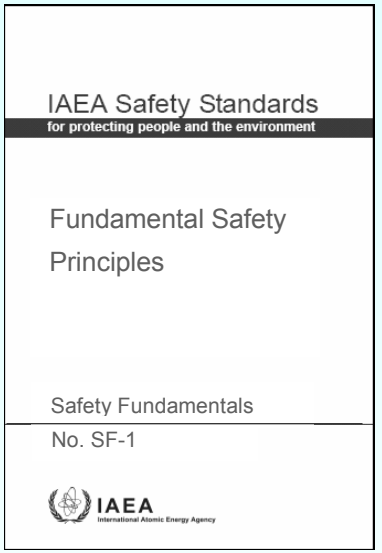
UNSCEAR, ICRP and IAEA



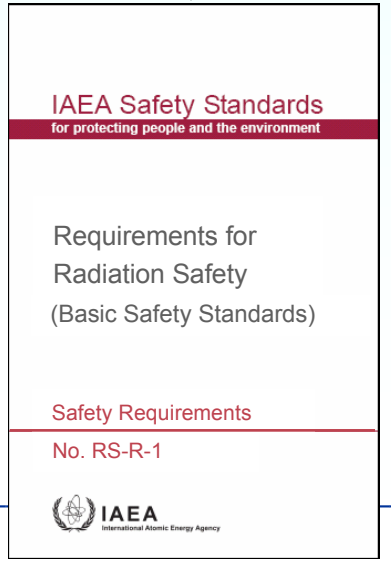
Effects of radiation



Recommendations for protection



Essential principles



Essential requirements

Future ICRP Challenges

Implementing RP07 in
- BSS
- Emergency and existing exposure situations
- NORMs, radon

Follow-up of scientific advancements particularly on alpha emitters and cancer risk, tissue reactions and other non-cancer effects of radiation

Enhancing radiation safety culture in the medical field

Developing a practical framework for the protection of the environment

Reinforcing the dialogue with experts, professionals and regulators