The 2007 Recommendations of ICRP
Dr Jack Valentin, Scientific Secretary, ICRP

- International Commission on Radiological Protection
  *ICRP: Who, why, what?*

- The 2007 Recommendations
  *Justification (political) – optimisation – limits & constraints*
  *The exposure situation*
  *Include non-human species*
About ICRP
ICRP, an Independent Registered Charity

Established to advance for the public benefit the science of Radiological Protection,
in particular by providing recommendations and guidance on all aspects of protection against ionising radiation.
Structure of ICRP, 2005 – 2009

Main Commission

Chair: Dr L-E Holm, SE
12 other members

Scientific Secretariat
Dr J Valentin, SE

C1- Radiation Effects Dr R J Preston, US

C2- Doses from Radiation Exposure Dr H Menzel, CH

C3- Protection in Medicine Dr C Cousins, UK

Task Groups

C4- Application of ICRP Recommend: s Dr A Sugier, FR

Working Parties

C5-Prot. of the Environment Prof J Pentreath, UK
The 2007 Recommendations of ICRP
Why Are We Updating...

- **New biological & physical information**
  Validity of the LNT model? (Linear, No Threshold)

- **Increasing use of radiation in medicine**
  Increase professional awareness?

- **Post-Chernobyl lessons; inclusion of natural exposures**
  Coherent, consistent implementation of ICRP Publication 60?

- **Protection of the environment**
  Scientific proof of adequate protection?
ICRP 1990 Rec’s: Logical But Complex

YAWN... PERHAPS I’LL READ THIS TOMORROW...
Aims of the Revision

- Take account of new science
- Feed back experience of current radiation safety standards
- Improve & streamline the presentation
- Use an open, transparent process (9 years gestation!)
- Maintain as much stability as is consistent with the new information
To Get the Recommendations...

- Buy printed or electronic copies
  * IRPA Associated Societies are eligible for a discount

- Developing countries: free download at HINARI

- Junior staff: coming summary in JRP

- For all of this, see www.icrp.org

- Or translate them (an Italian version is ready!)
Chapter 1: History, development, structure
ICRP In The Cosmic Scheme

Basic Scientific Studies

Scientific Evaluations (UNSCEAR, BEIR etc.)

ICRP Recommendations

Regional (PAHO, EC, NEA) & Topical (ILO, WHO, FAO) Stand’s

International Safety Standards: BSS (IAEA)

Industry Stand’s (ISO, IEC)

National Regulations

Demonstration of Compliance
Chapter 2: Aims and scope
Primary Aim of Our Recommendations

To contribute to an appropriate level of protection for people and the environment without unduly limiting the desirable human activities that may be associated with radiation exposure.
The Principles of Protection

Source-related, in all exposure situations:

- **Justification**
  More benefit than detriment

- **Optimisation of protection**
  Dose and risk constraints to
  (a) increase equity,
  (b) consider multiple sources

Individual-related, in planned exposure situations

- **Application of dose limits**
  Except medical exposure of patients
### ICRP Value Judgements - Constraints & Equity

<table>
<thead>
<tr>
<th>Utilitarian ethics</th>
<th></th>
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<tbody>
<tr>
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<td><strong>Dose constraints</strong></td>
</tr>
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<td>Increased equity = emphasise the individual</td>
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ICRP Value Judgements - Constraints & Equity
## Limits, Levels – Constraints & Multiple Sources

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*ICRP* INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION
## Limits, Levels – Constraints & Multiple Sources

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Chapter 3: Biology
Deterministic and Stochastic Effects

These words will still be the default terms!

- **Deterministic**
  Harmful, mostly late, tissue reactions

- **Stochastic**
  Cancer and heritable disease
  Cancer probability now based on incidence, not mortality
  LNT: Scientifically plausible but not unambiguous (cf. Central Limit Theorem, i.e., valid at the population level)
**Heritable Disease**

- **Induced mutation rates:** based on mouse studies
  
  *Induced genetic effects not demonstrable in man!*
  
  *Human spontaneous mutation rates used to estimate Doubling Dose*

- **Probability of heritable risk was over-estimated in 1990**
  
  *Particularly for multifactorial diseases*

- **Nominal probability coeff/s:** 2 generations only
  
  *Based on UNSCEAR 2001, agrees with BEIR VII*
  
  *1990 calculation to equilibrium – assumptions not sustainable*
  
  *Risk after 2 generations small, no substantial difference 2 – 10 generations*

  Thus, no significant underestimation of genetic risk
Epigenetic Responses to Radiation

- Genomic instability: Damage expressed after several cell generations
  
  Why and how does it happen?
  Does it really affect normal cells?
  If it does, does it change the total risk assessed epidemiologically?

- Bystander signalling: Damage to non-irradiated cells in an irradiated cell population
  
  Why and how does it happen?
  Does it change the total risk assessed epidemiologically?

- Important for understanding - currently no way to assess effect on risk – major effect unlikely
Adaptive Response to Radiation

- A priming dose sometimes confers increased resistance against a second dose
  
  *Not a universal feature*
  
  *Considerable variation, usually transient*
  
  *Mechanistic knowledge fragmentary*
  
  *Not evident at ‘protection’ doses*
  
  *No consistent evidence of reduction of adverse health effects*

- Thus, scientifically important but at present not relevant for radiological protection
Females and Males

- Nominal risk estimates for protection
  Individual retrospective assessments require specific information

- The average achieves adequate protection for both sexes
  A value judgement, based on science

- Thus, no need for sex-specific protection criteria
  Precludes discrimination
## Nominal Probability Coefficients (% Sv⁻¹)

<table>
<thead>
<tr>
<th>Exposed population</th>
<th>Cancer 2007</th>
<th>Heritable effects 2007</th>
<th>Total 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole</td>
<td>6.0</td>
<td>1.3</td>
<td>7.3</td>
</tr>
<tr>
<td>Adult</td>
<td>4.8</td>
<td>0.8</td>
<td>5.6</td>
</tr>
</tbody>
</table>

For practical protection purposes, the overall risk coefficient of ~5% is still appropriate.
A Reminder:

1 = 2
Does ICRP Over- Or Underestimate Risk?

B....y extremist!!
Chapter 4: Physical quantities
## Radiation Weighting Factors, $w_R$

<table>
<thead>
<tr>
<th>Type and energy range</th>
<th>Publication 60</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photons, all energies</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Electrons and muons, all energies</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Protons</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Alpha particles, fission fragments, heavy nuclei</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Neutrons</td>
<td>Stepwise function</td>
<td>Continuous function &lt;10 keV, 2.5</td>
</tr>
</tbody>
</table>
# Tissue Weighting Factors, $w_T$

<table>
<thead>
<tr>
<th>Tissue</th>
<th>$w_T$</th>
<th>$\sum w_T$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone-marrow, breast, colon, lung, stomach, remainder tissues (13/14)</td>
<td>0.12</td>
<td>0.72</td>
</tr>
<tr>
<td>Gonads</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Bladder, oesophagus, liver, thyroid</td>
<td>0.04</td>
<td>0.16</td>
</tr>
<tr>
<td>Bone surface, brain, salivary glands, skin</td>
<td>0.01</td>
<td>0.04</td>
</tr>
</tbody>
</table>

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INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION
New Reference Phantoms

MIRD Phantom  Voxel Male and Female Phantoms
Fetus; child: in preparation

New dose coefficients in 2008 😊
The Use of Effective Dose (E)

- For compliance and prospective planning

- *Not* for detailed retrospective dose and risk assessments after exposure of individuals
  particularly not for patients (old, unhealthy population)

- *Not* for epidemiological studies *(at least not for risk assessment)*
The Use of Collective Dose (S)

- For optimisation
- 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*
Collective Dose: Logical, But Is It Right?

Equates many small doses to few large doses…

Are 500 road traffic casualties just as bad as 500 plane crash victims?
Chapter 5:
System of protection, man
In 1990, a Process-Based Approach

<table>
<thead>
<tr>
<th>Practice</th>
<th>Intervention</th>
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</thead>
<tbody>
<tr>
<td>increases exposure or risk</td>
<td>reduces exposure or risk</td>
</tr>
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</table>
In 1990, a Process-Based Approach

Practice

increases exposure or risk

- Dose limit
- Dose constraint

Intervention

reduces exposure or risk

Protection optimised
In 1990, a Process-Based Approach

Practice

- increases exposure or risk

\[ \begin{align*}
\text{Dose limit} \\
\text{Dose constraint} \\
\text{Protection optimised}
\end{align*} \]

Intervention

- reduces exposure or risk

\[ \begin{align*}
\text{Optimisation…} \\
\text{Intervention level} \\
\text{…but what happens here?}
\end{align*} \]
2007, Exposure Situation:

Planned / Emergency / Existing

Prospective individual dose

reject planned options – even if collective dose is lower

Constraint/Reference level

acceptable planning options desirable final result

Inappropriate to plan to allow higher exposures
How to Select Constraints / Reference Levels

- **100 – 20 mSv**
  Direct benefit. Information, training, dose monitoring.
  Example: Radiological emergencies

- **20 – 1 mSv**
  Direct or indirect benefit. Information, training, dose monitoring or assessment.
  Examples: Occupational exposures in planned situations, radon in dwellings

- **Less than 1 mSv**
  Societal benefit. Dose assessment.
  Example: Public exposures in planned situations
The Collective Dose in Optimisation

- A key parameter (at least in occupational protection), but we usually also need to know
  - average dose, number exposed, range, etc
  - ...

- Perhaps give more weight to
  - a few large doses than to many small doses
  - doses now than to doses in the far future
**Dose Limits for Planned Exposure Situations**

- They remain the same as in 1990!

<table>
<thead>
<tr>
<th>PUBLIC</th>
<th>OCCUPATIONAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mSv in a year</td>
<td>20 mSv per year, averaged over defined 5-year periods</td>
</tr>
<tr>
<td>In special circumstances, an average of 1 mSv per year</td>
<td>100 mSv in 5 years, and less than 50 mSv in one year</td>
</tr>
</tbody>
</table>

averaged over defined 5-year periods
Chapter 6: Implementation
Planned Exposure Situations

- **Occupational exposure**
  
  *Constraint usually set by operator*
  
  *(small operators may need guidance)*
  
  *Transient/itinerant workers need special attention*

- **Public exposure**

  *Constraints usually set by regulator*

  *About 0.3 mSv in a year appropriate*

  *0.1 mSv in a year if prolonged exposure*
Potential Exposures

- **Workplace accidents**
  - Number of people affected is small.
  - Detriment = 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, incl. security
  
  *Particularly important to remember outside the nuclear fuel cycle*

- **Risk constraints:** guide optimisation of protection
  
  against risk (probability of death) =
  
  \[
  \text{Prob (accident)} \times \text{Prob (death | accident dose)}
  \]

- **ICRP continues to recommend established generic constraints:**
  
  - Potential exposure of workers: $2 \times 10^{-4}$ per year
  - Potential exposure of the public: $1 \times 10^{-5}$ per year
### Existing Exposure Situations: Radon

**Upper level of dose:** 10 mSv (radon/progeny equilibrium)

Upper level of activity conc. retained for continuity

National regulators can [should] set lower constraints

‘There is now evidence for what we thought all the time’

No real difference UNSCEAR-ICRP; an ICRP TG statement in preparation

<table>
<thead>
<tr>
<th>Situation</th>
<th>Reference level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic dwellings</td>
<td>600 Bq m⁻³</td>
</tr>
<tr>
<td>Workplaces</td>
<td>1500 Bq m⁻³</td>
</tr>
</tbody>
</table>
Regulatory Philosophy

RULES, RULES, RULES - HAVEN'T YOU HEARD OF MODERN PEDAGOGICS?
Chapter 7: Medical exposure of patients
Special Features of the System of Protection

- **Justification in medicine**
  Benefit and risk apply to the same person (patient)

- **Optimisation in medicine**
  Diagnostic Reference Levels, not constraints
  Radiation therapy, maximise PTV but minimise other dose

- **Dose limits**
  Do not apply to patients
Justification or Indiscriminate Referral

FIRST OF ALL, LET'S HAVE A CT TO SEE IF YOU GOT SOMETHING MORE THAN A COLD
'Buy Our CT, Earn $2,163,000 in 5 Years'

In addition to high performance, the latest generation of Siemens CT scanners offers you the flexibility to easily upgrade or reconfigure your CT equipment as part of our one-stop shopping solution. Your Siemens financial specialists provide you with a customized business pro-term, based on your actual practice needs—free of charge.

![CT Scan Room](image)

Minimum space requirement is 175 square feet.

Many small practices have limited space available. However, most physicians are surprised at how little space is actually needed to site an CT unit effectively. The dedicated Siemens in-clinic CT solution can be sized to meet the minimum space requirements and can be set-up on virtually any floor, providing a high degree of flexibility in a pre-engineered package.

Sitting at the apex of innovation and the world’s most affordable feature-rich CT solutions, the SOMATOM Spirit is a true breakthrough in diagnostic imaging technology. The SOMATOM Spirit offers a new level of diagnostic performance and ease-of-use tool that significantly improves workflow and efficiency. The SOMATOM Spirit continues to be the most advanced somewhere, with a single-slice, single-scan, single-exam, single-patient, single-location system. Our CT systems are designed to deliver a seamless, integrated solution to your practice needs, providing the support and support you expect from Siemens.

![CT Control Room](image)

Quick Check #3:
Potential CT room available? Yes No
What is the size of the room? Less than 1000 square feet?

Take a moment to recall: Is there a room or space where you can receive your own CT scan?

![Table](table)

<table>
<thead>
<tr>
<th>Procedures Per Day</th>
<th>Days Per Month</th>
<th>Average CPT</th>
<th>Income</th>
<th>FMVL Cost</th>
<th>ROI* Per Month</th>
<th>ROI for 5 Years</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>1.8</td>
<td>20</td>
<td>$220</td>
<td>$7,950</td>
<td>Break Even</td>
<td>Break Even</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
<td>20</td>
<td>$220</td>
<td>$7,950</td>
<td>$14,050</td>
<td>$843,000</td>
</tr>
<tr>
<td>C</td>
<td>10</td>
<td>20</td>
<td>$220</td>
<td>$7,950</td>
<td>$36,050</td>
<td>$2,163,000</td>
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![ROI Graph](image)

**ICRP**

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION
Is It Justified?

With x rays, perhaps I’d be able to see why it hurts, but it’s safer to extract them all.
Justification in Medicine...

blood

Fetal dose 20 mGy
...3 Min. Exam, Then OR (both survived!)

Free blood

Kidney ripped off aorta (no contrast in it)

Splenic laceration
Some Medical Is Justified – But...

Per caput dose, US: 1980, 0.54 mSv
2006 3.2 mSv
600% increase!

Annual collective dose, US, 2006: ~930,000 manSv
of which ~600,000 manSv due to CT
Annual collective dose from natural sources ~900,000 manSv
Chernobyl world-wide, all time also ~600,000 manSv

Collective medical exposure is >100x occupational
Removing 1% unnecessary medical is ‘better’ than removing
ALL occupational exposure!
Chapter 8: Protection of the environment
Why Protect Other Species?
Why Protect Other Species?

- *NOT* driven by concerns of existing radiation hazards

- Fills a conceptual gap
  
  *Science to show if the environment is adequately protected*
  
  *- and methods to improve protection if required*

- Further guidance will be provided
To Summarise, ICRP is...

- Retaining the fundamental principles of protection
- Clarifying how they apply to sources and the individual
- Changing focus from process (practice/intervention) to exposure situation (planned/emergency/existing)
- Extending the concept of source-related constraints to all situations
- Updating weighting factors and detriment
- Maintaining the current dose limits
2007 Recommendations

GEE, THESE ARE INTERESTING RECOMMENDATIONS!