2005 Annual Report
of the
International Commission on Radiological Protection

ICRP Annual Report on 2005
2006-08-20
ICRP Reg. No. 92/380/06

Cover photo: Roger Clarke (left), retiring Chairnan, and Lars-Erik Holm, new Chairman

This photo was taken during the Commission's meeting in March 2005 in Paris, France. At this occasion, Professor Clarke was given an engraved pewter plate commemorating his unprecedented 12 years at the helm of ICRP.

Our Mission Statement

**The International Commission on Radiological Protection, ICRP,
is 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.**

Chairman's Foreword

The Main Commission met twice in 2005 and the main topic was the preparation of the next recommendations. The first meeting was held in Paris in March when the report on Human Alimentary Tract Model for radiological protection was adopted. The reports on low-dose cancer risk, dosimetric quantities used in radiological protection, biological and epidemiological information on health risks attributable to ionising radiation, optimisation and on defining the representative individual were agreed for web consultation.

The second meeting was of the Commission and its Committees in Geneva during September with the Commission also subsequently meeting in Bern. This was the first meeting of the Committees in their 2005-2009 term. At the meeting in Bern, the Main Commission approved the reports on optimisation and on defining the representative individual.

The membership of the new Commission and Chairmen of Committees 2005-2009 is presented in the table overleaf.

Our contacts with other organisations were particularly intense in 2005, reflecting the development of our Next Recommendations project. During the year I participated in several meetings to present the programme of work of the Commission. I attended the workshop organized in January by the Swiss Federal Commission for Radiological Protection and Monitoring of Radioactivity in the Environment, the Seventh Internal Symposium of the Society for Radiological Protection held in Cardiff in June, and the International Conference on the Safety and Security of Radioactive Sources organised by the IAEA and others in June in Bordeaux.

I also participated in the 37th meeting of the German Society for Radiological Protection in Basel in September, the EC Article 31 seminar on the new Recommendations in November, and the 9th European Nuclear Conference in December in Paris.

Furthermore, I presented the work of the Commission at the NEA CRPPH meeting in Paris in March, at the 10th National Congress of the Spanish Society for Radiological Protection in Huelva in September, at the Senior regulators' meeting at the General conference of the IAEA in Vienna in September, and at the meetings of the Commission on Safety Standards in June and November in Vienna.

Position in the Main Commission	*Name*
Chairman	**Lars-Erik Holm** (Sweden)
Vice-Chairman	**Roger Cox** (UK)
Committee Chairpersons:	
C1 (Biological Effects)	**Julian Preston** (USA)
C2 (Dosimetry)	**Christian Streffer** (Germany; -2007)
	Hans-Georg Menzel (Switzerland, 2007-9)
C3 (Medicine)	**Fred Mettler** (USA, -2005-09-18)
	Claire Cousins (UK, 2005-09-19)
C4 (Applications)	**Annie Sugier** (France)
C5 (Environment)	**Jan Pentreath** (UK)
Other members	**John Boice** (USA)
	Abel González (Argentina)
	Jai-Ki Lee (Korea)
	Yasuhito Sasaki (Japan)
	Nataliya Shandala (Russia)
	Zi Qiang Pan (China)
Scientific Secretary	**Jack Valentin** (Sweden)

The main focus of the work of ICRP has been on the next Recommendations and on the Foundation Documents and Building Blocks that will underpin them. The list of Foundation Documents and Building Blocks now extends to significant texts on the cancer risk associated with low doses of radiation (now published), on the biological effects of radiation (has been subjected to public consultation), the dosimetry aspects of protection (has been subjected to public consultation), on radiological protection in medicine (draft being completed), on the scope of radiological protection (draft completed in 2005), on the definition of the 'individual' for the purposes of setting and assessing compliance with standards (has been subjected to public consultation), and a treatise on the approach to optimisation of protection (has also been subjected to public consultation).

These are very exciting times for the Commission and for me as its chairman. We are extremely grateful to the many organisations, experts, and individual members of the public who are devoting so much of their time and experience to helping us to improve our draft next Recommendations into a useful document. Their contributions are crucial for the future success of our reports.

Lars-Erik Holm

Professor Roger H Clarke (left), leaving Chairman of ICRP, Dr Lars-Erik Holm (right), the new Chairman, and Dr Jack Valentin (middle), Scientific Secretary, working together in Stockholm on the draft next Recommendations, spring 2005

The International Commission on Radiological Protection

The primary body in radiological protection is ICRP. It was formed in 1928, by the International Congress of Radiology, as the 'International X-ray and Radium Committee', but adopted its present name in 1950 to reflect its growing involvement in areas outside that of occupational exposure in medicine, where it originated.

Broad structure

ICRP consists of the Main Commission, Committee 1 (Radiation Effects), Committee 2 (Doses from Radiation Exposure), Committee 3 (Protection in Medicine), Committee 4 (Application of ICRP Recommendations), since 1 July 2005, Committee 5 (Protection of the Environment), *ad hoc* Task Groups and Working Parties, and the Scientific Secretariat.

Membership

The Main Commission consists of twelve members and a Chairman, while the Committees contain some 15 members each (except Committee 5 which has 8 members).

The Commission and its Committees run for four-year periods, from 1 July. On each occasion of a new period, at least three, and not more than five, members of the Commission must be changed. A similar rate of renewal is sought for the Committees. Such a new period began 1 July 2005, and the autumn 2005 meetings of the Commission and its Committees was the first time that the full set of members of the 2005 – 2009 term met.

Meetings

The Commission meets once or twice a year. Each Committee meets once a year. At least twice in each four-year period, the annual meeting of the Committees is conducted jointly and together with the Commission. These meetings are funded as necessary from monies available to ICRP.

Financing

The activities of ICRP are financed mainly by voluntary contributions from national and international bodies with an interest in radiological protection. (A list of the bodies providing such contributions in 2005 is appended at the end of this report). Some additional funds accrue from royalties on ICRP *Publications*. Members' institutions also provide support to ICRP by making the members' time available without charge and, in many cases, contributing to their costs of attending meetings.

Mode of operation

The Commission uses Task Groups and Working Parties to deal with specific areas. Task Groups are formally appointed by the Commission to perform a defined task, usually the preparation of a draft report. A Task Group usually contains a majority of specialists from outside the Commission's structure. It is funded as necessary from monies available to ICRP.

Working Parties are set up by Committees to develop ideas, sometimes leading to the establishment of a Task Group. The membership of a Working

Party is usually limited to Committee members. Working Parties receive no funding of their own, *i.e.* they operate primarily by correspondence and by meetings in direct conjunction with meetings of the Committee concerned.

These activities are co-ordinated with a minimum of bureaucracy by a Scientific Secretary, ensuring that ICRP recommendations are promulgated.

Thus, ICRP is an independent international network of specialists in various fields of radiological protection. At any one time, about one hundred eminent scientists are actively involved in the work of ICRP. The four-tier structure described provides a rigorous Quality Management system of peer review for the production of ICRP Publications.

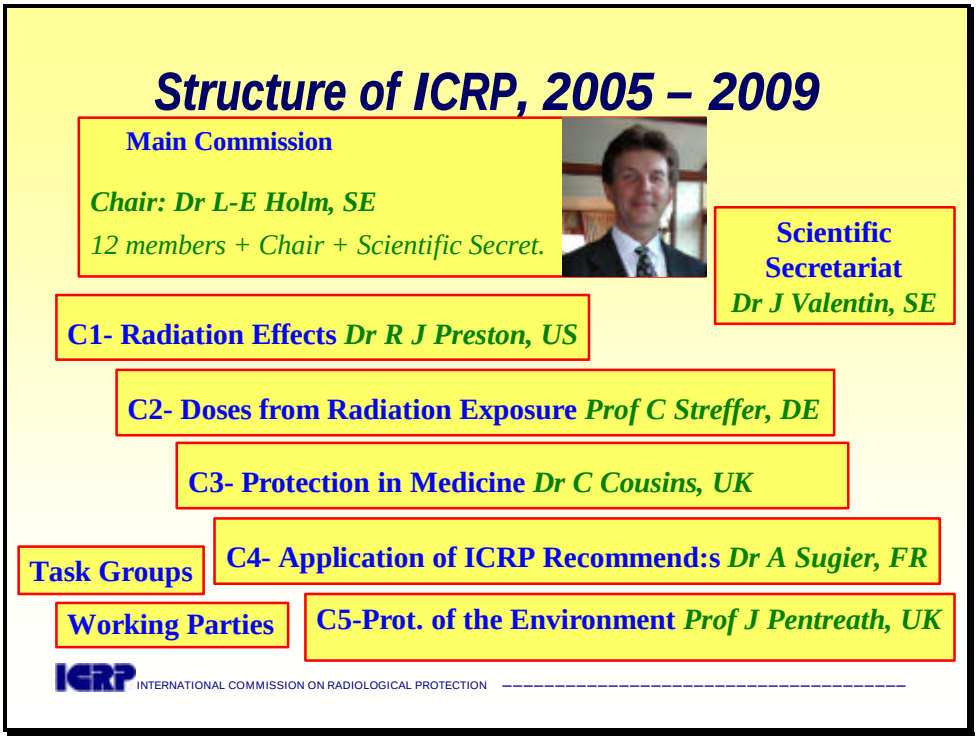
Furthermore, before draft ICRP reports are approved for publication, they are regularly circulated to a number of bodies and individual experts, and posted for public consultation on the Internet.

Objective

In preparing its recommendations, the Commission considers the fundamental principles and quantitative bases on which appropriate radiation protection measures can be established, while leaving to the various national protection bodies the responsibility of formulating the specific advice, codes of practice, or regulations that are best suited to the needs of their individual countries.

The aim of the recommendations of ICRP is to

- *provide an appropriate standard of protection for mankind from sources of ionising radiation, without unduly limiting beneficial practices that give rise to exposure to radiation.*



The structure of ICRP currently comprises a Main Commission and (from 1 July 2005) five Committees; there were also five Committees 1950 – 1962, but only four in 1963 – 2004.

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The Work Programme of the Commission and its Committees:

The Commission is 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.

Committee 1 considers the risk of induction of cancer and heritable disease (stochastic effects) together with the underlying mechanisms of radiation action; also, the risks, severity, and mechanism of induction of tissue/organ damage and developmental defects (deterministic effects).

Committee 2 is concerned with the development of dose coefficients for the assessment of internal and external radiation exposure, development of reference biokinetic and dosimetric models, and reference data for workers and members of the public.

Committee 3 is concerned with protection of persons and unborn children when ionising radiation is used for medical diagnosis, therapy, or for biomedical research; also, assessment of the medical consequences of accidental exposures.

Committee 4 is concerned with providing advice on the application of the recommended system of protection in all its facets for occupational and public exposure. It also acts as the major point of contact with other international organisations and professional societies concerned with protection against ionising radiation.

Committee 5 is concerned with radiological protection of the environment. It will aim to ensure that the development and application of approaches to environmental protection are compatible with those for radiological protection of man, and with those for protection of the environment from other potential hazards.

The Main Commission of ICRP met twice in 2005: In Paris, France, in March and in September in Switzerland: first in Geneva together with the five standing Committees, and immediately thereafter in Bern. The main issue at these meetings was the continued preparation of a set of draft fundamental ICRP Recommendations, intended to replace the current (1990) Recommendations. A draft had been subjected to world-wide public consultation in 2004, and the 2005 meetings focused on discussions of the comments received.

New publications

Four reports and a supplement were published in the *Annals of the ICRP* in 2005. These are:

- *Publication 95*: Doses to infants from ingestion of radionuclides in mothers' milk (this was the last issue of the 2004

volume of the *Annals*, but was not printed until early in 2005);

- *Publication 96*: Protecting people against radiation exposure in the event of a radiological attack;
- *Publication 97:* Prevention of high-dose-rate brachytherapy accidents;
- *Publication 98:* Radiation aspects of brachytherapy for prostate cancer; and
- *Supporting Guidance 4:* Development of the Draft 2005 Recommendations of the ICRP (a supplement provided free of charge to subscribers to the *Annals*).

In addition, *Publication 99* on low-dose cancer risks is the final issue of the 2005 volume of the *Annals* and the preparation of the report was completed in 2005, but it was printed early in 2006.

Breast milk transfer: In *Publication 95*, ICRP provides information on radiation doses to the infant due to intakes of radionuclides in maternal milk. As in *Publication 88* (ICRP, 2001) on doses to the embryo and fetus following intakes of radionuclides by the mother, intakes by female members of the public and female workers are addressed. Acute and chronic intakes are considered at various times before and during pregnancy as well as during the period of breastfeeding. Dose coefficients per unit intake by the mother (Sv/Bq) are given for the selected radionuclides of the same 31 elements for which age-specific biokinetic models were given in *Publications 56, 67, 69, and 71* (ICRP, 1989, 1993, 1995a,b). For these elements, doses were calculated for the most radiologically significant natural or artificial radionuclides that might be released into the environment due to various human activities. Dose coefficients are also given in this report for radionuclides of an additional four elements: sodium, magnesium, phosphorus, and potassium.

Relevant human and animal data on elemental and radionuclide transfer to milk are reviewed. The biokinetic models for adults given in earlier ICRP publications are adapted to include transfer to milk. Model predictions of fractional transfer of ingested or inhaled activity to milk are discussed in the report, and the corresponding dose coefficients for the infant are compared with dose coefficients for in utero exposure, as given in *Publication 88* (ICRP, 2001). Illustrative information is also given on doses to the female breast from radionuclides in breast milk, and external doses received by the child from radionuclides retained in the tissues of the mother. For the additional elements considered in this report, but not in *Publication 88* (ICRP, 2001), information is also given on doses to the embryo and fetus following maternal intakes of radioisotopes during or before pregnancy.

A CD-ROM is to be issued giving data that will supplement the information given in this report. In addition to the dose coefficients given here, committed equivalent doses to the various organs and tissues of the offspring will be given. Dose coefficients will also be given for inhalation of a range of aerosol sizes for the selected radionuclides of the elements covered by this report.

Radiological attacks: There is a need for professional advice on measures to be undertaken should a radiological attack occur. *Publication 96* reaffirms the applicability of existing ICRP recommendations to such situations. It is mainly concerned with attacks involving ‘radiological dispersion devices’.

Many aspects of emergency scenarios after a radiological attack may be similar to those arising from radiological accidents, but there are also differences. For instance, a radiological attack would probably be targeted at a public area, possibly in an urban environment, where the presence of radiation is not anticipated and the dispersion conditions commonly assumed

for emergencies in nuclear facilities may not be applicable. First responders and rescuers need to be adequately trained and have the proper equipment to identify radiation and radioactive contamination. Radiological protection specialists must be available to provide advice. It may be prudent to assume that radiological, chemical, and/or biological agents are involved until proven otherwise. This calls for an 'all-hazard' approach to the response.

The main aim must be to prevent acute health effects of a 'deterministic' nature and restrict the likelihood of late health effects of stochastic nature such as cancer and hereditary effects. A supplementary aim is to minimise environmental contamination and general disruption. Actions to avert exposures are much more effective than possible medical treatment after exposure has occurred.

Responders at recovery and restoration should be protected according to normal occupational standards and dose limits. This restriction may be relaxed for informed volunteers undertaking urgent rescue operations, and is not applicable for volunteered life-saving actions. However, specific protection measures are recommended for female workers who may be pregnant or nursing an infant.

The immediate countermeasures to protect the public in the rescue phase are primarily caring for people with traumatic injuries and controlling access. Subsequent actions include respiratory protection, personal decontamination, sheltering, iodine prophylaxis (if radioiodines are involved) and temporary evacuation. In the recovery phase, definitive relocation and resettlement may be needed in extreme cases. This phase may require restoration and cleanup, management of resulting radioactive waste, management of corpses containing significant amounts of radioactive substances, and dealing with long-term exposure caused by remaining radioactive residues.

The guidance is based solely on radiological protection considerations and should be seen as a decision-aiding tool to prepare for the aftermath of a radiological attack. It is expected to serve as input to a final decision-making process that may include other societal concerns, consideration of lessons learned in the past, and the participation of stakeholders.

A radiological attack could cause radioactive contamination of consumer goods such as water, food and other commodities. This possible outcome, however, is unlikely to lead to significant internal contamination of a large number of people due to the large amounts of radioactive material that would be required to reach high levels of contamination. Intervention measures in the aftermath of the radiological attack should result in a systematic and flexible approach, taking into account the conditions and invoking actions as warranted by the circumstances. Many potential scenarios clearly cannot induce immediate severe radiation injuries. In order to prevent overreaction, radiological protection decisions must be proportional to the magnitude of the radiological attack.

HDR brachytherapy: High dose rate (HDR) brachytherapy is a rapidly growing technique replacing low dose rate (LDR) procedures over the last few years in both industrialised and developing countries.

It is estimated that about 1/2 million procedures (administrations of treatment) are performed by HDR units annually. LDR equipment has been discontinued by many manufacturers over the last few years leaving HDR as the major alternative for brachytherapy.

HDR brachytherapy techniques deliver a very high dose, in the order of 1.6-

5 Gy per minute, so mistakes can lead to under- or over-dosage with the potential for clinical adverse effects. More than 500 HDR accidents (including one death) have been reported along the entire chain of procedures from source packing to delivery of dose. Human error has been the prime cause of radiation events. In *Publication 97*, the International Commission on Radiological Protection concludes that many accidents could have been prevented if staff had had functional monitoring equipment and paid attention to the results. Since iridium has a relatively short half-life, the HDR sources need to be replaced about every 4 months. Over 10,000 HDR sources are transported annually with the resultant potential for accidents, and the appropriate procedures and regulations must be observed.

This Figure from ICRP Publication 97 shows a high-dose-rate brachytherapy treatment machine. The source is housed in the white cylinder at the top of the machine and the guide catheters are hooked to holes in the stainless steel faceplate. A portable source shield is in the corner.

A number of specific recommendations on procedures and equipment are given in the report. The need for an emergency plan, and for practising emergency procedures, is stressed. The possibility of loss or theft of sources must be kept in mind. A collaborating team of specifically trained personnel following

quality assurance (QA) procedures is necessary to prevent accidents. Maintenance is an indispensable component of QA; external audits of procedures reinforce good and safe practice and identify potential causes of accidents. QA should include peer review of cases. Accidents and incidents should be reported and the lessons learned should be shared with other users to prevent similar mistakes.

Prostate brachytherapy: The use of permanent radioactive implants (^{125}I or ^{103}Pd seeds) to treat selected localized prostate cancer patients has been rapidly increasing all over the world in the last fifteen years. To date, it is estimated that more than 50,000 patients are treated this way every year in the world, and this number is anticipated to increase in the near future. Although no accident or adverse effects involving the medical staff and/or members of the patient family have been reported so far, this brachytherapy technique raises a number of radiation safety issues which need specific recommendations from ICRP.

All data concerning the dose received by the persons approaching the patients after the implantation have been reviewed in *Publication 98*. Those doses have been either directly measured or calculated. The available data show that, in the vast majority of cases, the dose to comforters and carers remains well below the 1 mSv/year limit. Only the (rare) case where the patient's partner is pregnant at the time of implantation may need specific precautions.

Expulsion of sources through the urine, the semen or the gastro-instestinal tract is rare. Specific recommendations should be given to the patient to allow him to deal adequately with this event. Of note, due to the low activity of an isolated seed, and to its low photon energy, no incident/accident linked to a seed loss has ever been recorded.

Cremation of bodies (frequent in some countries) raises, when it is performed in the first months post-implantation, several issues related to: 1) the activity which remains in the patient's ashes and 2) the airborne dose, potentially inhaled by the crematorium staff or by the members of the public. Review of available data shows that cremation can be allowed if 12 months have elapsed since an implantation with ^{125}I (3 months for ^{103}Pd). If the patient dies before this delay has elapsed, specific measures must be undertaken.

Specific recommendations have to be given to the patient to warn his surgeon in case of subsequent pelvic or abdominal surgery. A ‘wallet-card’ with all relevant information about the implant is useful.

In most cases, brachytherapy does make the patient infertile, although the therapy-related modifications of the semen reduce fertility. Patients must be aware of the possibility of fathering children after such a permanent implantation, with a limited risk of genetic effects for the child.

Patients with permanent implants must be aware of the possibility of triggering certain types of security radiation monitors: the ‘wallet-card’ including the main information about the implant (see above) may prove to be helpful in such a case.

Considering the available experience after brachytherapy and external irradiation of prostate cancer, the risk of radio-induced secondary tumors appears to be extremely low. The demonstrated benefit of brachytherapy clearly outweighs, by far, the very limited (mainly theoretical) increase of the radiation-induced cancer risk.

Draft Recommendations: The supplement on this topic was provided primarily in order to ensure that subscribers to the *Annals* would have full access to

certain discussion papers that had been published in the *Journal of Radiological Protection* rather than in the *Annals* because of the shorter publication times and different readership of *JRP*.

Thus in 1997, the International Commission on Radiological Protection initiated a project intended to lead up to the replacement of its 1990 Recommendations (*Publication 60*) with a view to producing new, consolidated Recommendations 10-15 years after those of 1990.

In order to stimulate comprehensive discussion, an open and iterative consultation process was used. An initial set of conceptual proposals to be considered by the Commission, and two later progress reports describing how and why ideas evolved in interaction with the radiological protection community, were published in the *Journal of Radiological Protection*. These three papers are reproduced in *ICRP Supporting Guidanve 4* with kind permission by the Institute of Physics Publishing.

As a result of consultation on the initial conceptual proposals and subsequent debate, the Commission drafted a proposed text for its 2005 Recommendations. This was intended not as a radical revision, but as a more coherent statement of current policy and a simplification in its application. The summary of that draft is also reproduced in *Supporting Guidance 4*, while the full text can be downloaded from the Commission's website, www.icrp.org.

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This increases penetration of our reports through the scientific and regulatory community very significantly, and also allows for a pricing structure that takes regional differences into account.

Committee 1 (Radiation Effects):

Committee 1 of the International Commission on Radiological Protection has the responsibility for maintaining the biological effects of ionising radiation under review and developing documents that relate such effects to the needs of radiological protection.

Input from Committee 1 on the biological effects of radiation constitutes a platform for the current ICRP project of devising a set of next fundamental Recommendations on radiological protection. The most important task for Committee 1 has been to produce a 'Foundation Document' on health effects of ionising radiation. Since the publication of the 1990 Recommendations of the ICRP (*Publication 60*, ICRP 1991), Committee 1 has continued to maintain broad surveillance on scientific developments regarding the quantification of health effects attributable to ionising radiation exposure and the biological mechanisms that underlie these effects. Much of the output of Committee 1 is represented in ICRP Task Groups reports and Committee 1 working parties have reviewed data in other relevant areas.

The purpose of the Foundation Document report is to summarise all post-1990 Committee 1 judgements relating to the health effects of radiation in order to support the development, by the Commission, of its next Recommendations. In many of the areas considered, Committee 1 had already provided specific judgements, e.g. on risk of multifactorial diseases (*Publication 83*) and on Relative Biological Effectiveness of different radiations (*Publication 92*). However, the revision of judgements on the induction of tissue reactions, on the nominal risk coefficients for cancer and heritable disease, the transport of cancer risk between different populations, and on the choice of tissue weighting factors, required much additional work by the Committee. An additional feature is the extent to which the accumulation of epidemiological and biological knowledge since 1990 has served to strengthen some of the judgements made in *Publication 60* or, in some cases, has led to a revision in procedures for risk estimation. In spite of the detailed nature of these gains in knowledge the principal objective of this report is the provision of broad judgements for practical purposes of radiological protection.

The Foundation Document underpins the dose limits recommended by ICRP for occupational and public exposure, and it continues to be based mainly on the assessment of the risk of cancer and severe hereditary disease. The primary risk of radiation-induced cancer is now based upon incidence data rather than the information on fatal cancer risks, as was used in *Publication 60*, because of improved data from the extended follow-up of the A-bomb survivors in Japan. Overall, however, when assessing total radiation detriment there is little difference from that given in *Publication 60*, reflecting little change in the assessment of the overall risk of radiation-induced cancer. There is, however, an increase in the risk of breast cancer that is based upon the A-bomb survivors and some medically exposed groups. The risk estimate of hereditary disease is decreased because multifactorial diseases are now known to contribute less than previously assumed and because the overall estimate is now to be based upon the first two generations rather than on all future generations. The dose response for both cancer and hereditary effects, at low doses, continues to be based upon a simple

proportional relationship between dose and risk (i.e. the LNT hypothesis). A dose and dose rate effectiveness factor (DDREF) of 2 continues to be used for assessing risks at low doses from risks obtained in populations exposed at high doses. New information on the risk of cancer in different tissues and of the treatment of hereditary disease given in *Publication 60* has resulted in some changes to tissue weighting factors w_T for individual organs and tissues, with the main changes being an increase for breast and a decrease for the gonads.

The Foundation Document is structured in the following way. It begins with a brief summary of the gains in knowledge on the biological processes that underlie the health effects of radiation exposure since 1990. This is followed by a review and updated judgements on the mechanisms and risks of radiation-induced tissue reactions. The document then considers the mechanisms and genetics of cancer induction, summarises previous judgements on radiation weighting factors and details new epidemiologically-based judgements on nominal risk coefficients, transport of risk, radiation detriment and tissue weighting factors. There is then a section that summarises an earlier judgement on cancer risk *in-utero*. The document also briefly considers non-cancer diseases resulting from radiation exposure. The estimation of risks of heritable disease is detailed in a newly developed approach that provides a revised estimate of this risk. Finally, a simple tabular format is used to summarise the principal recommendations from the Committee that are to be used in the new Recommendations.

For 2006, Task Groups and Working Groups have been formed on (a) tissue reactions and non-cancer risks, (b) stem cell biology, target cells for cancer and implications for radiological protection, and (c) cancer risk from alpha emitters. In addition, Working Parties will continue to:

? review published epidemiological studies,
? survey developments in cell and molecular biology relevant to the effects of ionising radiation,
? identify cells at risk for carcinogenesis,
? provide evidence of dose and dose-rate effects from animal studies,
? advise on genetics risks in relation to both mendelian and multifactorial disorders, and
? survey the evidence of synergism or additivity between the effects of ionising radiations and chemical carcinogens on cells and tissues.

Committee 1 members in October 2004, in Beijing.
Top row, from left to right: Julian Preston (Chairman from 2005), Margot Tirmarche, Alex Akleyev, Dale Preston, Fiona Stewart, Pingkun Zhou, Colin Muirhead (Secretary to 2004), Maria Blettner, Roy Shore, Elaine Ron, Ohtsura Niwa, Bob Ullrich. Bottom row, left to right: K Sankaranarayanan (now retired from the Committee), Roger Cox (Chairman to 2004 and now retired from the Committee)), Jack Little (now retired from the Committee), Charles Land (now retired from the Committee(, Jolyon Hendry (Secretary from 2005).

Committee 2 (Doses from Radiation Exposures):

Committee 2 has the responsibility for establishing dose coefficients for internal and external exposures. This involves developing the dosimetric models to be used in the calculations.

The committee is currently responsible for the preparation of a Foundation Document on dosimetry that will be published with the new ICRP recommendations, probably as an annex. There will also be a chapter for the main recommendations that summarises the information provided in the foundation document.

The foundation document explains the dose quantities used by ICRP and their application. The draft was presented for comments on the ICRP web site for several months in 2005. After a further revision the draft will be discussed by the Main Commission at a meeting on 22-24th March with the aim of completion of the new recommendations within the year.

The Foundation Document on dosimetry provides a detailed discussion of ICRP dose quantities and their application in radiological protection in the asssessment and limitation of doses resulting from external and internal exposures. It explains the basis for and use of radiation weighting factors in the calculation of equivalent dose to organs and tissues and discusses the use of age- and gender- averaged tissue weighting factors, derived by Committee 1, in the calculation of effective dose.

The document also discusses the relationship between these dose quantities and operational quantities used in dose monitoring and assessment. Doses calculated using ICRP methodology are single-valued, based on calculations for reference individuals, although in practice there is variation between individuals and uncertainties in the assumptions made in calculating dose. The document discusses sources of uncertainty and limitations on the use of ICRP dose quantities.

There are some changes to the recommended radiation weighting factors, wR, used in the calculation of equivalent dose. In particular a continuous energy function is to be given for neutrons (with some change in the function above 1 MeV from that given in Publication 92) and the wR for protons is to be reduced from 5 to 2. For low-LET x-rays and gamma rays as well as tritium, the wR will continue to be one and the values for alpha particles remains as 20.

Effective dose has been widely used in radiological protection and is a valuable quantity for demonstrating compliance with dose limits in relation to exposure to external radiation and intakes of radionuclides. It is not appropriate in all circumstances and guidance is given on where its use is not appropriate, for example in retrospective assessments of organ/tissue dose for epidemiological studies, in individual risk estimates after exposures above dose limits and especially after exposures to high radiation doses.

The Committee 2 Task Group on Dose Calculations (DOCAL) is concerned with dosimetry for both external and internal radiation exposures. Recent work has provided input to *Publication 95* on doses from the transfer of radionuclides in mothers' milk and *Publication 100* providing a new model of the human alimentary tract. Work for *Publication 95* included consideration of doses to maternal breast tissue from radionuclides in milk and

external doses to the child during breast-feeding and nursing, resulting from radionuclide retention in maternal tissues.

Members of DOCAL have also been involved in the development of dosimetry for aircrew exposures and reconsideration of the most appropriate treatment of radiation weighting for neutrons. Work is also in progress on nuclear decay data to provide an update of *Publication 38.*

A major part of the DOCAL current work programme is the completion of reference anatomical models for the adult male and female. These voxel-based computational phantoms, based on segmented tomographic images, will replace the stylised phantoms used previously in organ and tissue dose calculations for external and internal radiations.

Work is also in progress to improve the calculation of doses to regions within the skeleton that represent targets for the induction of bone cancer and leukaemia.

The Task Group on Internal Dosimetry (INDOS) recently completed work for *Publication 95* on doses to infants from the transfer of radionuclides in breast-milk. This followed from *Publication 88* on doses to the embryo, fetus and newborn child from intakes of radionuclides by the mother and completed a series of publications giving dose coefficients for intakes of radionuclides by infants, children and adults.

With the forthcoming publication of new recommendations by ICRP the emphasis of the work of Committee 2 on internal dosimetry is now concerned with occupational exposure. It is intended to replace *Publications 30* and *68*, that give biokinetic data and dose coefficients for intakes of radionuclides by inhalation and ingestion, and *Publications 54* and *78*, that give information for bioassay interpretation, with a single series of publications.

The first report will cover radionuclides of the 31 elements covered in the series of publications on dose coefficients for the public. Biokinetic models are being reviewed and updated as appropriate. The new ICRP model of the human alimentary tract will be used and revisions to the Human Respiratory Tract Model are being considered. Doses will be calculated using revised nuclear decay data and new anatomical phantoms (see text above concerning the Task Group on Dose Calculations, DOCAL).

The publications on occupational exposure will be accompanied by a supporting Guidance Document (GD) that will give advice on the interpretation of bioassay data. Recent inter-laboratory comparisons have shown variations in the way that bioassay data can be interpreted in different laboratories and have demonstrated the need for improved guidance.

In addition to the data for bioassay interpretation given in previous publications, tables of ‘dose per unit content’ are proposed. These will give effective dose directly as a function of measured activity in body tissues or excreta. This should facilitate the assessment of doses from bioassay data. A consultation draft of the GD was posted on the ICRP web-site in January 2006.

The Task Group on the Human Alimentary Tract Model completed its work during 2005. The report will be issues as *Publication 100*. In this report, ICRP provides a new biokinetic and dosimetric model of the human alimentary tract to replace the *Publication 30* (ICRP, 1979) model. The new Human Alimentary Tract Model (HATM) will be used together with the Human Respiratory Tract Model (HRTM: ICRP, 1994) in future ICRP

publications on doses from ingested and inhaled radionuclides.

The HATM is applicable to all situations of radionuclide intake by children and adults. It provides age-dependent parameter values for the dimensions of the alimentary tract regions and associated transit times for the movement of materials through these regions. For adults, gender-dependent parameter values are given for dimensions and transit times.

The default assumption is that radionuclide absorption takes place in the small intestine but the model allows for absorption in other regions and for retention in or on tissues within the alimentary tract when information is available. Doses are calculated to target cells for cancer induction in the oral cavity, oesophagus, stomach, small intestine and colon.

The report provides reviews of information on the transit of materials through the alimentary tract and on radionuclide retention and absorption. It considers data on health effects, principally in order to specify the target cells for cancer induction within the mucosal lining of the tract and to justify approaches taken to dose averaging within regions. Comparisons are made between doses calculated using the HATM and Publication 30 model for examples of radionuclide ingestion for which absorption is assumed to occur only in the small intestine. Examples are also given of the effect on doses of considering absorption from other regions and the effect of possible retention in the alimentary tract.

The report also considers uncertainties in model assumptions and their effect on doses, including alimentary tract dimensions, transit times, radionuclide absorption values and the location of targets for cancer induction.

A Task Group on Radiation Exposures in Space was set up in 2005 to assess exposures from the complex radiation fields encountered in space, which include high energy particles with unique high LET components, very different from radiation fields on earth. Thus, the Task Group takes over amends earlier work by a Committee 4 Task Group on a similar topic, which however focused more on the administrative protection issues.

The main discussion points will be: analysis and effects of the high LET components; dose estimation systems / detectors; development of reference doses; and application of the system of radiological protection

Committee 2 members, Geneva 2005. From left: John Stather, François Paquet, John Harrison, Joyce Lipsztein, Hans Menzel, Nobuhito Ishigure, Ambika Pradhan, Günther Dietze, Mikhail Balanov, Herwig Paretzke, Yong-Zeng Zhou, André Bouville, Vladimir Berkovski.

Committee 3 (Protection in Medicine):

The responsibility of Committee 3 is radiological protection and safety in medicine.

The draft new recommendations of ICRP were presented to the Committee together with an outline of a 'building block' document to be prepared by Committee 3 for the new ICRP Recommendations.

It was felt that very few changes would be needed in the medical parts of the main Recommendations document. The need for a supporting 'building block' from Committee 3 was confirmed.

Patients are to be considered in a separate section of the 'building block' document. The medical section should include the current problems with digital radiography, interventional radiology, nuclear medicine, therapy, paediatric radiology, comforters and carers of patients, biomedical research, needs for training, etc. The key material will be selected from the documents prepared by Committee 3 during the last two terms.

The Committee discussed advances in a document on 'Exposure of hands to ionising radiation while preparing and handling radiopharmaceuticals' (a WP, Working Party, was agreed in the Beijing annual meeting in 2004). A first formal draft is anticipated next year.

The draft of a document on 'Radiation protection for cardiologists performing fluoroscopically guided procedures' was presented to the Committee. The target group will be Cardiologists and Medical Physicists. Completion of the document is expected for the next Committee meeting in 2006.

The summary conclusions of the Malaga Conference (International Conference on the Radiological Protection of Patients: Diagnostic and Interventional Radiology, Nuclear Medicine and Radiotherapy, Malaga, Spain, 26-30 March 2001) could be used as a guide for the current challenges of radiation protection in medicine.

Information required by Committee 3 for the draft next Recommendations includes: risk factors by age (for men and women), protection of working women, lens injury threshold, risk estimation: organ doses and the limitations for the use of effective doses. It was pointed out that the 'source related dose constraints' could be easily misused for medical workers, e.g., work in different x-ray rooms.

A document on 'Radiation protection issues of modern radiotherapy techniques', which is being prepared jointly with ICRU (the International Commission on Radiation Units and Measurements), was presented. At least 2 years will be required to finish the document. It was suggested to include some information concerning potential accidents.

The Committee took note of the 'Activities of the Atomic Bomb Survivors Health Care Commission'.

Tentative contents for a document on 'Radiation protection training for clinical personnel using ionising radiation in medicine' were outlined. Training and certification of medical users should be included in such a document. It was decided that diagnostic (including nuclear medicine) and interventional radiology should be included with some specific

annexes for CT, fluoroscopy, paediatrics and digital radiology.

The outline of a document on Medico-Legal exposures (using ionising radiation without direct benefit to the exposed individual) was presented. A Working Party proposal was prepared to deal with this topic.

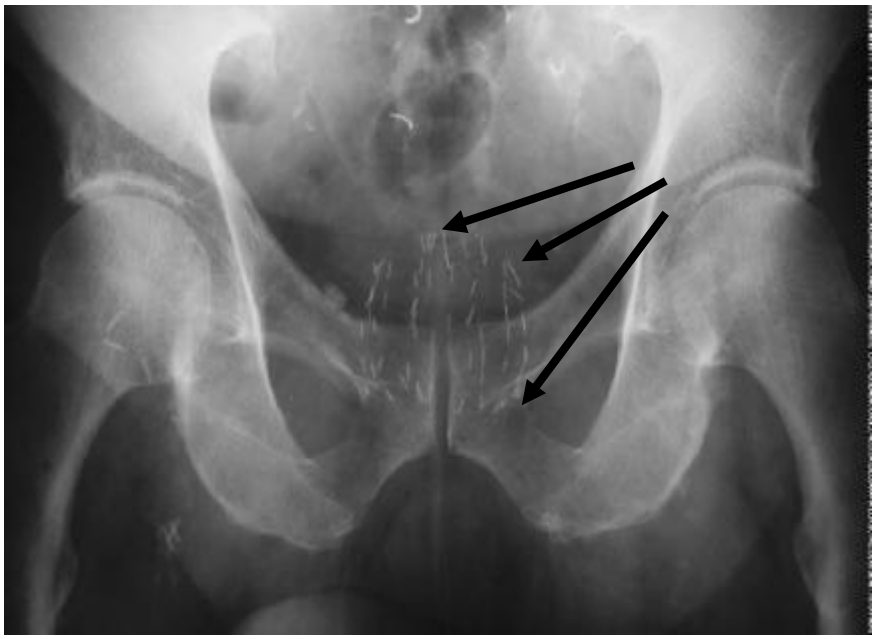
Some aspects of the expected documents on 'Medical examinations and follow-up of persons accidentally or occupationally exposed to ionising radiation' and 'Medical screening of asymptomatic persons using ionising radiation' were presented. It was agreed to postpone these documents for 2 years as they are not considered urgent at present.

The latest report of the Joint Committee 3 / Committee 2 Task Group on 'Dose to patients from radiopharmaceuticals' was discussed. One of the most difficult aspects is how to make this data available to the users. Committee 3 would prefer that this material be published, if possible, with the full data set being made freely available on the internet in a digital format for downloading. It is understood that Committee 2 will have data from voxel phantoms within a few months.

New information that had become available concerning lens radiation injuries was discussed. Committee 3 was seriously concerned about the impact that some of this new data, which has been recently presented at scientific Congresses, might have on the ICRP dose limits if it were confirmed. The data has not yet been published in a peer-reviewed journal, however.

The Committee also received information about some of the results of Chernobyl Forum report.

The activities of IEC in the area of interest of Committee 3 (TC-62 Medical Electrical Equipment and Subcommittees) were also presented. The possibility of co-operation between ICRP Committee 3 and IEC TC-62 was highlighted.



ICRP Publication 98 (2005) on prostate brachytherapy using permanently implanted iodine or palladium 'seeds' was prepared by ICRP Committee 3. It discusses radiation safety aspects for patients, staff, and members of the public meeting patients with such implants. Above, the 'seeds' are visible as thin white rods (arrows indicate 3 of the 20+ seeds).

Committee 4 (Application of the Commission's Recommendations):

ICRP Committee 4 has the responsibility to consider the practical application of the Commission's recommendations. The Committee also acts as a major point of contact between the ICRP structure and other international organisations and professional bodies concerned with protection against ionising radiation.

Committee 4 counts 8 new members in the 2005-9 membership, on a total of 16. They all attended the meeting, as well as 7 observers (IAEA, ILO, WHO, NEA, CEC, ISO) under the chairmanship of Annie Sugier. Committee 4 discussed the new draft of the recommendations and the relevant building blocks, and established its program of work for the 4 next years in accordance with the two aspects of its mission: to provide advice on the application of the recommended system of protection in all its facets for occupational and public exposure, and to act as the major point of contact with other international organisations and professional societies concerned with protection against ionising radiation.

The latest version of the next Recommendations was considered as a real improvement even if some further work is needed. In particular, the Committee unanimously welcomed the abandonment of the 'double regime' for practices and intervention. The constraint can now be seen as a minimum level of ambition which applies to all sources and exposure (planned, existing and emergency situations) and under which the optimisation principle must be implemented. The Committee strongly supports the establishment of primary constraints. However, more linkage needs to be made with the existing values and explanatory material in the text. The proposed unified system should allow to develop responses to several issues which in the past caused difficulties particularly as far as emergencies and existing situations are concerned.

Committee 4 also discussed the document on the scope of radiological protection regulations. This document provides a good clarification of the underlying concepts and principles. However, there are no universal numbers which match these concepts and principles in all situations. Thus building on previous ICRP recommendations and international consensus is important. If other quantities than those already adopted internationally are finally introduced by the Commission, a clear rationale must be developed and they should be coherent with the proposed system of protection. The question of contaminated foodstuffs must be considered with care (problem of contaminated territories).

In order to improve the relationship between ICRP and observer organisations, an Observers Coordination Group (OCG) was created, chaired by A. Sugier. Its role is to organise exchanges on observer organisations activities and on Committee 4 program of work, and to make recommendations on the interface between observer organisations and ICRP committees.

Committee 4 intends to pursue its present work, i.e. to support the Main Commission work up to the adoption of the new recommendations and to complete in 2005 its two building blocks: on Optimisation and on the Representative Individual. Those documents, modified after web consultation, were presented in Geneva, as well as the report on the ICRP

Numerical Reference Values (recommended in ICRP Publications since *Publication 60*).

For its future work, Committee 4 agreed on the following Task Groups and Working Parties:

C4-TG on the application of the Commission's Recommendations for the protection of the populations during nuclear or radiological emergencies, chaired by W. Weiss (2005-07): The objective is to develop a report updating and complementing *Publication 63*, on the application of the Commission recommendations for the protection of populations during a nuclear accident or a radiological emergency. It will establish the principles for: setting the constraints for the planning and management of emergency response, implementing optimisation for identifying countermeasures at the planning stage, and for the withdrawal of early countermeasures and the interface with the rehabilitation phase.

C4-TG on the application of the Commission's Recommendations for the protection of populations living in contaminated territories after a nuclear accident or a radiological event, chaired by J. Lochard (2005-07): the objective is to develop a report updating and complementing *Publication 82* taking into account the building blocks and the new Recommendations. It will establish principles for: setting dose constraints for planning and implementing long term rehabilitation, involving stakeholders in the management of radiological protection, implementing optimised protection actions, developing radiation monitoring and health surveillance, and managing contaminated commodities including foodstuffs.

C4-WP on the application of the Commission's Recommendations to NORM[1], chaired by M. Clark (first draft of a background paper in 2006): the objective is to determine, as an input for a planned TG on NORM in 2007, if there are gaps in existing international recommendations/ guidance which require development of a conceptual framework for practical application of radiation protection for NORM, and to provide proposals for the appropriate path forward. NORM is intended to cover the entire stream of activities from mining to materials, shipment, processing, waste, and disposal; radon will not be covered.

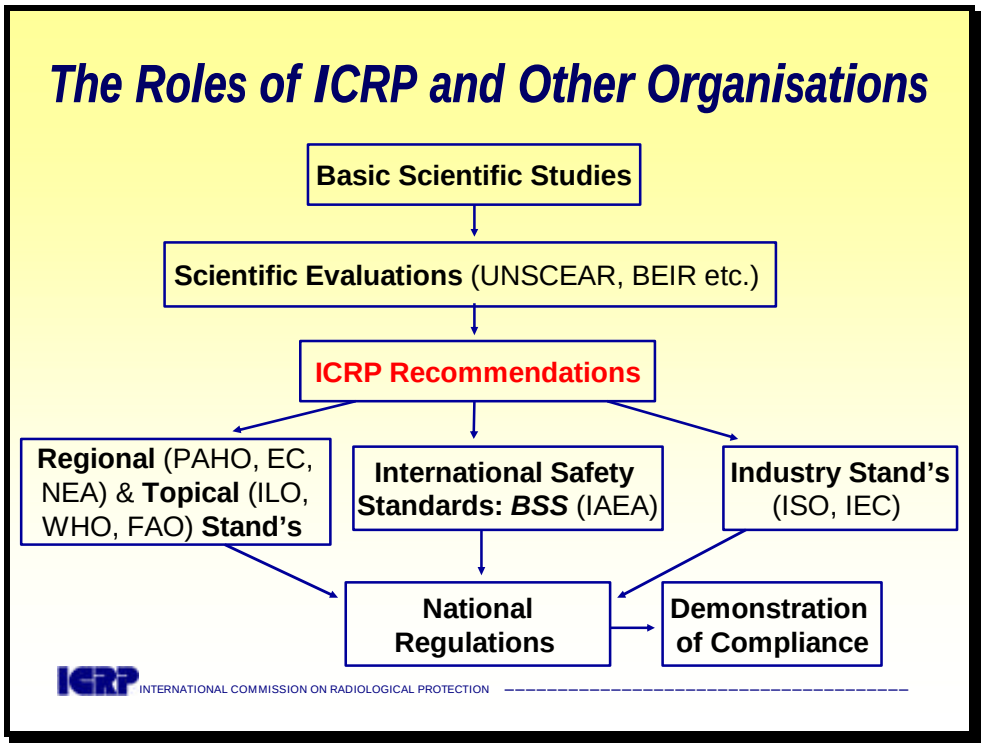
C4-WP on the application of the Commission's Recommendations to occupational exposure, chaired by G. Massera (first draft of a background paper in 2006): the objective is to review past ICRP documents to determine if there are gaps or issues in the existing body of guidance. Examples of possible gaps and areas where further guidance might be of use include: occupational exposure in medicine, women at work and pregnancy, attributable risk and probability of causation, itinerant workers and constraints, dose reporting; quantities and units, comparison with other occupational risks, and radon exposure.

Committee 4 also set provisions for the interface with other Committees. A standing WP, chaired by J. Cooper, was agreed, with C4 members who would follow the work of the other Committees: Michiaki Kai (C1), Peter Burns (C2), Wolfgang Weiss (C3), Kirsti-Liisa Sjöblom (C5). J. Cooper is also corresponding member of the new C2-TG on radiation protection for crew in low earth orbit space flight, and D. Cool is co-chair (with Chris Sharp, C3) of the C3-C4-WP on medico-legal exposure using ionising radiations without direct benefit to the exposed individual. Finally, J-F. Lecomte and A. Tsela were designated to write a topical

[1] NORM: Naturally Occurring Radioactive Material

paper on radon and several members have volunteered to be critical reviewers of the different documents provided by the Committee.

Thus, according to the new organisation of Committee 4, each member has responsibilities assigned, either as Vice chairman, C4 Secretary, OCG Secretary, chairperson of a TG, or as member of a WP, drafter of a Topical paper and Critical reviewer.



Committee 4 is the major point of contact between ICRP and international organisations. This diagram shows how ICRP interacts with organisations creating legal or industrial standards.

The members of ICRP Committee 5 at their first meeting, in Geneva 2005. Unfortunately, the Committee suffered a serious loss in 2006 when Dr Doi passed away.

Committee 5 (Protection of the Environment):

Committee 5 is concerned with radiological protection of the environment. It will aim to ensure that the development and application of approaches to environmental protection are compatible with those for radiological protection of man, and with those for protection of the environment from other potential hazards.

All members were present at this first meeting of the new Committee 5: J Pentreath, (Chair); C-M Larsson (Vice-chair); K Higley (Scientific Secretary); F Brechignac ; M Doi (✍); A Real; A Johnston; G Pröhl; P Strand.

The chairman gave a general welcome and a brief introduction to the origins of Committee 5 via the two earlier Task Groups to the Main Commission, to its mission statement, to the overall reference animal and plant concept, and to the current state of play in terms of the Main Recommendations.

The views of committee members were sought on the overall approach, together with an analysis of the views received from the consultation on the Task Group 2 report.

The Committee discussed in some detail the overall Reference Animal and Plant approach; the proposed set of Reference Animals and Plants (RAPs); the concept of Derived Consideration Levels (DCLs); the biological descriptions of the Reference Animals and Plants; the current status, and present and future needs of dosimetric modelling; the data sets necessary for calculating reference external and internal background dose rates; concentration and transfer factor values for artificial radionuclides; dose-effect data bases; terms, definitions, quantities and units; applications of the RAPs approach, and its relationship to other approaches, at national level and other levels; and finally the most recent draft of the revised ICRP Recommendations.

The Committee also discussed possible working relationships with the other ICRP committees, and with the work of UNSCEAR, IAEA, IUR, Euratom, ERICA, and other international and national programmes.

An outline four-year work programme was developed, with three principal products: a comprehensive document on RAPs that would incorporate much of the material of the 2nd. Task Group report – which would not now be published in its present form; a review of the issues relating to radiation weighting factors, RBE etc; and a document exploring the relationships between the approach of ICRP to environmental protection with other environmental protection frameworks.

A Task Group was initiated, chaired by G Pröhl, that was requested to summarise current modelling approaches; identify significant differences and their limitations; select and justify a preferred approach and use it to calculate a set of dose per unit concentration factors (DPUCFs in Gy day^{-1} / Bq kg^{-1}) with respect external and internal exposure pathways; and then identify further issues for consideration as appropriate.

A Working Party was also set up, chaired by F Brechignac, to explore and examine the interface with, and relevance to, other approaches to environmental protection, in order to ensure that the Committee's approach is compatible with them, or justifiably different.

At larger meetings, considerable Secretariat efforts necessitate assistance from host organisations. Here, the Chairman of ICRP thanks local staff members of the Swiss Federal Office of Public Health for their participation in making the ICRP meeting a success.

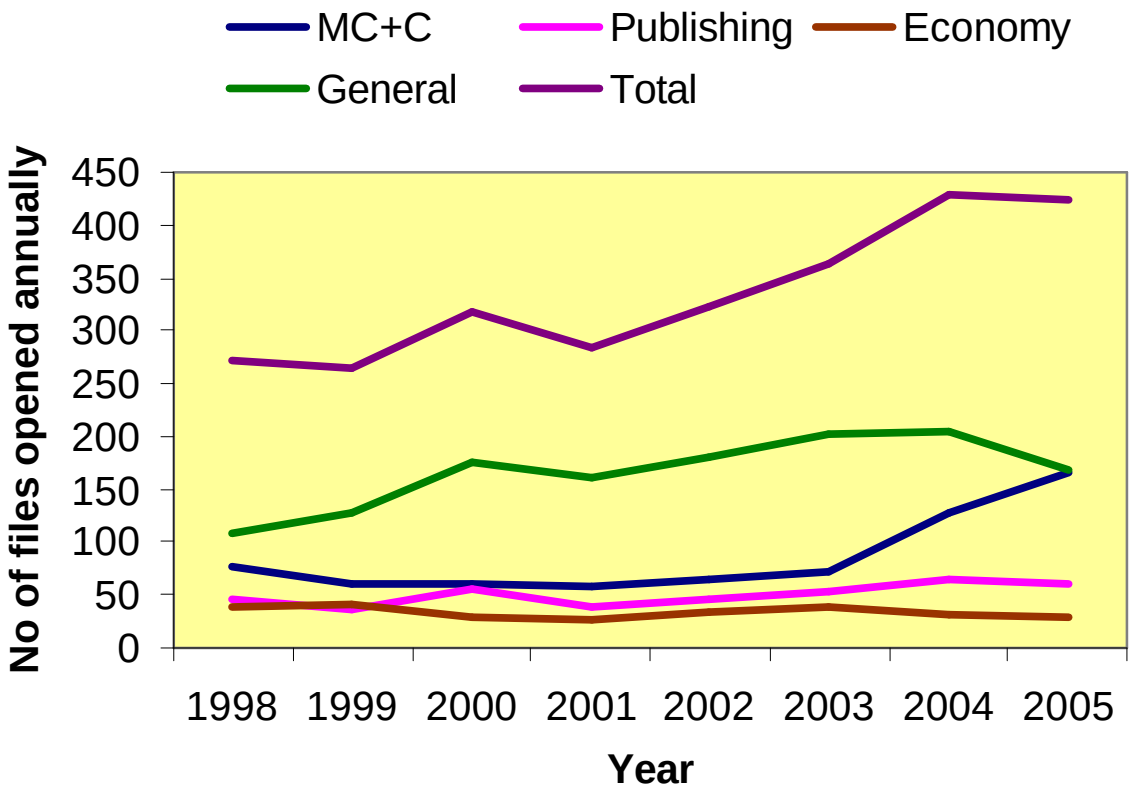
The Scientific Secretariat

The Scientific Secretariat is currently situated in Stockholm, Sweden. The seat of ICRP remains in the United Kingdom where ICRP is a Registered Independent Charity.

Tasks of the Secretariat include preparations for and organisation of meetings, final editing of reports for publication in the *Annals of the ICRP*, maintenance of contacts with all collaborating organisations, and administrative issues.

The Secretariat also devoted an increasing part of its efforts to running the ICRP Internet web site. Apart from providing general information about ICRP, the web site has proved particularly useful when ICRP wants to consult on its own draft documents. A drawback was that the resources of the Secretariat were not always quite commensurate with the demand for information and assistance generated through the web site, so that at times, considerable delays in attending to queries from the public were inevitable.

The diagram below shows the number of files opened each year.



Contacts, Meetings, etc.

As usual, numerous different contacts were maintained, formally and informally, during the year.

In addition to the many instances where the Chairman, Professor Clarke, represented the Commission as described in the Foreword, the Vice-Chairman, Dr Holm, the Scientific Secretary, Dr Valentin, and members of the Commission represented ICRP in meetings of various kinds.

Thus, contacts were held and continued with IAEA, the International Commission on Radiation Units and Measurements (ICRU), the International Radiation Protection Association (IRPA), the International Society for Radiology, the OECD Nuclear Energy Agency, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and many other organisations.

The persons mentioned also took part in many meetings with national regulatory organisations, research establishments, and professional societies.

During the meetings of the Main Commission in Geneva and in Bern, Switzerland, in September, informal meetings were arranged with the considerable local community of experts interested in various aspects of ionising radiation and radiological protection.

ICRP also continued its relationship with the International Electrotechnical Commission (IEC) and the International Standards Organization (ISO), primarily through exchange of draft reports and information. On a number of occasions when ICRP was unable to send a formal representative, we arranged to obtain observers' reports so as to keep abreast with developments.

There was also a brisk demand for informal enlightenment and information via telephone, e-mail, and regular mail to the Secretariat.

ICRP Publications, etc., printed in 2005

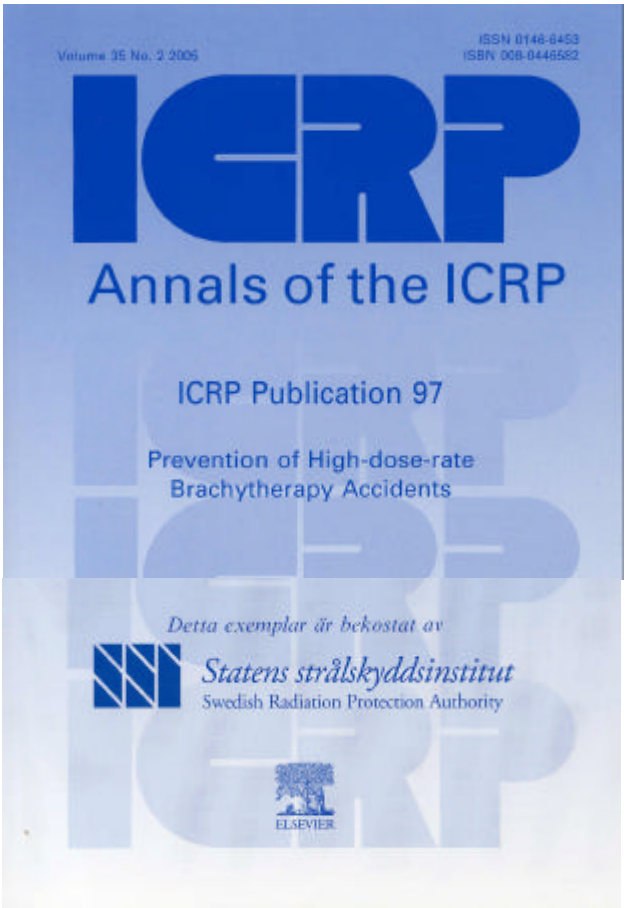
ICRP. Doses to infants from ingestion of radionuclides in mothers' milk. ICRP Publication 95. *Ann. ICRP* 34 (3-4).

ICRP. Protecting people against radiation exposure in the event of a radiological attack. ICRP Publication 96. *Ann. ICRP* 35 (1)

ICRP. Prevention of high-dose-rate brachytherapy accidents. ICRP Publication 97. *Ann. ICRP* 35 (2)

ICRP. Radiation safety aspects of brachytherapy for prostate cancer using permanently implanted sources. ICRP Publication 98. *Ann. ICRP* 35 (3)

ICRP. Development of the Draft 2005 Recommendations of the ICRP. ICRP Supporting Guindance 4. *Ann. ICRP* 35 (suppl).



ICRP Publications can be obtained through subscription (in printed format and/or as an electronic file) or individually as printed books or as files for downloading (from www.sciencedirect.com. *) An increasingly popular option is for organisations to buy 'sponsored copies' for distribution, if desired with their own logo overprinted. The Swedish Radiation Protection Authority, and several others, bought a number of copies of ICRP Publication 97 for distribution for free to licensees.*

Contact Information

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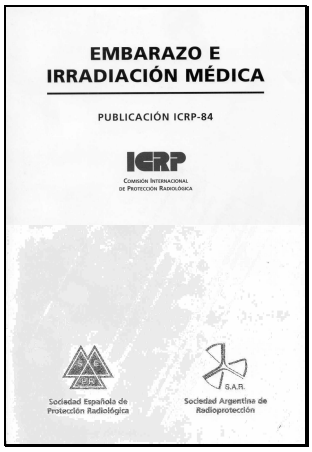

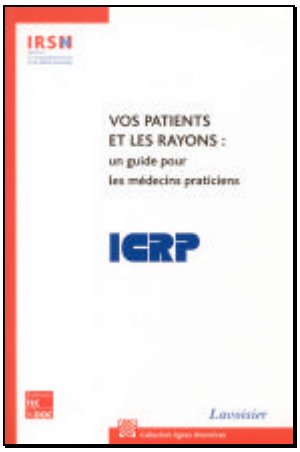

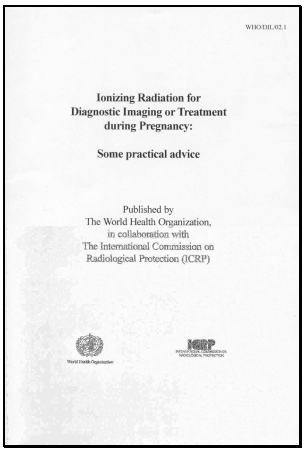

ICRP encourages translation of its reports (left: Spanish version of Publication 84; centre: French version of Supporting Guidance 2), and often abstains from any royalty on such translations. Through the HINARI initiative (www.healthinternetwork.net), there is free access to ICRP reports for the 69 poorest countries in the world. Through co-operation with WHO, it has also been possible to disseminate certain reports for free in regions where otherwise it would be difficult to obtain ICRP documents (right: WHO adapted version of Publication 84 for distribution in Africa only).

Organisations providing grants to ICRP in 2005

Unrestricted funds totalling 238 979 US dollars were received from:

IAEA;
ISR;
IRPA:
OECD/NEA;
Australia: ARPANSA;
Canada: CNSC;
France: IRSN
Germany: Bundesmin UNR;
Iceland: GR;
Japan: JAERI and PNC;
Spain: CSN;
Sweden: Min. Env.;

Restricted funds totalling 71 121 US dollars were received from:

CEC (to finance activities concerning protection of the environment);
Swiss Federal Office of Public Health (to subsidise the annual meeting of ICRP).

Thus, the total amount of grants received in 2005 was 310 100 US dollars (2004: 300 422 US dollars).

The actual drafting of ICRP reports takes place in the Commission's Task Groups – here, Task Group No. 21 INDOS on internal dosimetry, a Committee 2 standing project, at its meeting in Atlanta, GA, USA, in 2005.

. The unpaid volunteer work that goes into the drafting and editing of ICRP reports represents many man-years annually. The value of this benefit-in-kind cannot easily be expressed in exact monetary terms. However, it is certainly orders of magnitude bigger than the Commission's budget, which represents direct meeting and secretariat costs only.

Composition of the International Commission on Radiological Protection and Committees, 2001 - 2005

MAIN COMMISSION

L-E Holm *(Chairman)*

J D Boice
R Cox *(Vice-Chairman)*
A J González
C Cousins *(Chair C3)*
J-K Lee
Z Q Pan
J Pentreath *(Chair C5)*
J Preston *(Chair C1)*
Y Sasaki
N Shandala
C Streffer *(Chair C2)*
A Sugier *(Chair C4)*

Emeritus Members:
R H Clarke
B Lindell
F A Mettler
W K Sinclair

Scientific Secretary:
J Valentin

COMMITTEE 2 (Doses from Radiation Exposure)

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M Balonov
V Berkovski
W Bolch
A Bouville
G Dietze
K F Eckerman
J D Harrison
N Ishigure
J Lipsztein
H Menzel
F Paquet
H Paretzke
A S Pradhan
J Stather *(Vice-Chairman)*
Y Zhou

COMMITTEE 1 (Radiation Effects)

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A Akleyev
M Blettner
R Chakraborty
J Hendry *(Secretary)*
W F Morgan
C Muirhead
O Niwa
D Preston
E Ron
W Rühm
R Shore
F Stewart
M Tirmarche
R Ullrich *(Vice-Chairman)*
P-K Zhou

COMMITTEE 3 (Protection in Medicine)

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I Gusev
Y Li
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S Mattsson
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L Pinillos-Ashton
M Rehani
H Ringertz
M Rosenstein
C Sharp
E Vañó *(Secretary)*
Y Yonekura

COMMITTEE 4 (Application of ICRP Recommendations)

A Sugier *(Chair)*

P A Burns
P Carboneras Martinez
M E Clark
D Cool
J Cooper
J-F Lecomte *(Secretary)*
H Liu
J Lochard
G Massera
A McGarry
K Michiaki
M Savkin
K-L Sjöblom
W Weiss
A Tsela

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F Bréchignac
M Doi ✍
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A Johnston
C-M Larsson *(Vice-chair)*
A Real Gallego
G Pröhl
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