IRPA12

THE 12TH CONGRESS OF THE INTERNATIONAL RADIATION PROTECTION ASSOCIATION

'*Strengthening Radiation Protection Worldwide*'

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1. INTRODUCTION

1.2. FOREWORD

(1) The aim of this paper is to describe concisely the ***12th Congress of the International Radiation Protection Association*** (IRPA), which was held in Buenos Aires, Argentina, on October 19-24, 2008. Termed IRPA12, the Congress was organized by the *Sociedad Argentina de Radioprotección* (Argentine Radiation Protection Society), SAR, under the motto '*strengthening radiation protection worldwide*'. It was declared of 'national interest' by the Argentine Government, and wholly supported by the relevant governmental offices, notably by the Argentine's Chancellery and Nuclear Regulatory Authority (ARN). The Congress was inaugurated by the Argentine representative to the UN organizations in Vienna, Ambassador Eugenio María Curia, and the President of the Board of Directors of ARN, Dr. Raúl Racana, welcomed by SAR President, Ana María Bomben, and formally opened by IRPA President, Phil Metcalf.

(2) This initial introductory chapter will summarily portray the essential organizational features and objectives of IRPA12. The subsequent chapters will resume the proceedings of the three fields covered by the Congress' unusually comprehensive programme: the epistemological basis of the essential radiation science, the paradigmatic models used to protect people against radiation exposure and the practical implementation and achievements of radiation safety. An epilogue will summarize the author's personal views on the outcome.

(3) IRPA12 was a real mammoth endeavour involving more than 1700 participants and 1500 papers, including 88 chairmen and co-chairmen, 36 rapporteurs, and 36 technical secretaries, 30 conference speakers, 36 keynote speakers, and 250 presenters. All its activities were planned and coordinated by the Congress' Organizing Committee and SAR authorities, over four year of intensive work. The Congress programme was developed by the IRPA12 Programme Committee, chaired by Prof. Eduardo Gallego (Spain), in consultation with the Congress' President.

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(4) The extraordinary professional ensemble making possible IRPA12 will remain in records for their magnificent work. The outcome of all their activities was recorded and compiled by the IRPA12 Secretariat and is being incorporated into the IRPA12 website (www.irpa12.org.ar.)

(5) It will be presumptuous to try to recap again the magnificent work of those who summarized the finding and conclusions in each scientific area. The reader's indulgence is therefore requested for the summary presentation of the outcomes of the various Topical sessions. The summaries are necessarily inhomogeneous reflecting different attitude of the authorities of the different sessions. Sometimes they are simply incomplete; sometimes they identify some authors personally, sometimes not. For further detail the reader is referred to the various sessions' officers whose names and e-mails addresses are recorded.

(6) Notwithstanding the above caveats, the following summary points aims at squeezing the various outcomes into a concentrate of the main findings. These are as follows:

- The epistemological basis of the sciences of radiation exposure and its effects, which provides the foundation for radiation protection, was generally corroborated and found to be sound, reliable and sensible.
- The globally accepted radiation protection paradigm, which has been developed by the ICRP over the years and currently provides the foundations for the most national and international radiation protection normative, was generally re-endorsed while recognizing that is being reviewed and will be adjourned.
- The radiation protection practitioners in nuclear, medical and other activities making use of radiation, who massively attended the Congress, shown satisfaction with the developments and contentment with the progress reached by the fast growing global radiation safety regime being build up by relevant national and intergovernmental organizations.

1.2. DESCRIPTION

1.2.1. Wide Outreach

(7) 1710 people gathered at IRPA12. This surprisingly elevated attendance turned Congress into one of the more popular international events dedicated to the protection against radiation exposure. More than 1382 of the attendees were radiation protection and safety specialists and practitioners, including 46 members of the Organizing Committee. There were also 140 exhibitors, 140 accompanying persons and 48 organizing staff. More than 1500 papers were submitted. It was very encouraging to see such global expertise, travelling to a distant austral destination, willing to share experience with Latin-American colleagues.

1.2.2. Global Strengthening

(8) It is to be underlined that the attending experts arrived from all over the world: participants from about more than 90 countries turned up at IRPA12. Excluding Argentina, they arrived from the following countries (in alphabetical order, name followed by the number of participants): Albania, 1; Armenia; Australia, 10; Austria, 33; Bahamas, 1; Bangladesh, 1; Belarus, 7; Belgium, 23; Bolivia, 3; Bosnia, Herzegovina, 1; Brazil, 131; Bulgaria, 3; Canada, 28; Chile, 17; China, 27 and Taiwan, (China), 1; Colombia, 3; Costa, Rica, 3; Croatia, 20; Cuba, 26; Czech, Republic, 6; Denmark, 13; Egypt, 2; Estonia, 1; Finland, 25; France, 71; Germany, 70; Ghana, 1; Greece, 3; Hungary, 15; Iceland, 1; India, 2; Indonesia, 1; Iran, 1; Ireland, 1; Israel, 19; Italy, 34; Jamaica, 1; Japan, 65; Jordan, 1; Kenya, 2; Korea, 12; Kuwait, 1; Latvia, 1;

Libya, 2; Lithuania, 1; Luxembourg, 1; Macedonia, 1; Madagascar, 1; Malaysia, 3; Mexico, 10; Moldova, 1; Mongolia, 1; Morocco, 1; Netherlands, 33; Nicaragua, 3; Nigeria, 2; Norway, 10; Pakistan, 2; Paraguay, 5; Peru, 13; Philippines, 6; Poland, 2; Portugal, 2; Romania, 21; Russia, 10; Saudi Arabia, 3; Senegal, 1; Serbia and Montenegro, 3; Slovenia, 3; South Africa, 18; Spain, 77; Sri Lanka, 1; Sudan, 1; Sweden, 13; Switzerland, 15; Tajikistan, 1; Tanzania, 1; Thailand, 1; Tunisia, 1; Turkey, 1; U.K., 47; U.S.A., 97; Ukraine, 2; Uruguay, 8; Venezuela, 8; and, Yemen, 1.There were in addition 20 no-Argentine participants that preferred no to specify their country.

(9) This global presence was an extraordinary uncommonness for IRPA Congresses, as people coming mainly from central countries have usually attended these events. This unique universal participation converted into reality the Congress motto –which could crudely be reformulate as follows: in the current globalized world there will is not radiation protection unless it is achieved for all its inhabitants.

(10) It should not be unexpected that more than 500 participants were from the Latin-American region, showing how important is for IRPA to promote venues for its Congresses in all corners of the world and not only in the 'central' countries. The number of participants from Argentina, 379, and from Brazil, 131, were even higher than the traditionally numerous delegation from the USA, which with 97 participants became third in the ranking.

1.2.3. International Cooperation

(11) Such wide, ample and extensive attendance could be reached thanks to the support of many national and international bodies coordinated by the Congress Support Committee chaired by Khammar Mrabit (Morocco). The International Atomic Energy Agency (IAEA), the World Health Organization (WHO) and the Pan-American Health Organization (PAHO) co-sponsored the event. The ARN Committee provided an extraordinary financial support to Latino-American scientist wishing to attend the Congress. There was also substantive help from many national radiation protection societies, from many regional organizations, such as the Forum of Ibero-American Regulators, the Nuclear Energy Agency of the OECD (NEA), the European Commission and, off course, from IRPA itself.

(12) In the case of the IAEA, the Resolution GC(50)/RES/10 of the IAEA General Conference (GA), had encouraged the IAEA Secretariat to support the dissemination of information arising from IRPA12 and to support the participation in IRPA12 of experts from developing countries. The IAEA has unique statutory functions in radiation protection and, in 2005, was awarded the Nobel Peace Prize for its efforts (inter alia) 'to ensure that nuclear energy for peaceful purposes is used in the safest possible way'. The GA Resolution was an unprecedented intergovernmental step that may indicate a renewed political interest in radiation protection and safety, which is good news for the radiation protection profession around the world, particularly for scientists from developing countries.

1.2.4. Programme

1.2.4.1. Main Fields

(13) IRPA12 programme addressed the three *main fields* of radiation protection, as follows:

- the ***epistemology of radiation***, namely the theory of current knowledge on the physics and biology of radiation exposure and its effects, particularly in relation to its methods, validity and scope;
- the ***paradigm of radiation protection***, namely the universal conceptual models used for keeping people safe from health effects due to radiation exposure; and,
- the ***practice of radiation safety***, namely the actual application and use of radiation protection plans and methodologies by practitioners and industries making use of radiation.

Three *Background Sessions* provided the status of information in these three fields.

1.2.4.2. Areas of Knowledge

(14) Within the above fields, IRPA12 focused on 10 *Areas of Knowledge* as follows: characterization of radiation exposure, biological effects of radiation exposure, radiation protection framework, protection policies, criteria, methods and culture, emergency planning, preparedness & response, and protection in nuclear installations, non-ionizing radiation, medicine, natural occurring radioactive materials in industry, and other applications and practices.

1.2.4.3. Topical Sessions

(15) Thirty-eight *Topical Sessions* addressed the major topics within the areas of knowledge inside the three fundamental fields. The topics covered included: external exposure, internal exposure, biological dosimetry, effects on molecules, organelles & cells, effects on tissues and organs (including hereditary and prenatal effects), radiopathology, radioepidemiology, evolving international safety regime, national infrastructures, education, training and staffing, safety and security of radiation sources, scope of radiation protection, protection of the public & environment, occupational protection, protection of patients, nuclear and radiological emergencies, medical response in emergencies, emergency aftermath and recovery, and radiation protection against ionizing radiation in nuclear reactors, in nuclear fuel-cycle facilities, in decommissioning and restoration, radioactive waste management, in diagnostic radiology, in interventional radiology, in nuclear medicine, in radiotherapy, in uranium mining and processing, in other minerals mining and processing, oil and gas, in norm and radon issues in building, in transport of radioactive materials, in industrial, research applications and security screening, for radon and the public, and in flights and space. There were also sessions covering radiation protection against non-ionizing radiation in power frequency electric and magnetic fields, in mobile telecommunications, in optical radiation and ultrasound, and in emerging electromagnetic field technologies.

(16) *Keynote speakers* addressed the status in each topic and were considered at these Topical sessions. A *Rapporteur* summarized the relevant the findings of more than 1500 *contributed papers*, namely papers accepted by the Congress' Programme Committee. Around 250 contributed papers were presented orally and the rest as posters. More than 1000 poster were displayed and discussed at three very well attended poster sessions. Four *Round Tables* discussed specific issues, some of them distinctive for IRPA Congresses, such as the legal aspects of radiation protection or the denial of radioactive material transport.

(17) Each session featured an open forum for ample debate and, as a result. Topical contributions were widely discussed, The *Chairpersons* of the Topical Sessions, with the

assistance of local *Scientific Secretaries* summed up the various outcomes in *Concluding Plenary Sessions.*

(18) In addition, also for the first time in IRPA Congresses, IRPA12 featured *Working Lunches* presenting speakers on selected topics. Two very punctual but high-in-the-world-agenda issues were discussed: on the one hand, the strategy for radiological security –a must in today's world–and, on the other hand, radiation protection in life-extension programs for nuclear power plants –a *de facto* aperitif for nuclear renascence.

1.2.4.4.Refreshing Training

(19) A comprehensive refreshing programme for uplifting specific radiation protection issues was also part of the Congress. In total, more than 1000 inscriptions were registered in the educational activities –another record number! The material will be available in the IRPA12 website.

(20) The programme included 20 *Refreshing Courses*, with accreditation. They covered the following topics: external dosimetry, dosimetry in new radiotherapeutic techniques, cellular and molecular effects –non-targeted biological effects of ionizing radiation, regulatory infrastructure and basic administration of radiation safety –implementing the regulatory authority information system, security of radioactive sources –implementing the code of conduct and the export/import guidance, diagnostic reference levels in medical practice –establishing diagnostic reference levels in medical practice, internal dosimetry. the science and art of internal dose assessment, epidemiology –epidemiological methods on residential radon and cancer risk, knowledge management in nuclear science and technologies, environmental surveillance programs and dose assessment –characterization of individual members of the public, 'as low as be reasonably achievable' and professional networks --promoting optimization of protection through professional network, non-ionizing radiation measurements –principles and practices of electromagnetic field characterization and measurements, biological dosimetry –"early biodosimetry response: recommendations for mass-casualty radiation accidents and terrorism", consequence management of malevolent use of radioactive material, radiation protection in diagnostic radiology –optimization of protection in pediatric radiology --radon monitoring and control of radon exposure, implementation of the international obligations on emergency notification and response, radiation protection in waste management and disposal, implementing the joint convention on the safety of spent fuel management and on the safety of radioactive waste management, shielding of medical facilities –shielding design considerations for PET-CT facilities, safe transport of radioactive materials –security in the transport of radioactive materials, and radiation protection in industrial applications of radioactive sources –prevention of accidents in gammagraphy.

(21) There were also 3 *Updating Seminars* covering the areas of radiological protection of patients, radiation protection in NORM industries and radiation protection in the nuclear industry.

1.2.4.5. Awarding and Commemoration

(22) There were also several awarding ceremonies, some involving outstanding plenary presentations. Dr. Christian Streffer (Germany) received the *2008 Sievert Award* and presented the traditional "*Sievert Lecture*", entitled *Radiological Protection: Challenges and Fascinations*

of Biological Research. The Congress was also very privileged to host a ceremony marking the 80th jubilee of the International Commission on Radiological Protection, ICRP, which included an *ad hoc* presentation by the former ICRP Chairman, Professor Roger Clarke (U.K.). The President of US National Council on Radiation Protection and Measurements, NCRP, Dr. Thomas S. Tenforde (USA), summarized findings of the 2008 NCRP Forty-Fourth Annual Meeting on the critical issue of "low dose and low dose-rate radiation effects and models". Dr. K. Sankaranarayanan (India/ the Netherlands) was awarded with the 2008 Gold Medal of the Swedish Academy in recognition of his long standing on hereditable radiation effects; the medal was presented by H.E. the Swedish Ambassador in Buenos Aires. In addition, the memory of Dr. Dan J. Beninson, the founder of radiation protection in Argentina, was evocated in a simple ceremony. Dr. Bo Lindell (Sweden), one of the forefathers of radiation protection, addressed the Congress in a film remembering Dr. Beninson. Last but not least, SAR instituted at IRPA12 the *Celso Papadopulos Award* for radiation protection regulators.

1.2.5. Socializing

(23) Socializing is an important issue of IRPA Congresses. Informal social gatherings of the radiation protection community are habitually organized by organizing national societies to allow the social mixing of community members and therefore fostering information exchange among them. IRPA12 has been particularly keen in this important activity. On the first inscription day, on Sunday 19th, the long waiting of the inscribing participants (nearly 1000 tuned up to be inscribed when lest than few hundred were expected!…collapsing the organization!) was entertained with tango lessons…a sure mean of social encounter!. On the first day of the Congress, Monday 20th, a mammoth cocktail party for nearly 2000 people was offered at the 'Palacio Paz', surely the most architecturally sophisticated building of Buenos Aires and perhaps of the Americas (see (www.circulomilitar.org/web2/salones.htm). On Tuesday 21st, a Tango Show was offered at the Congress venue. On Wenesday, 22nd, a Public Exposition (see hereinafter) was opened with a small reception; and on Thursday 23rd, a show and Congress dinner was offered with a large local spectacle. In sum, there was plenty of room for socializing and fostering information exchange among the participants.

1.2.6. Technical Exhibition

(24) IRPA 12) presented the traditional Technical Exhibition of IRPA Congresses. It occupied a large section of the Congress Venue and gave the opportunity to industrial and commercial companies to show their latest developments in all the fields in which radiation protection is playing an active role; a technical exhibition guide was provided where all company names, products and stand location will be detailed. In line with the Congress motto, a distinctive feature of the IRPA12 Technical Exhibition was the participation of enterprises from outside the central countries.

1.2.7. Business

(25) IRPA12 also presented the occasion for IRPA to conduct its business. This included the *Associate Societies Forum*, which featured a presentation of the *Status of the Association*, followed by a review of a draft guidance document on *Stakeholder Engagement*, the treasurer report with the proposed budget for 2008 to 2012, a proposed revision of the IRPA Constitution – the first since the founding of IRPA, and a French Society's proposal to establish an IRPA Working Group to develop an IRPA guidance document on improving radiation protection culture. The formal decisions were adopted at the IRPA General Assembly (GA), with decisions made by the delegates of the Associate Societies, as follows: The budget for 2008 to 2012 was

approved but not the full revised Constitution. A crucial amendment that would require balanced regional representation on the IRPA Executive Council (E.C.), was not approved. The GA also selected Glasgow as the venue for IRPA 13, on May 13-18, 2012, and asked the South African Society to prepare a bid for IRPA 14 in 2016.

(26) IRPA12 was also the occasion for electing new IRPA E.C. officers and members; the occasion was ripe for renewal and geographical expansion of IRPA. But the GA election would become IRPA12 black-mark, certainly in the opinion of the IRPA12 President and even of at least one retiring member of the EC. It selected a fundamentally pure 'North-Atlantic' E.C., namely an executive council basically composed by members from North America and Europe (the only exception being one member from the Far East –Korea). This decision was badly received by all of those who worked very hard for making reality the IRPA 12 motto of strengthening radiation protection worldwide and converted the event in the more widely attended IRPA Congress in history. Because of this predicted decision and other related issues, the IRPA12 President did not attend the GA and in his closing speech suggested to the new E.C. membership that the time was ripe for them to decide whether they wish IRPA to be a society with a wide international outreach or just a North Atlantic gathering.

1.2.8. Public Outreach

(27) An extra unique feature of IRPA12 was a parallel exhibition on radiation protection for the general public. Under the motto ¨*Have you said Radiation Protection?*" this impressive technical/artistic display took place in the 'Casa de la Cultura' (Culture Hall) of Buenos Aires City. The show was organized by a collaborating effort of the Governments of France and of the Buenos Aires City together with the Argentine Nuclear Regulatory Authority. This original initiative was aimed at bridging the gap in understanding that seems to exist between the specialists and the general public. It was inaugurated at the time of the Congress and remained open after it, being visited by thousand of curios citizens.

2. PROCEEDINGS

2.1. EPISTEMOLOGY OF RADIATION

2.1.1. Background

(28) The first session of the IRPA12 was the Background Plenary Session B.S.1 on the epistemology of radiation, which was chaired by Dr. F. Spano, Vice President of the Board of directors of the Argentine Nuclear regulatory Authority, Argentina (fspano@sede.arn.gov.ar). In the words of its Chairman, this first session summarized the international consensus on the scientific know-how that serve as base to the paradigm of the protection against the radiation. It was session on the international epistemological bases supporting radiological protection, that is to say, a session that recapitulated the methods, validity and reach of the global know-how on the physics and the biology related to exposure to radiation, be it ionizing or not. The two most representative relevant institutions inside the system of the United Nations delivered the synthesis of the international status. On the one hand, the Scientific Secretary of UNSCEAR, Malcolm Crick (U.K.-UNSCEAR) (malcolm-crick@unscear.org), presented the latest scientific information on the levels and global effects of ionizing radiation. UNSCEAR had just submitted

them to consideration of the General Assembly of the United Nations. On the other hand, the Director of the Department of Public Health and Environment of WHO, Maria Neira (Spain-WHO), presented the global state of the scientific know-how in the area of non-ionizing radiation.

(29) UNSCEAR is a scientific committee of the UN General Assembly whose purpose is to assess levels, effects and risks of ionizing radiation by identifying emerging issues, evaluating levels and effects and improving knowledge for the UN General Assembly, the scientific community and public. He described the process to produce the UNSCEAR reports, which provide the scientific bases considered by the ICRP to build the protection philosophy and principles and to develop recommendations. Safety standards and protection programmes of the relevant international organization (IAEA, WHO, ILO, FAO, etc) are the established to be implemented by Member States. .

2.1.1.1. Sources and levels of ionizing radiation

(30) Natural sources of ionizing radiation, i.e. cosmic rays and terrestrial sources, are the major contributors of human radiation exposure through external exposure and internal exposure (inhalation and ingestion) with a global average dose of 2.4 mSv per year and a range between 1 to 13 mSv. This large range is mainly due to radon (internal exposure, inhalation) which presents a global average of 1.3 mSv with a dispersion 0.2 to 10 mSv/year. It was explained that while the majority of people around the world average are included within this global average annual natural background dose of 2.4 mSv, there is few people in few areas with very high background (100 mSv) and many people in many areas with high background (10 mSv). He then addressed the artificial sources of ionizing radiation: medical uses, military activities, civil nuclear power, occupational exposures and accidents. Medical exposures are the largest artificial sources and during the last 15 years the number of annual examinations increased to 3.6 billion (50% increase). There are major differences among countries on doses from diagnostic medical exposures. In some countries medical exposures even exceed the exposures from natural sources. He highlighted the high growth of the use of computerized tomography (CT). In US the annual growth of CT frequency during the last 15 years was 10% while the US population increased 1% per year. We are now living in the era of digital radiology, with new associated risks. In digital radiology underexposed procedures cannot be corrected but overexposed can be corrected by simply adjusting computer parameters, thus dose to patients may be higher. Dose to neonates in diagnostic radiology should be controlled; very often whole body is exposed instead of focusing in the target area (e.g. chest). The occurrence of unintended medical exposures such as radiotherapy accidents and injuries resulting from interventional procedures was discussed. .

(31) Concerning exposure resulting from military activities, the nuclear weapons tests conducted between 1945 and 2000 included more than 540 atmospheric and 1800 underground events. Atmospheric nuclear tests implied the largest environmental release. Maximum world average dose was 0.11 mSv in 1963 and the present world average dose is 0.005 mSv. High exposures were only observed in individuals living near some sites. Exposures in underground tests were of little concern. Some examples were shortly discussed e.g. Semipalatinks nuclear test site (more than 30,000 people; doses from 0.04 to 2.4 mSv, with thyroid doses up-to 8 Gy). With regard to production of nuclear weapons, when arsenals were in development (1945-1960) control over discharges was often lacking and some significant exposures were delivered to local residents (e.g. Hanford plant, Chelyabinsk). .

(32) Regarding civil nuclear power, there are 438 nuclear power reactors in 31 countries (2007) and nuclear energy provides about 15% of world's electricity, with a global average dose of 0.0002 mSv and up to 0.02 mSv near the NPP.

(33) Occupational exposures did not change significantly during the last years. A summary of mean annual effective doses from different activities was presented, including the nuclear industry, defence activities, medicine, mining, air crew and other workplaces. .

(34) Exposures from accidents were addressed particularly focusing on Chernobyl, for which it was concluded that data reconfirm essential conclusions on the nature and magnitude of consequences. Between the emergency workers there were 2 victims killed by the explosion and 134 cases of acute radiation syndrome (28 died in 1986 and 19 died after 1986, mostly from no-radiation related causes; skin injuries, cataracts). For the 600,000 recovery workers, findings about leukaemia and cataracts showed higher incidence for higher doses. Among general public in Ukraine, Russia and Belarus it was observed an increase in thyroid cancer incidence among those exposed during childhood (6000 cases with 15 deaths). No consistent evidence was observed for other radiation health effects.

(35) Finally, an illustrative comparison of collective doses was presented showing that atmospheric nuclear weapon testing resulted in 22 million man Sv; Chernobyl release implied 295,000 man Sv, Goiania accident implied 60 man Sv and Tokai-mura accident resulted in less than 0.6 man Sv. From the global average exposure, 80% is due to natural sources, 20% to medical sources, <0.2 % to weapons fallout, <0.1% to Chernobyl release and < 0.01% to nuclear power.

2.1.1.2. Effects of ionizing radiation

(36) UNSCEAR's pathway to knowledge is the systematic review of clinical, epidemiological, animal models, cellular and molecular research, their scope, areas of work and limitations (in terms of clinical evidence and statistical detectability). He presented an overview of current knowledge on biological effects of ionizing radiation at molecular and cellular level including mechanisms of radiation-induced cell damage and its reparation. The implication of these mechanisms on the development of deterministic and stochastic effects was discussed. Regarding radiation epidemiology, it was discussed the relation between size of the sample and dose distribution versus the possibility of detecting increasing trends with dose. Many epidemiological studies were reviewed by UNSCEAR (e.g. radium dial painters, population at Semipalatinsks test site, Mayak workers, atomic bombs survivors, medical exposures, and many others).

(37) The cohort of Hiroshima and Nagasaki (Life Span Study: LSS) included 86,611 individuals of both sexes and all ages, with a wide dose range (average 0.1 Sv, maximum 4 Sv). Total deaths were 10,127 for solid cancer (radiation-attributable excess: 479) and 296 for leukemia (radiation-attributable excess: 93). He listed the specific cancer sites for which a radiation risk was demonstrated by the LSS, including those already described in UNSCEAR Report 2000 and adding other sites such as salivary glands, small intestine, rectum, pancreas, uterus, ovary, kidney and cutaneous melanoma. He then presented the lifetime cancer risk estimates as an average for 5 populations, all ages and both sexes. For 1 Sv acute dose the risk 4.3 – 7.2 %/Sv and 0.6-1 %/Sv for solid cancer and leukaemia respectively. For an acute dose

of 0.1 Sv the risk 3.6-7.7 %/Sv and 0.3-0.5 %/Sv for solid cancer and leukaemia respectively. He noted that present risk for solid cancer following 1 Sv is lower than the risk reported in the previous report, due to the fact that the new dosimetry was 10% higher. This was also related to the longer follow-up and the applied risk projection and transfer models. Risks in children are 2-3 times higher than in adults. He concluded that no major changes were required in the current values applied for cancer risk estimation. Regarding hereditable effects, the total risk to first generation from parental exposure is 0.0002%/Sv .

(38) He then addressed the subject of non-targeted effects, already mentioned in UNSCEAR Report 2006: genomic instability, bystander effects, abscopal effects and clastogenic plasma effects. He reminded two basic paradigms of radiobiology considering that fixed damage in the nucleus of irradiated cells, if it was not lethal, would be transmitted to the descendant cells and that effects occur only in cells whose nucleus was impacted by radiation. The concepts of genomic instability and bystander effects challenged those two paradigms. He then presented an overview of the non-targeted effects and the mechanisms involved in their production. It was concluded that non-targeted effects dominate at low doses and epidemiology implicitly encompasses those effects. Their causal relationship with possible health effects is still under debate.

(39) Radiation-induced heart disease is well demonstrated at very high doses used in radiotherapy. It was observed an increase in cardiovascular disease in atomic bomb survivors exposed at high doses. Evidence is not so clear at low doses and mechanisms are not clearly understood.

(40) While immuno-depressive effects of radiation are evident, the effects of low doses are still uncertain with both stimulatory and depressive consequences on the immune system.

(41) The main risk from radon exposure is lung cancer. New epidemiological data from occupational and residential exposures are consistent. More work is still needed to account for time since exposure, attained age, dose rate and smoking. Given this uncertainty, there are no changes to UNSCEAR 2000 estimates. .

(42) A wide-ranging review of health effects was conducted, new cellular and molecular studies, more epidemiological data resulting from longer follow-up. Although there are some differences at detailed level, the overall risk factors remain essentially unchanged. .

2.1.1.3. Effects of non-ionizing radiation

(43) The lecture of Dr. Maria Neira, addressed the sources and health effects of static field (0 Hz), extremely low frequency fields (>0-100 kHz), radiofrequency fields (>100 kHz - 300 GHz) and ultraviolet radiation. .

(44) After mentioning natural and man-made sources of *static fields,* their interaction mechanisms were summarized. While *static electric fields* only involve surface charge (no internal fields), *static magnetic fields* imply (1) electrodynamic interactions leading to electric fields, (2) magnetomechanical interactions leading to orientation effects and (3) interactions with electron spin state which may result in metabolic changes. Acute health effects of static magnetic fields may occur only when there is a movement in the field and/or in the body (e.g. internal body movement like blood flow and heart beat). There is not available evidence (neither

experimental nor epidemiological) regarding long-term effects of static fields and recommendations are focused on the adoption of international standards, implementation of protection programs and promotion of research.

(45) Industrial and residential sources of *extremely low frequency fields* (ELF) were presented and their interaction mechanisms summarized. External ELF induce electric fields and currents which, at very high field strengths, can cause changes in the central nervous system. Short-term effects of ELF may result from acute exposure at high levels, well above 100 μT. Long-term effects were suggested by some epidemiological studies which showed increased risk of childhood leukaemia associated with chronic ELF exposure. However, the evidence for a causal association is weak and the public health impact is uncertain. International exposure guidelines should be adopted at country level and governments should develop protection programs as well as effective and open communication programs. Research in this area should be encouraged. .

(46) Sources of *radio-frequency (RF) fields* are spread worldwide as a result of the use of telecommunication devices (mobile phones, Wi-Fi technology), broadcasting, navigation/radar, residential sources and emerging technologies. The health effects of RF fields are related to their thermal effects (i.e. tissue heating). It was demonstrated that heating > 1 °C activates physiological processes that can influence the activity of the nervous system, fertility, fetal development and cataract induction. No study has shown non-thermal adverse health effects of RF fields. Two case control studies are being conducted on the possible health effects of the use of mobile phones in adults and children (INTERPHONE and CEFALO respectively) and their results are expected by 2009. One cohort study (COSMOS) started on 2008 and it is expected to last 20-30 years. Present scientific evidence does not indicate the need for any special precautions for use of mobile phones. If regulatory authorities have adopted health-based guidelines, precautionary measures should be introduced as a separate policy that encourages the reduction of RF fields through voluntary means (by manufacturers and public).

(47) Exposure to *ultraviolet (UV) radiation* involves both public and workers. Indeed, in addition to occupational exposure to UV, the general public is exposed to natural UV radiation coming from the sun as well as to artificially generated UV (e.g. sun beds). Although UV radiation has some beneficial effects (e.g. vitamin D formation, phototherapy for some diseases), its detrimental health effects have been demonstrated including induction of skin cancer, skin burns, immune system suppression, cataracts and other ocular damage. Those effects can be prevented by implementing personal protection measures and controlling UV exposure of public and workers. .

(48) In summary, the background session demonstrated the existence of a wide international consensus on the epistemology of the radiation exposure and effects is very wide. The Chairman indicated that he, as a regulator, was happy to see that a) the consensus reached on a worldwide basis and the scientific knowledge accumulated to date support the radiation safety standards in force and, b) that the international interest for the scientific basis for radiation safety was present from the beginning of the peaceful applications of radiation and continue to be present today. This was a good beginning for the promising adventure on knowledge offered by IRPA12.

2.1.2. Characterization of Radiation Exposure

(49) The epistemology of the characterization of radiation exposure was defined narrowly, as the study of knowledge and justified belief in this area. Under the motto *harmonization on the quantification of ionizing radiation exposure,* this area of knowledge covered topics of external and internal exposure and biological dosimetry.

(50) For *external exposure* the topics included: the development of quantities and units (radiation weighting factors and equivalent dose, tissue weighting factors and effective dose), assessment of dose from external radiation exposure, computational methods (for dosimetry, determination of conversion factors, response of devices, analysis of radiation environments, assessment of uncertainties), development in instrumentation and methods, harmonization of the quantification of radiation exposure (regional and international intercalibrations and intercomparisons and quality assurance programs), monitoring and assessment of radiation fields, assessment of uncertainties, assessment of external dose in accidental exposures, and microdosimetry.

(51) For internal *exposure* the topics included: assessment of dose from internal radiation exposure, assessment of internal dose in accidental exposures, current and novel biokinetic and dosimetric models. assessment of uncertainties, current and novel physical and mathematics phantoms, internal dosimetry software, development in instrumentation and methods, harmonization of the quantification of radiation exposure (regional and international intercalibrations and intercomparisons and quality assurance programs); and monitoring plans (interpretation and bioassay data and uncertainties)

(52) For *biological dosimetry* the topics included: dose assessment by scoring unstable chromosomal aberrations (international standardisation and statistical uncertainty), rapid dose assessment in mass casualties incidents (biodosimetry, triage, automation, networking, biological dosimetry of victims exposed to very high doses, dicentric calibration curves, PCC [chemically induced] techniques, and EPR), biological dosimetry networks (reference and deployable laboratories, quality assurance programs), novel biomarkers (h2ax-loci, whole blood microarrays for radiation injury specific genes, radiation induced protein biomarkers), and retrospective assessment of radiation exposure (FISH, EPR).

(53) The large number of papers in this area of knowledge somehow covered all these ample scope of topics. This wide participation was dominant over all other areas covered by IRPA12, and certainly impressive. There were 184 papers dealing with external radiation, 79 papers on internal contamination, and 25 papers on biological dosimetry. There was one keynote lecture for each of these areas and the oral papers were 16, 10, and 4 respectively.

2.1.2.1.External Radiation

(54) The Topical Session I.1.1 on *External Exposure to Ionizing Radiation* reflected on the wide range of techniques and applications of external dosimetry systems. The Session' officers were: Ken Kase (kr.kase@stanfordalumni.org); Christian Wernli (Christian.wernli@psi.ch); Antonio Delgado (Antonio.delgado@ciemat.es); Christopher Perks (Christopher.perks@virgin.net) and Gustavo Santa Cruz (santacr@cnea.gov.ar).[2]

[2] All over the report, the Sessions' officers will be indicated in this order: Co-chairpersons, Keynote, Rapporteur and Scientific Secretary.

(55) IRPA12 has sown that there continues to be much interest in the external dosimetry as evidenced by the number of papers presented for this session. The fact that there were few radical new developments perhaps demonstrates maturity in the area. Nonetheless, there were many interesting papers outlining recent developments and potential ideas for the future.

(56) The new 2007 ICRP recommendations (ICRP publication 103) have only introduced minor changes that affect quantities and units, weighting factors and definitions relevant to external dosimetry. As a consequence there were few contributions in this area and the discussions concentrated on other issues.

(57) Computational techniques continue to be a growing area of importance. Historically they have largely been used in the design and evaluation stage and also in the development of phantoms for the evaluation of operational quantities. These areas remain of importance. Artificial neural networks and genetic neural networks are increasingly being developed and optimized particularly in the assessment of neutron doses. As the power of computational techniques improves, they are also increasingly being used to directly assess doses, both for environment and indoor areas.

(58) A large number of papers addressed the topics of national, regional and international intercomparisons. They covered all aspects of external dosimetry including dosimetry systems and services as well as computational techniques. Many focused strongly on the lessons to be learned. Calibration systems and their application were also described.

(59) An improved understanding of uncertainties and limitations in dosimetry assessments is increasingly important. In particular, the uncertainties of routine personal dosemeters were discussed and effects, such as anisotropic response for photons as well as the more widely discussed neutron response, were highlighted.

(60) Overall, the importance of easy to understand, accurate and validated dosimetry systems was underlined as a basic factor for rational decision-making for radiation protection professionals, and in particular in maintaining the ALARA principle. It was concluded that the proceedings on external dosimetry concentrated in the system evolution. The topics in the evolution were classified as follows: new developments, including genetic neural networks, artificial neural networks, uncertainty analysis, anisotropy, and 3-D dosimetry; approval, including type testing and documentation; application, including calibration, performance testing and adaptation to real fields; and, monitoring and identification of issues, including QA programes, inter-comparisons and lessons learned. The new evolutions in dosimetric techniques that were discussed were luminescence, including thermo-luminescence, optically stimulated luminescence, LiF, Al_2O_3, $CaSO_4$, Salt, etc.; scintillation, including $LaBr_3$, $LaCl_3$ etc; neutron measurement techniques, including multi-sphere spectrometry, tracks in CR-39, and activation; and, other techniques, such as film, gel, ion chambers, EPR, ESR, etc. There were also computational techniques such as the wide use of Monte Carlo, and the arising application of artificial neural networks and genetic algorithms. The applications described covered: occupational, including medical, nuclear, uranium mining and industry; public, including general public and patients in diagnostic and therapy and care/ward people;environmental, including indoor and outdoor; and, accident/emergency, including measurement and calculation and retrospective assessments

(64) The key outcomes were: that external dosimetry continues to be a diverse and thriving area of interest, key to monitoring and developing ALARA and, that there is an increase in the use of computational techniques (basic physics to dose assessments) and in the reliability and validity of assessments.

2.1.2.2.Internal exposure

(65) The Topical Session TS I.1.2 on *Internal Exposure* was also well covered. The Session' officers were: Sergei Romanov (roma@telecom.ozersk.ru); Michael Bailey (mike.bailey@hpa.org.uk); Hans Doerfel (info@idea-system.com); Ray Guilmette (rguilmette@lrri.org); and, Ana Rojo (arojo@cae.arn.gov.ar).

(66) There were presentations on the following topics: dosimetry models, applications and uncertainties, 15 papers; dose assessment, 14 papers; *in vivo* monitoring, 11 papers; internal dosimetry programs, 9 papers; human bioassay data & incident analysis, 7 papers; instrumentation and calibration, 7 papers; radiochemistry and quality assurance, 6 papers; intake source term characterization, 5 papers; and, radionuclide biokinetics, 5 papers. The key themes highlighted in this topical session were computational methods, use of *voxel* phantoms, statistical methods, and development of guidelines and training events

(67) It was concluded that there continues to be a strong vitality and interest in the field of internal exposure. Many of the presentations reflect the trend towards more sophisticated scientific and mathematical methods: in computational procedures, voxel phantoms, and application of more advanced statistical (notably Bayesian) approaches. Important new epidemiological studies of workers who were internally exposed are driving some of the developments, for example on assessment of uncertainties in internal dose. Identification of critical target tissues in organs requires close collaboration with radiobiologists but then presents challenges in calculation of the appropriate dose.

(68) Conversely, there were relatively few reports of new experimental studies for internal dosimetry, reflecting reduced commitment to such field in many countries. However, this may change if there is a renaissance in nuclear power. Interpretation of monitoring data of complex cases requires expert judgment, and measures are being taken to achieve greater harmonization through the continued development of guidelines, inter-comparison exercises and training. A major milestone in this field that is approaching in the next few years will be the publication by ICRP of new documents on occupational intakes of radionuclides, which will apply the 2007 ICRP recommendations, with new *voxel* phantoms, decay schemes, and bio-kinetic models, including the human alimentary tract model.

2.1.2.3.Biodosimetry

(69) The Topical Session TS I.1.3. on *Biological Dosimetry* covered the following areas: retrospective dosimetry, 7 papers; EPR-dosimetry, 5 papers; radiation protection in patient diagnostic and treatment, 5 papers; and, and various other techniques in 8 papers. The Session' officers were: Richard Toohey (Dick.Toohey@orau.org); Omar García (omar@cphr.edu.cu); Firrouz Darroudi (F.Darroudi@LUMC.NL); Philippe Voisin (philippe.voisin@irsn.fr); and Marina Digiorgio (mdigiorg@cae.arn.gov.ar).

(70) The key themes highlighted in this topical session were the methods for use from low dose (about < 50 mGy) for acute exposure, such as premature chromosome condensation (PCC), and the methods for use for retrospective dosimetry for acute or chronic exposure, such as FISH.

(71) It was encouraged the application of several techniques other than dysenteric analysis, such as EPR and PCC, and translocation. It was also recalled that multi-parametric dissymmetry is required to guide medical treatment in case of accidental overexposures, medical staff, and occupational exposure.

(72) It was emphasized that calibration curves and also dose range application of different dosimeters are required, which moves the concept of the biological dosimetry into the bio-dosimetry concept. The contribution of biological dosimetry to solve evaluation in the low dose range for risk analysis purposes was recommended. Inter-comparison and networks for cooperation and assistance purposes were requested.

2.1.3. Biological Effects of Radiation

(73) Under the motto towards global understanding on the effects attributable to radiation exposure, this area of knowledge covered the following topics: effects on molecules, organelles and cells, effects on tissues and organs, radiopathology, and, radio-epidemiology. These topics were talked at the following Topical Sessions:

- TS I. 2.1 on e*ffects on molecules, organelles and cells*, where the Session' officers were Sisko Salomaa (sisko.salomaa@stuk.fi); Herwig Paretzke (Paretzke@helmholtz-muenchen.de); Edouard Azzam (azzamei@umdnj.edu); Michel Bourguignon, France (Michel.BOURGUIGNON@asn.fr); and Alba Guerci (albaguerci@yahoo.com.ar);
- TS I2.2. on *effects on tissues and organs,* where the Session' officers were P. Gourmelon; Andrey Bushmanov, (radclin@yandex.ru; Wolfgang-Ulrich Mueller (wolfgang-ulrich.mueller@uni-essen.de); Makoto Akashi (akashi@nirs.go.jp); and Mercedes Portas (mportas@uolsinectis.com.ar);
- TS I.2.3 on *radio-pathology*, where the Session' officers were P. Gourmelon; Andrey Bushmanov (radclin@yandex.ru); Marc Benderitter, France (marc.benderitter@irsn.fr); Makoto Akashi (akashi@nirs.go.jp, supported by rioboss@nirs.go.jp); and, Mercedes Portas (mportas@uolsinectis.com.ar); and,
- TS I.2.4 on *radio-epidemiology*, where the Session' officers were Jan Zielinski, Canada (Jan_Zielinski@hc-sc.gc.ca); Ladislav Tomasek Republic (ladislav.tomasek@suro.cz); Elisabeth Cardis (ecardis@creal.cat); Ausra Kesminiene (kesminiene@iarc.fr); and, Marta Vacchino (vacchinomarta@yahoo.com.ar).

The outcome of these Topical Sessions was specifically and extremely well summarized by Dr. Bourguignon (France) at the relevant concluding plenary session. There was also a special review on low dose and low dose-rate radiation effects and models.

(74) The topic *effects on molecules, organelles and cells* included: progress in understanding molecular biology, gene-role and cell function (simple DNA damage vs. clastogenic effects), efficiency of repair mechanisms, influence of apoptosis, effect of genomic instability, impact of bystander effects, adaptive response, individual radiosensitivity: genetic and epigenetic factors, mechanisms involved in radiation-induced carcinogenesis, and effects on germ cells).

(75) The topic *effects on tissues and organs* (end hereditary and prenatal effects) included: health effects on tissues and organs, new information on cell-killing 'deterministic' effects at

high dose-rate, progress in understanding deterministic effects at low dose-rate, abscopal effects, induced clastogenic plasma factors, effects on the immune system, hereditary effects (experimental data and epidemiological approach) and, effects attributable to prenatal exposure (teratogenesis and mental retardation).

(76) The topic *radiopathology* included: acute radiation syndrome (pathogenesis, categorization, haematopoietic damage, gastro-intestinal injury, neurovascular involvement, impact on other organs (e.g. lung, kidney) and multi-organ dysfunction/failure), local radiation injury (pathogenesis, diagnosis, evaluation of the extension of injury –thermography, ultrasound, MRI, others, dosimetric modelisation, treatment –pharmacological & surgical, novel therapeutic strategies, including dose reconstruction-guided surgery and mesenchymal stem cell therapy, internal radionuclide contamination (diagnosis & assessment procedures, protocols for treatment, new decorporation agents), management of combined injuries, prevention and management of sequelae, long-term follow-up of radiation victims and ongoing research in radiopathology.

(77) The topic *radio-epidemiology* included: new epidemiological information ("life span study", Mayak-cohort studies, Chernobyl studies, occupational studies, patients studies, residential radon exposures, and molecular epidemiology, and new information on non-ionizing radiation fields –MF, ELF, MRI, RF, UV, etc, epidemiological studies & uncertainties (bias, confounding factors, etc), health-risk estimates (attributability of cancer to radiation exposure, "genetic" impact on populations, children, the unborn child, the frail and the elderly, and assessment of radiation detriment).

(78) The coverage of such a wide menu was due to be limited. However, the statistic in this scientific area was also very impressive. There were 38 papers on effects on molecules, organelles and cells; 27 on effects on tissues and organs; 11 on radio-pathology; and, 45 on radio-epidemiology.

2.1.3.1.Effects on molecules, organelles, cells, tissues and organs

(79) Some important phenomena were observed in the area of DNA lesions, which can be detected and evaluated with fluorescent antibodies, after doses as low as 100mGy in human bladder cancer cells. The response of mouse melanoma cells irradiated with high LET charged particles (p or Li), which have the capability to kill low LET radioresistant cells, was presented. Cytogenetic effects (FISH) of low energy X-ray of mammography (30 kV) were informed to be 1.5 greater than effects with 120 kV photons due to the different energy deposition pattern after photoelectric interaction. For mitochondrial DNA there was presented a description of new mitochondrial radiation induced deletions and an analysis of several known mitochondrial deletions in human lymphoblastoid cells exposed to 10 Gy Co60 gamma rays.

(80) In the area of non targeted effects, there was a presentation of the European integrated project NOTE, which involve 20 countries and it is aimed at investigating the mechanisms of bystander, genomic instability and adaptive response and whether they modulate cancer risk in the low dose region (protection or harmful effect?) and their role in non cancer diseases, as well as at assessing their relevance in radioprotection to eventually contribute to new radiation biology paradigms.

(81) It was observed that bystander effects, which are mostly observed at low dose, low dose rate, is an important issue in radiation protection. It raises the issue of supra linearity since more cells than directly hit cells are concerned. On the opposite, low dose gamma-rays seems to reduce the spontaneous neoplastic transformation. However it was recommended not to look at one single mechanism alone but to have a broad view. Bystander effect has been observed with 2 Gy 4MV photons from a linear accelerator in human breast carcinoma cells by using the technique of irradiated conditioned medium where culture medium from irradiated cells is used for unexposed cells. Serious genotoxic effects were observed with a clonogenic assay pointing out that standard radiotherapy may induce bystander effect. It was also observed that bystander effect in artificial tissue system can help understand its role which is still basically unknown.

(82) Regarding genomic instability it was observed that Techa riverside population exposed from 1949 on exhibits genomic instability at late time after chronic.

(83) A regional medico-dosimetric register was created at the Siberian Group of Chemical Entreprises (SGCE) and it is studying workers exposed to long term occupational radiation in low dose range. The preliminary conclusions show that there is an increase incidence of hemoblastosis and an increase in myocardial infarction. However, causality was not unambiguously established. There were also reported effects of chronic contamination by Cs127 in rats: slight modifications of physiological systems without apparent development of pathologies .

(84) The issue of gene influence on radiation sensitivity was lively discussed with much new information being presented. The on-going RISC-RAD European project on individual radiosensitivity was reviewed and highlighted. Gene influence on radiosensitivity was reviewed and it was reported an effect increase in combination with 2Gy radiotherapy. There was also a report presenting major mitotic delay in cultured lymphocytes after 0.5 Gy of gamma-rays.

(85) The IRM2 inbred strain mouse seems to exhibit a resistance to radiation due to a stronger hemato-immune system in comparison to parents strain. A transcription factor seems to be induced in mammalian cells by ionising radiations with a time and dose dependence. Histamine, a growth factor for many neoplasms, seems to modify the radiosensitivity of human malignant mammary cells, but does not seems to affect the radiosensitivity of human pancreatic adenocarcinoma cells, and seems to protect bone marrow (reduction of aplasia) against cellular damages induced by 10 Gy of gamma-rays Cs137. The adenosine membrane receptors seem to have different pharmacological effects on myelo-suppression induced by ionizing radiation.

(86) The synergy of interaction of radiotherapy and anticancer drugs needs to be properly managed in cancer patients. In mice, the highest synergistic effects are observed when the 2 treatments are simultaneous. The interaction of radon exposure and cigarette smoking on human bronchial epithelial cells seems to be synergistic and is impacted by the order of exposure. Radiosensitivity tests in patients were also reported: dynamic cytogenetic studies in time (0-120 minutes) appears to have good predictive potential for the detection of patients with a greater risk of side effects after radiotherapy and the ratio of comet tail length before and after diagnostic exposure in children seems to correlate with the dose.

(87) Many compounds are being tested as protective agents against radiation exposure and many results were reported to the Congress..

2.1.3.2. Radiopathology

(88) IRPA12 featured an extended coverage of the area of *radio-pathology*. It should be highlighted that tissue reaction effects were also high in the agenda. A review paper reported the latest results of radiation injuries on tissues and organs. The classical description of stochastic effects on cells and deterministic effects on tissues seem to be no so clear today because threshold values are lowered. For cataracts the threshold seems to be lower by a factor10; for cardiovascular from 500 mGy, much lower dose than initially implied by the bomb survivors data; for teratogenesis, different thresholds in embryo are reported; for mental retardation there seems to be no change in the paradigm; and for hereditary risk, there is a real decrease in previous estimations which has trigger a decrease in tissue weighting factor for gonads from 0.25 to 0.04.

(89) Impressive advances were reported in the treatment of radiation burns. A new paradigm in the treatment of radiation burns was presented as a breakthrough in this domain. It included early treatment, dose evaluation –MRI + modelisation, surgical removal of tissue for doses > 20 Gy, skin grafting and plastic surgery, and mesenchymal stem cells (MSC) grafting. Spectacular results were reported for accidents involving workers in Chile and Senegal: there was an early disappearance of pain and excellent follow-up after 2-3 years. It was also reported that clinical trials for treatment by MSC of hematopoietic disorders after irradiation were about to start at the Ural Research Center for Radiation Medicine.

(90) A number of reports addressed irradiation protocols and dosimetry. An experimental system has been developed to give reproducible and controllable conditions for low dose and low dose rate beta irradiation in vivo (for ^{32}P, ^{90}Y, ^{131}I and ^{177}Lu).The effectiveness of the system has been validated by measuring the production of ROS in normal human fibroblasts. A dosimeter to evaluate the radiosensitivity of irradiated pharmaceuticals has been developed. Validation has been made with Electron spin resonance for a range of doses from 1 to 15 kGy.

(91) Some reports addressed the issue of modelisations. The concept of "breaking barrier cell (antioxidant defence, repair & apoptosis) mechanisms" can be used to build a stochastic model to simulate studies of irradiations and predict carcinogenetic effects, e.g., leukaemia. A dose rate model has been applied to human fibroblasts and leukaemia cells and predicts that in the low dose range, biological response depends on dose rate rather than total dose.

2.1.3.3.Radioepidemiology

(92) *Radio-epidemiology* was due to be well covered in IRPA12. The keynote summarized the scientific bass for radiation protection. At this time there is a large amount of information arising from radio-epidemiological studies, which complement animal experiments and mechanistic developments. Current questions in radio-epidemiology are: cancer effects of low doses and dose-rates, effects of different types of radiation and of mixtures, better knowledge over effect modifiers such as age, sex, environmental exposures, host factors, including genetic polymorphisms and iodine deficiency, cardiovascular effects at low doses and dose-rates and cognitive effects.

(93) The new issues in molecular and cellular mechanisms addressed heretofore, such genomic instability, adaptive response, by-stander effects, DNA repairs, are important but its

epidemiological significance is still unknown in humans. An integrated epidemio/biology project.

(94) Epidemiological assessments must be carefully design, including all important "epidemiological variables" such as age, sex, dose and dissymmetric uncertainties, important risk factors for the disease using biological samples to measure relevant genetic, epigenetic and other relevant biological parameters, and this care has not been common in many radio-epidemiological studies.

(95) The contributions to IRPA12 included many studies on health effects in exposed populations to low dose exposure, including cancer and no cancer effects. Unsurprisingly, most of the epidemiological communications concentrated in workers exposure: uranium miners, Mayak workers and chemical, nuclear and medical workers. Studies on Chernobyl exposures in clean-up workers and residents of contaminated areas were also presented. Other topics were related to better methods to assess exposure, biodosimetry to improve radiation epidemiology studies, new software, and also on epidemiological surveillances, such as the Belarusian Chernobyl Register and Canadian National Dose Registry of Radiation Workers. Some studies were related to radon, smoking and lung cancer.

(96) The role, advantages and limits of epidemiology in radiation research and radiation protection was thoroughly reviewed; the major issues being to find evidence of a small risk at low dose LET radiations. It was indicated that more information will come from cohorts with aging of the people. There was expressed a wish for closer work between radio-epidemiologists and radiation biologists.

(97) A meta-analysis was reported of more than 40 articles and reports published since 1999 on cancer risk associated with alpha emitters of radon in miners. The findings were that there is evidence of excess of lung cancers, compatible with the linear-non-threshold model, that radon lung cancer risk persists after taking into account smoking, that there is a decrease of magnitude of the association with time since exposure, that there is no inverse exposure-late effect at low levels of dose, and that there is shown an excess of leukaemia but causality could not be demonstrated. Similar results were reported in a 3 case control European studies. An overview was presented of research with Canadian national dose registry of 600,000 radiation workers between 1951 and 2007, being a first analysis of 200,000 workers reports on cancer incidence and risk evaluation. It also was reported an study of occupationally exposed people at Mayak, in the Urals, covering 12309 workers, exposed between 1948 and 1958) showing that they present an excess risk of leukaemia, lung, bone and liver cancers. French workers of Areva and EDF were reported to have a lower mortality than the French national population due to a healthy worker effect. It was also reported that medical workers in Canada present a 1.74 excess risk of thyroid cancer following a study of 67562 workers between 1951 and 1987. Chinese medical workers present a 1.2 overall excess risk of cancers (skin, oesophagus and leukaemia in males, breast in females) following a study of 27011 workers between 1950 and 1995 compared to controls.

(98) As far as exposure of patients is concerned, it was found that cardiovascular disease mortality following cancer during childhood has long term risk after radiotherapy or after chemotherapy if the heart and brain doses is higher than 5Gy.

(99) The controversial issue of depleted uranium also has some papers. Haematological effects in cleanup workers in Serbia and Montenegro were reported as well as a variety of effects in offspring of military personnel.

(100) Biological indicators to support epidemiological studies were also reported. Changes in homeostatic balance parameters were reported to be an indicator of prolonged exposure of medical workers in low dose range. It was also found that occupational exposure to ionising radiations in medical field does not induce any adaptive response. Chromosomal instability evidenced as premature centromere division during prometaphase or metaphase has been observed in interventional cardiology personnel in comparison to a normal group. Biological indicators of occupational radiation exposure were searched by looking for differences of response of lymphocytes of workers to complementary irradiation, by subsets of clusters of differentiation may be useful indicators.

(101) The post Chenrobyl related epidemiology was also high in the agenda. In Belarus the state registry includes 276,000 people. Cohorts of people living in the evacuation zone and of people participating to liquidation are identified and form the base for further prospective research. Dose distribution regarding thyroid disease indicates that 26% of collective dose was received by 7% of the population in the most contaminated territories. It was reported the creation of a uniform Chernobyl register of Russia and Belarus on the basis of medical and dosimetry data banks for further research on sub-registers of uniform population groups or diseases, e.g., thyroid cancers. In Moldova, a follow up study of 850 patients among 3500 Chernobyl liquidators seems to indicate some impairment of the immune system.

(102) The contribution also included papers on environmental results. Serious cytogenetical effects in embryo tissue of gastropod snails and in root meristem of higher aquatic plants in lakes nearby Chernobyl were reported. The reported corresponding doses were up to 3.4 Gy per annum.

(103) Epidemiological thyroid studies became particularly relevant after Chernobyl. Thyroid dose estimates were reported as being improved for 2994 subjects exposed to nuclear tests fallout in Kazakhstan at Semipalatinsk during 1949-1962. Thyroid doses of 126,000 Belarusian exposed after Chernobyl were reported to be revisited and found to be reasonably consistent. Validation that thyroid mass, one parameter of dose evaluation, was found to be correlated with body surface area: 12000 controls performed with ultrasound measurements. A new re-evaluation risk of thyroid cancer among Chernobyl liquidators was reported, as well as a re-evaluation of thyroid dose estimates in 12,000 Belarusian who were children in 1986. There was also a report on an ongoing meta-analysis of 6 studies regarding the risk of thyroid cancer following exposure to ^{131}I in early life. Significantly, it was reported that the post Chernobyl thyroid cancer morbidity in 65575 children of Gomel and Bryansk shows excess risk of 4.5.

(104) An important aspect to take into account in epidemiological studies is the issue of probability vis-à-vis provability of effects at low radiation doses, a key issue for the attributability of effects to radiation exposure situations. This was also discussed at the Congress.

2.1.3.4.Special Review: "Low Dose and Low Dose-Rate Radiation Effects and Models"

(105) In a special keynote presentation, Thomas S. Tenforde, President of the US National Council on Radiation Protection and Measurements (NCRP) (thomas.tenforde@ncrponline.org) summarized the highlights of presentations at the 44th NCRP Annual Meeting, primary conclusions drawn by the speakers, and future activities of NCRP in analyzing the biological and potential human health effects of exposure to low doses of ionizing radiation. A related subject that was discussed by speakers at the meeting was the effect of the rate of delivery of radiation doses (*i.e.,* dose rate). The goal of the 2008 NCRP Annual Meeting was to bring these subjects into the perspective of currently available data and models of the biological responses and human health impacts of exposure to low doses of radiation. Views of the public and the role of growing knowledge of low-dose radiation effects on regulatory decision making were also discussed. Future plans of NCRP to continue its analysis of biological and human health effects of low dose and low dose-rate ionizing radiation are described.

(106) The Concluding Plenary Session C.S I. provided a nice digest of the rich technical sessions in the field of epistemology of radiation, both as far as the characterization of exposure and on the biological effects of exposure. Chaired by M. Crick, featured C. Wernli and M. Bourguignon who squeezed the outcome of the rich technical session.

(107) On the *characterization of radiation exposure* it was found that, while there continues to be much interest in both internal and external dosimetry, there were few radical new developments, what perhaps demonstrate maturity in this area. Nevertheless, many interesting papers outlined recent developments and ideas for the future that could be summarized as follows:

- Computational techniques have historically been used in the design and evaluation of dosemeters, in the development of phantoms for the evaluation of operational quantities, and in dose evaluation for internal dosimetry. In particular, the use of *voxel* phantoms in internal dosimetry is increasing in importance. Artificial neural networks and genetic neural networks are increasingly being developed for the computations.
- Many national, regional and international inter-comparisons covering all aspects of external and internal dosimetry, for routine as well as accident dosimetry, have identified lessons.
- There is an increasing need to improve understanding of the uncertainties and limitations in dosimetry assessments, and for training in all aspects of dosimetry for a growing number of people.
- Overall, easy to understand, accurate and validated dosimetric methods and systems underpin rational decision making for radiation protection professionals, and in particular implementation of the ALARA principle.

(108) On the *biological effects of radiation exposure*, IRPA12 confirmed that undoubtedly DNA lesions are key to understanding the effects of ionizing radiation, and that FISH and fluorescent antibody imaging are major cytogenetic techniques able to visualize these lesions and thus help increase knowledge. On the other hand, non-targeted effects, i.e. DNA lesions that do not result from the direct interaction with the ionizing radiation, were described in detail at IRPA12, namely bystander effect, abscopal effect and genetic instability. The intrinsic mechanisms of these effects, which appear mostly at low doses and low dose rates must yet be characterized to help understand their importance for health effects.

(109) DNA lesions are repaired through various mechanisms that operate more or less accurately depending on their nature (single-strand breaks, double-strand breaks, etc.), their number, and the rate at which they were produced. In this regard, humans are not identical and about 5% of the population is more sensitive, because at least the DNA repair mechanisms and possibly other pathways are weak. These people may suffer from complications, e.g. tissue burns. A breakthrough in the last three years is the use of mesenchymal stem cells (MSCs) for the treatment of cutaneous burns resulting from high accidental doses. In combination with early surgery guided by dosimetry, skin grafting including millions of MSCs provides fast pain relief and durable healing of the wound.

(110) Since epidemiology is limited and unable to demonstrate a radiogenic effect such as cancer when the background incidence is high, progress might be improved by applying epidemiological techniques to cellular molecular signals. Thus collaboration between epidemiologists and radiation biologists should be encouraged.

(111) Finally, it appears more clear that exposure to radon, long known as a carcinogenic agent, is the second cause of lung cancer after cigarette smoking. Therefore it is a challenge for radiation protection authorities to take immediate actions to reduce exposure to radon in buildings and private homes.

2.2. PARADIGM OF RADIATION PROTECTION

2.2.1. Background

(112) The background for this field was provided by the three scientific non-governmental organizations that recommend the global paradigms on which international safety standards are based: the ICRP, the ICRU and the ICNIRP.

2.2.1.1.The International Commission on Radiological Protection

(113) The protection philosophy of ICRP was presented by the ICRP Scientific secretary. It comprises (1) justification of the practice or intervention considered; (2) optimization of protection; (3) dose and risk limits and constraints to restrict the options in optimization. These fundamental principles of radiological protection are retained in the new 2007 Recommendations issued as ICRP Publication 103. The principles of justification and optimization aim at doing more good than harm. Thus, they represent utilitarian ethics, in which actions are judged by their consequences. The utilitarian approach is primarily a way of ensuring good conditions for the group concerned. However, even if the average conditions for a group are satisfactory, risks could be unevenly distributed. The aim of dose limits is to ensure that no single individual is exposed to undue harm. This is a case of deontological (duty) ethics, according to which some duties are imperative. For these reasons the new recommendations give somewhat more emphasis to protection of the individual rather than protection of society than the previous 1990 Recommendations, by stressing the importance of source-related restrictions, particularly for public exposures. The new recommendations also summarize and simplify advice given in various reports after 1990.

(114) The risk of cancer induction is now regarded by ICRP as slightly higher than assumed in 1990, but the risk of hereditary disease is definitely smaller than assumed in 1990. The total risk

estimates are therefore somewhat smaller than they were in the 1990 Recommendations. ICRP stresses that the 2007 total risk numbers are very similar to those in the 1990 Recommendations, and that for practical purposes it makes sense to continue to regard 5% per Sv as a reasonable approximation of the risk of fatality. Therefore, the dose limits remain unchanged. However, some of the tissues weighting factors that are used in the definition of the effective dose have changed appreciably, with gonads down, breast up, several 'new' tissues/organs being specified, and more tissues/organs being listed among the 'remainder' organs. The radiation weighting factors that are needed for the equivalent dose are mostly the same as in 1990, but the weighting factors for protons and neutrons have been amended. The risk assessment of ICRP assumes an individual of average age, average sex, and average population background. As an example of an explicit value judgement by ICRP, this is regarded as adequate for prospective practical protection purposes and in line with the statistical uncertainty of some of the underlying data; it also avoids some potential gender/age/race discrimination issues. However, this also means that for retrospective analysis of risks to a given individual after a specific radiation incident, effective dose is not a suitable measure – a more sophisticated approach considering absorbed doses, RBE values, age, gender, and other circumstances would be more appropriate. Similarly, collective effective dose is useful for prospective optimization purposes (particularly in cases of occupational exposure), but is not a reliable tool for population risk assessments. In particular, due to the inherent uncertainties and the uncertainty resulting when a large number is multiplied with a small number, it should not be used to prognosticate the number of deaths expected from minute individual doses to large populations.

(115) ICRP continues to emphasise the benefits of performance- and goal-related regulation, which encourages licensees to improve, while in many cases, prescriptive regulations would transfer responsibility from licensees to regulators. Thus, in many cases, particularly in occupational exposure contexts, licensees should select and set dose constraints. A 'safety culture' where all employees feel a personal responsibility for safety and protection issues is highly desirable. Earlier ICRP advice on generic risk constraints remains valid as a starting point for further deliberations. An appropriate system for incident reporting and dissemination of knowledge is essential; in order for this to work, the system must focus on learning from experience, not on punishments.

(116) The new recommendations address with emphasis protection against medical exposures. The benefit of radiation as a tool in diagnostic examinations and radiotherapy is overwhelming, and in many countries, access to the appropriate radiation methods needs to be increased significantly. However, at the same time there is a potential for over-utilisation of radiation. This is aggravated where training in radiation biology and radiological protection is inadequate, and ICRP emphasizes the need for appropriate criteria to avoid indiscriminate referral of patients and accidental over-exposures.

(117) For the first time the ICRP recommendations also aim at protection of non-human species as well as man. Hitherto, the policy of ICRP concerning protection of the environment has been anthropocentric: that if humans are protected to the degree thought necessary, then other species are assumed to be adequately protected. The 2007 Recommendations state that protection of the environment may need to be considered in its own right, leading to a more holistic system. While the existing policy for protection of man may, as a side effect, actually provide sufficient protection for other species too in most cases, ICRP needs a more comprehensive system that should be in line with control of other pollutants, transparent, and of course should have proper scientific references.

2.2.1.2.International Commission on Radiological Measurements and Units

(118) The Chairman of ICRU Main Commission, Paul M. DeLuca, Jr (USA) provided a summary of the past and future activities of the Commision. The ICRU mission is to develop and promulgate internationally accepted recommendations on radiation related quantities and units, terminology, measurement procedures, and reference data for the safe and efficient application of ionizing radiation to medical diagnosis and therapy, radiation science and technology, and radiation protection of individuals and populations.

(119) In following this mission the ICRU has engaged in several new activities, such as approaches to the dosimetry of low-doses and exploring when absorbed dose loses meaning. There is also new work on computational phantoms and on QA and imaging. ICRU is dedicating a lot of energy to the quantification in radiotherapy and radiodiagnosis, particularly in the areas of; bone densitometry, major diagnostic devices and performance, quality assurance and feature detectability. And also in mammography, focusing on relationships between image quality and needed X-ray fluence, manufacture specifications and new phantoms. There is also new activities on prescribing, recording and reporting conformal photon beam therapy, focusing on full 3D approach and revision of reporting and dose specifications to CTV/PTV => DVH. CT dose/image quality is another area of interes, focusing on 2D NPS and relationship with image quality, provide DVH for heavily irradiated sites, and manufacturer specifications and new phantoms. And certainly there is also work on carbon ions. Doses from cosmic ray exposure for aircrew will require computational phantom and new dose conversion coefficients.

(120) A new challenge is the so-called ISO effective dose. For external beams the issues are changes in fractionation, and beam quality and relationship to "transitional tissue". For internal dosimetry the major issues will be: inhomogeneous dose distributions and partial volume irradiation, variable and decreasing absorbed dose rate, microdosimetric effects associated with decay products, small field irradiation, lack of charged particle equilibrium at any point, mixture of deterministic and stochastic outcomes; it is a major concern in modern oncology and fundamental to new high energy heavy particle beams, and important to small field irradiations.

(121) Small-field dosimetry is another new scientific challenge that covers difficult and un-addressed issues, no primary standards that measure dose in non-standard fields and the fact that no standard protocols are established for such beams; the connection between standard and non-standard is absent and introduces uncertainties. Finally, ICRU is addressing second cancers at heavily irradiated sites and doses distant from irradiated site. As it can be see, a full menu was presented to keep the characterization of ionizing radiation exposure well alive!

2.2.1.3. International Commission on Non-ionizing Radiation Protection

(122) Similarities and differences of protection standards for non-ionizing radiation (NIR) vis-à-vis ionizing radiation were presented by Paolo Vecchia (Italy), Chairman of ICNIRP. NIR include electromagnetic fields (EMF), static magnetic fields, extremely low frequency (ELF) electric and magnetic fields, Radiofrequency (RF) electromagnetic fields, Microwaves, High frequency (THz) radiation, optical radiation, visible light, Infra-red (IR) radiation, Ultra-violet (UV) radiation, laser radiation, ultrasound, and infrasound. The primary aims of ICRP recommendations, namely 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, are shared by ICNIRP. The ICRP principles of protection, justification, optimization of protection, and application of dose limits, are also shared.

(123) In spite of all this sharing, the fundamentals of ICNIRP guidelines were defined somehow distinctly as follows: procedures and criteria are defined a priori, restrictions are based on science, no consideration for economic or social issues, and only established effects are considered. The systems of protection were characterized by: health threshold based systems, adequate for well established, threshold effects; optimization systems, adequate for no-threshold known hazards; and, precautionary measures, adequate for suspected, not established hazard. There was a description of established effects for ELF fields, including: induction of internal electric fields and currents and stimulation of electrically excitable tissues (the effects are related to the internal electric field (V/m) or the internal current density (A/m^2)). Also for effects due to RF fields, including: absorption of electromagnetic energy, increase of body temperature (general or local) (thermal effects are related to specific absorption rate (SAR), i.e. to the energy absorbed per unit time and per unit body mass (W/kg)). The EMF "dose" in practice was also discussed including the facts that there is neither evidence of effects from cumulative exposure nor equivalence between exposures to different kinds of EMF (e.g. ELF vs RF) or between short exposure to low-intensity and long exposure to high-intensity fields. The health effects of EMF were synthesized as follows: established acute effects only above given exposure thresholds; different mechanisms identified for ELF and RF; hypothesized long-term effects well below threshold for acute effects but with no mechanism identified.

(124) In summary, exposure limits and precautionary measures were described as follows: no quantitative exposure limits can be established for long-term effects; precautionary measures have been envisaged to prevent or reduce long-term effects, although hypothetical; measures aimed at the minimization of exposure have been claimed, and the ALARA principle has been invoked. In this regard, the optimization principle (ALARA) of balancing risks and benefits was described as actions on limiting the exposure of the general public to electromagnetic fields should be balanced with the other health, safety and security benefits that devices emitting electromagnetic fields bring to the quality of life, in such areas as telecommunications, energy and public security.

(125) It was concluded that: EMF exhibit peculiar characteristics, and no direct parallel can be established with other agents; high-level exposures can, and should, be regulated through exposure limits; low-level exposures must be considered as a separate issue; there is no scientific basis for quantitative limits to low-level chronic exposures; separate precautionary measures may be considered, provided they are complementary and not alternative to science-based standards; precautionary measures require social and economic consideration that are outside the remit of ICNIRP and, science should however be an essential input for any precautionary policy, including precautionary measures.

2.2.2. Developing the Radiation Protection Framework

(126) Under the motto *towards an effective radiation safety and security regime*, this area of knowledge covered the following topics: evolving international safety regime; national infrastructures, education, training and staffing; and safety and security of radiation sources.

(127) The area of *evolving international safety regime* included the following topics: international standards (harmonisation of exposure standards and codes of practice for

protection), legally binding undertakings and other international instruments ((international conventions, regional agreements, codes of conduct and new proposal for legally binding undertakings), fostering information exchange (examples of dissemination information, networking, publications: outreach), technical co-operation and assistance in radiation protection (strengthening national infrastructures, helping less developed countries) and international appraisals.

(128) It was decided that it was convenient to combine the topics *evolving international safety regime* and *scope of radiation protection*. The latter, which was originally planned for the area of developing protection policies, criteria and methods (see hereinafter), included general principles and criteria for protection against ionising radiation (types of exposure situations: planned, existing and emergency exposures, justification, optimization of radiation protection (planned, existing, emergency, individual dose limits, dose constraints and reference levels, exclusion and exemption, use and misuse of collective doses.

(129) The area of *national infrastructures* included the following topics: legislative and statutory framework (legislation and regulations), regulatory body establishment and independence (regulatory body funding, regulatory body staffing and training, co-ordination at national and international level), basic administration of radiation safety (registration, licensing, authorisation, inspections, enforcement, quality management, the regulators' discretion to exempt and clear, the need of international harmonization, and the administration of intervention), participation of stakeholders in the decision-making process, and public communication and outreach.

(130) The area of *education, training and staffing* included the following topics: education and training proper and co-ordination of research and development in focus areas.

(131) The area of *safety and security of radiation sources* included the following topics: prevention of malevolent uses of radioactive sources (regulatory control, notification and inventory of radiation sources, orphan sources (recovery, regaining control, late recognition of radiation consequences) and transborder movement of radioactive sources (export-import, border monitoring and illicit traffic).

2.2.2.1.Evolving International Safety Regime and Scope of Radiation Protection System

(132) The session officers of Topical Session TS II.1.1., *Evolving International Safety Regime* were Sigurdur Magnusson (smm@gr.is), Fernando Lopez Lizana (oirs@cchen.cl), Jack Valentin (Jack.Valentin@ssi.se), Peter Burns (Peter.Burns@arpansa.gov.au) and Sonia Fernández Moreno (sfmoreno@sede.arn.gov.ar). The session was combined with Topical Session TS II.2.1., *Scope of Radiation Protection System*, as the issues were related and could be discussed together. Fourteen papers addressed the first topic; four of them were orally presented. Eighteen papers covered the field of scope of radiation protection system; two of them were oral presentation. Chairman Magnusson provided an detailed summary of the outcome of these two sessions at the relevant concluding session.

(133) Jack Valentin (Sweden), the Scientific Secretary of ICRP, focused in his key lecture on what the ICRP does and why. He emphasized, in particular, the recent ICRP 2007 general recommendations, ICRP 103, that replaced ICRP 60. Why there was a need to revise and what

had been the aim of the revision. He also gave an overview of the publications that support the general recommendations.

(134) Ted Lazo (USA) of the NEA, presented the outcome of a NEA workshop on *Science and Value in Radiation Protection – Impact on radiological Decision Making*. The topics discussed at the workshop had demonstrated that ethical and regulatory issues arise when uncertainty prevails and that "what if" questions are relevant when discussing scientific findings from the perspective of values. There is a need to share understanding and develop a pluralistic evaluation of the issues at hand. The 2nd NEA Science and Values Workshop is to be held in France towards the end of 2009. He also presented the input of the ICRP/NEA dialogue to the recent evolution of the system of radiological protection leading to the 2007 ICRP General Recommendations. The NEA through its Committee on Radiation Protection and Public Health (CRPPH) actively engaged with the ICRP from 1999-2007. This included 7 International workshops to discuss the ICRP evolution, 4 detailed assessments of the ICRP draft recommendation with input from all NEA Standing Topical committees, 13 relevant CRPPH publications and mobilization of over 100 experts from 17 countries and 25 national governmental organizations. The ICRP/NEA dialog is a good example of successful stakeholder engagement and seems to have had a significant effect on the final ICRP Recommendations Publication 103.

(135) Dan Strom (USA) addressed who can take actions to protect from radiation, where their empowerment comes from and what knowledge they need to act appropriately.

(136) Sylvain St Pierre (Canada), of the World Nuclear Association (WNA), presented the WNA's vision for greater harmonization of the system of radiological protection with a clear focus on integrated safety management as the way forward. Radiation protection is a part of the global safety regime and should be managed in an integrated way rather than a separate way. His key message was: integrated safety for all.

(137) Bernard Lorenz (Germany) addressed possible consequences for operating nuclear facilities of the new ICRP general recommendations. In his view, there had been a considerable move towards pragmatism from the 1st draft. He expressed concern that dose constraints become lower, *de facto* limits which is not justified but in spite of some criticism, the new ICRP will contribute to strengthen the protection regime and industry will help to improve the already good safety records.

(138) Graham Smith (UK), addressed optimization under uncertainty in the case of applying the '*as-low-as-be-reasonably-achievable*' principle in management of the nuclear legacy. He used examples from past and ongoing legacy management projects in the Russian Federation and the USA to illustrate and drew conclusions on future application of the ALARA principles in this context.

(139) In summary, IRPA12 noticed that the system of radiation protection is currently under review. The main themes discussed at the sessions dealt with the ICRP and the recent review process that concluded in the ICRP 2007 Recommendations. The importance of the process of revision as well as the outcome was highlighted as important issues for the evolution of the international safety regime. Views from the industry on the relevance of furthering greater harmonization of the radiation protection system were presented. The concept of optimization

under uncertainty in the application of optimization of radiation protection in management of the nuclear legacy and the lessons learnt for future application was also described.

(140) The issues discussed within the scope of radiation protection dealt with a broader approach to the classical notions of radiation protection when dealing with prevention, noting what actions can be taken at different levels and the principles on which they are based.

(141) On the development of new radiological protection and emerging scientific matters, it was stressed the need to develop a shared understanding of emerging challenges of radioprotection among all relevant parties. To this aim, workshops to reflect on scientific and societal issues that might challenge radiological protection in the coming years are being organized by NEA/OECD.

(142) The main conclusions and next steps are related with the importance of working towards ensuring harmonized, coherent and consistent implementation of the international system of radiation protection and the safety regime in a context of a growing expansion of energy needs and the expected role of nuclear energy.

2.2.2.2. National Infrastructures for Radiation Protection

(143) The officers of Topical Session TS II.1.2., on *National Infrastructures for Radiation Protection*, were as follows: Hermenegildo I Maldonado Mercado (hmaldonado@cnsns.gob.mx), Eulinia Valdezco (emvaldezco@pnri.dost.gov.ph), Shakilur Rahman, Khammar Mrabit (K.Mrabit@iaea.org) and Dora Vidal (dvidal@sede.arn.gov.ar) . This was an extremely important session for the objective stated in the Congress' motto. The Congress found that it seems to be an important issue for the strengthening of national infrastructures of radiation protection to look for a better communication between the Regulatory Authority and other stakeholders in order to achieve safety for the radiation workers, the public and environment. In this sense, it is necessary a spread of knowledge that must be shared rather than being viewed as a 'property' of scientist or technicians. It is not a matter of confidence in a regulatory authority because of its past history only. The regulatory authority must demonstrate that it is for the public.

(144) Risk and its perception are themes that had been presented as a matter of study, from the point of view of the management quality system and from the point of view of communication between the actors involved in radiological safety issues. In some way, it seems that understanding the various "sensitivities" about risk and its perception could be the key to satisfy all the actors involved in radiological safety issues and to learn how to face the interaction with them successfully.

(145) At least two presentations were focused on initiatives to share the activity of updating national infrastructures. One of them proposed a model for networking, cooperation, information exchange and regulatory harmonization, with international experts providing the necessary assistance to small national organizations.

2.2.2.3.Education, Training and Staffing

(146) Topical Session TS II.1.3, on *Education, Training and Staffing* was very much in line with the above reflections. The session officers were Carlos Terrado

(cterrado@sede.arn.gov.ar), Pierre Noel Lirsac (Pierre-noel.lirsac@cea.fr), Joanne Stewart (Joanne.Stewart@hpa.org.uk) and Noemí Gigli (ngigli@sede.arn.gov.ar). The session concluded that effective radiation protection will only be ensured by an adequate number of competent persons at the appropriate levels.

(147) In order to develop and maintain national capability to meet radiation protection needs, it is essential: addressing initial training at all levels for all personnel – this means varying educational backgrounds; and, maintaining competence via appropriate specialist and refresher training. For building competence, mixing national, regional and international resources will contribute by bringing a greater effectiveness, accelerating its implementation and providing a constructive dialogue.

(148) It was specifically concluded that: sustainability must be the objective; knowledge management must be addressed to ensure retention of expertise; for a developing radiation protection infrastructure the initial focus should be the education and training of the regulatory body staff. It was noted that the IAEA provides a ready resource for establishment of education and training activities, but professional Societies can play a significant role in the development of national competence. The growing international network of Regional Training Centres was specially praised. National Certification and Competence Recognition Schemes should form part of a national strategy for building competence. They should help to build mutual recognition at regional level and must be based on a common understanding of roles and responsibilities.

2.2.2.4. Safety and Security of Radiation Sources

(149) The Topical Session TS II.1.4 on Safety *and Security of Radiation Sources*, was also well attended. 38 papers were presented from 33 countries. Of these, 32 were poster presentations and 6 were oral. The session officers were as follows: Milagros Couchoud , (milagros.couchoud@ciemat.es), Mark Alexander (mark.alexander@ansto.gov.au), Brian Dodd (BDC.mail@cox.net), Oleg Pavlovski (pavl@ibrae.ac.ru), and Stella Bonet Durán (sbduran@sede.arn.gov.ar).

(150) A number of common themes arose from the papers presented. There continues to be an increasing recognition of the importance of, and interest in, radioactive source security. Of the papers submitted, there was an almost equal representation between safety and security issues. While acknowledging this increase in priority for radioactive source security, there remains much work to do on securing sources in many countries. The international radiation protection community has a leading role to play in meeting this challenge. Safety and security concerns are a global responsibility. Accidents or the potential malicious misuse of radioactive material can affect any country and all countries must work together to ensure that sources are managed safely and securely.

(151) Orphaned radioactive sources continue to represent a large safety and security risk due to their uncontrolled nature. It is important that efforts to detect and remediate these sources, as well as prepare for any related emergency situations continue to be developed.

2.2.3. Developing Protection Policies, Criteria, Methods and Culture

(152) Under the motto *providing for the global application of radiation protection*, this area of knowledge covered the following topics: protection of the public and the environment, occupational radiation protection and protection of patients.

(153) The area *protection of the public and the environment* included the following topics: common international issues (ICRP and IAEA approaches), public radiation protection (controlling discharges of radioactive materials into the environment, safety of radioactive waste management, safety of radioactive waste disposal, safety of termination of activities involving radioactive substances, decommissioning, management of radioactive residues, restoration of environments protection of critical groups –the unborn child, children, the frail, the elderly, those taking certain medications etc), assessing environmental exposure, assessing environmental contamination (open field, urban environment, surface, commodities, foodstuff, and environmental surveillance and sampling), radiological impact on non-human species (individual vs. population and ecosystem effects, reproductive capacity, genetic effects, mortality and biological diversity, and framework for radiation protection of non-human species (national and international approaches, research activities, and reference organisms concept.

(154) The area of *occupational radiation protection* included the following topics: obligations of employers and workers: the role of the unions, risk assessment, protecting the pregnant worker and the unborn, dealing with occupational 'natural' radiation exposures (including aircrew), attributability of occupational illness, holistic approach to occupational radiation risks, and medical surveillance of radiation workers.

(155) The area of *protection of patients* included the following topics: protection of volunteers, justification of referral, optimization, reference levels for diagnostic radiology, prevention of incidents and accidents in radiotherapy, protection criteria in nuclear medicine, radiation protection of children, radiation protection in research activities, radiation protection of comforters and carers, radiation protection in medico-legal exposure, radiation protection in new techniques (addressing those techniques which produce real radiation protection problems e.g. particle accelerators, etc), and security in medical uses of radiation.

2.2.3.1.Protection of the Public and the Environment

(156) The Topical Session II.2.2, on *Protection of the Public and the Environment* was another uniqueness of IRPA12, as it was the first time that an IRPA Congress addresses the protection of the public and the protection of the environment itself in a joint session. The session officers werw David Cancio and Peter Burns (david.cancio@ciemat.es), (Peter.Burns@arpansa.gov.au), Carl-Magnus Larsson (carl.magnus.larsson@ssm.se), Jan Pentreath (janpentreath@yahoo.co.uk) and Adriana Curti (acurti@sede.arn.gov.ar).

(157) The keynote lecture put in perspective the long history of the Protection of the Public and the consideration for the evolving concept of protection of biota. A relevant aspect pointed out was that both subjects have to be developed in parallel but within the same framework. Only some international organizations follow this approach.

(158) Contributions from international organizations did show the increasing developments in protection of non-human species against ionizing radiation. It is of interest to emphasize the presentation of the IAEA, which put in perspective the international laws and developments or actions in some countries. The analysis of case studies supported by WNA shows that for most

normal discharges into the environment no effects would be expected in biota. There has been already an important development of methodologies and tools to assess the protection of animals and plants, pointing up the presentation of the tool developed within the European Project ERICA. It is clear that there is room for further development of some important aspects such as the estimation of uncertainties, dosimetry, weighting factors for different types of radiation, relevant endpoints, and the demonstration of the suitability of using the concept of reference plants and animals. Finally, it should be noted that the radiological protection of the environment is not an urgent or important issue in a number of countries that obviously have other priorities.

(159) As far as environmental radioactivity monitoring, discharges and assessments is concerned, the Congress recalled that the demonstration of radiation protection of the public is the main objective for the worldwide monitoring activities. Some contributions are related with the compliance with limits or constraints, the environmental radiation quality and the long-term behaviour of residual contaminations from accidents or old practices. The contributions included studies about specific types of nuclear or other industrial uses of radioisotopes, involving not only artificial but also natural radionuclides, standing out the growing interest in this subject that is responsible of a relevant exposure of the population.

(160) Other papers presented were related to effluents in routine discharges made in medical, industrial and nuclear facilities. Only one paper has addressed the use of collective doses in the population, which may reflect a lowering use of this magnitude. Finally, several papers referred to the study of parameters for the transfer of radionuclides in different ecosystems, the radiological impact assessment based on measures and modelling.

(161) It is interesting to mention that there is some evolving work in monitoring and techniques derived from improvements in instrumentation and software or requirements in decommissioning of installations including the legacy of old uranium mines.

2.2.3.2.Occupational Radiation Protection

(162) The Topical Session TS II.2.3, on *Occupational Radiation Protection*, featured 63 papers, 57 posters and 6 oral presentations. The session officers were Shengli Niu (niu@ilo.org), Clóvis Abrahão Hazin (chazin@cnen.gov.br), Seong Ho Na (shna@kins.re.kr) Renate Czarwinski (*r.czarwinski*@iaea.org) and Ana Castellanos (acastella2003@yahoo.com.ar).

(163) Due to the wide field of occupational radiation protection, it was not easy to segregate themes. The main aspects covered were related to: internal dosimetry (5 papers), where the common theme was the necessity of improve and harmonize assessment methodologies; occupational radiation protection in general (18 papers); methods/equipment/dosimetry (14 papers); examples of occupational radiation protection (10 papers); and safety culture (10 papers).

(164) The main concerns expressed were in relation to occupational radiation protection in medical practices, where it was noted that occupational doses trend to increasing due to the introduction of interventional radiology and new practices in nuclear medicine. Other concerns related to the necessity of training and safety culture improvement not only for big facilities but for small ones, and not mainly industrial uses but especially for medical uses.

(165) Another issue particularly discussed was the occupational doses in mining activities and another natural exposure sources. UNSCEAR studies show their importance taking into account the decreasing trends of other activities like nuclear fuel cycle.

(166) Two important questions remained floating: Are the available monitoring systems adequate for the new and complex facilities, particularly in the medical area? Is there a risk of excessive use of new software for dose assessment?

2.2.3.3.Radiation Protection of Patients

(167) The Topical session TS II.2.4, on *Radiation Protection of Patients* had 35 submitted papers, with 8 oral presentations and 27 posters. The session officers were María Pérez (perezm@who.int), Leopoldo Arranz (larranz.hrc@salud.madrid.org), Madan Rehani (M.Rehani@iaea.org), Claire Cousins (dpd24@cam.ac.uk), and Ana Larcher (alarcher@sede.arn.gov.ar).

(168) The submitted papers addressed the following subjects: optimization, justification, exposure risks, incidents, quality assurance, protection process, internal dosimetry of radiopharmaceuticals in nuclear medicine. The following techniques were considered: mammography, computerized tomography (CT), dental radiology, nuclear medicine, teletherapy and brachytherapy.

(169) Medical imaging has become the largest controllable source of radiation exposure. Although this remains unregulated, the dedication to radiological protection demonstrated in the posters submitted shows a high level of awareness amongst those committed to the subject. Our aim should be to broaden knowledge of radiological protection to professionals involved in the wider practice of medicine. It was emphasized the issue of training of medical staff as an important factor to improve the protection of patients. It was underlined that training should be undertaken before the transition from film/screen to digital imaging. Reducing dose in computed tomography (CT) was recognized to be an important objective that can be achieved by tailoring the protocols for the level of acceptable noise according to: the clinical indication, and the size of the patient (particularly in paediatrics CT).

(170) The keynote lecture was delivered by Madan Rehani (IAEA) who pointed out that the overall objective of the radiological protection of patients is that benefits should outweigh risks, delivering no more radiation than the necessary to achieve the expected outcome of the procedure. Annually 3,6 billion X ray examinations, 35 million nuclear medicine examinations and about 5 million radiotherapy treatments are performed. In terms of collective dose radiology results in ~2,300,000 person.Sv annually, with ~ 800,000 person.Sv due to CT.

(171) In the past, the main concern was focus on protecting staff but, during the last years, the focus of radiation protection in medicine shift towards the patient. A single patient may get more radiation dose in 5 CTs that a staff member working the whole life in an X-ray department under appropriate radiation protection conditions. However, he noted some particular issues concerning occupational radiation protection such as prevention of deterministic effects in interventional radiologists (e.g. cataracts). He then presented an overview of the key actions to implement radiation protection in diagnostic radiology, CT and interventional procedures. The introduction of better intensifying screen as well as the use of diagnostic reference levels

(DRLs) improved significantly patient protection in diagnostic radiology. He discussed the challenges related to the increasing use of digital imaging, actions for patient dose management in CT, particularly focusing on the need for dose reduction in paediatric procedures. With regard to patients undergoing interventional procedures, there is a great concern about prevention of deterministic effects. This is particularly critical in cardiac patients (around 6% have 3 or more interventions along their life). IAEA established the International Action Plan for Radiological Protection of Patients in collaboration with relevant international organizations and professional bodies. The main activities developed under this Action Plan were summarized (diagnostic radiology, interventional radiology and radiotherapy). A web site is available at http://rpop.iaea.org with valuable information, guidance and recommendations as well as downloadable training packages.

(172) In summary, it was concluded that:

- Referral guidelines should be encouraged as a tool for implementing justification by primary referrers, with review as necessary.
- Diagnostic reference levels (DRLs) should be used appropriately as a tool for optimization after engagement of professional bodies.
- Error reporting systems are required and should be both graded and harmonized.
- Improving the radiological radiation protection of patients requires engagement of all involved parties to strengthen co-operation.

2.2.4. Emergency Planning, Preparedness and Response

(173) This area of knowledge covered the following topics *nuclear and radiological emergencies, medical response in emergencies* and *emergency aftermath and recovery.* There were 27 papers on nuclear and radiological emergencies, 19 on medical response in emergencies and 12 on emergency aftermath and recovery.

(174) The area of *nuclear and radiological emergencies* included the following topics: emergency preparedness and response, comprising rescuers, contamination, protecting people in the aftermath of a terrorist attack (national capabilities for nuclear and radiological emergencies, assessment of the consequences –environmental impact, modelling atmospheric dispersion, radiological monitoring and data collection, intervention criteria and countermeasures, decision support systems, dose reconstruction, first responders occupational protection issues, public information and press communication, synergism in emergency preparedness for nuclear accidents and malevolent acts, criteria for dealing with different scenarios, and education and training, exercises and drills) and: lessons learned in real situations –regional and international assistance.

(175) The area of *medical response in emergencies* included the following topics: radiation emergency medicine systems (planning, arrangements, guidance, capabilities, pre-hospital response, local hospital, referral hospitals, networks for medical response and international assistance, stockpiles for radiation emergencies), medical response in mass casualty events – prevention and management of psychological impact, public health response, education and training, and lessons from past events.

(176) The area of *emergency aftermath and recovery* included the following topics: consequences and lessons of past events (e.g., Chernobyl), protection of individuals living in contaminated territories after a nuclear accident or a radiological event (countermeasures and

protection strategies, criteria for the setting of reference dose levels, justification and optimisation of protection strategies, participation of stakeholders in the decision-making and long-term management), management of contaminated foodstuffs and other commodities, and management of radioactive wastes generated.

2.2.4.1. Nuclear and Radiological Emergencies

(177) The officers of Topical sessions TS II.3.1. on *Nuclear and Radiological Emergencies* were Warren Stern(W.Stern@iaea.org), Juan Carlos Lentijo (jcll@csn.es), Vincent Mc Clelland (vincent.mcclelland@nnsa.doe.gov), Finn Ugletveit (Finn.Ugletveit@nrpa.no) and Daniel Hernandez y Alejandro Sandá (dhernand@sede.arn.gov.ar) and those of TS II.3.2 on *Medical Response in Emergencies*, were Patrick Gourmelon (Patrick.gourmelon@irsn.fr, Albert Wiley (albert.wiley@orise.orau.gov), Elena Buglova (E.Buglova@iaea.org), Zhanat Carr (carrz@who.inT) and Marina Vazquez and A. Robinson(mvazquez@cae.arn.gov.ar and anibaljr@fibertel.com.ar).

(178) The sessions reported to have a good quality of papers submitted. 65 papers were accepted: 40% from Europe; 25% from Latin America; 20% from Asia; 10% from North America; and 5% from Africa. There were 6 oral presentations and around 60 posters. They covered: risk assessments, strategies and planning (27); measurement capabilities (18); modelling capabilities (9); decision support (3); training/exercises (7); and actual emergencies (5). The topics addressed most aspects of nuclear and radiological emergencies providing a lot of interesting information to the international societies.

2.2.4.2.Emergency Aftermath and Recovery

(179) The Topical session TS II 3 3 on *Emergency Aftermath and Recovery* discussed a number of key issues. The session officers were Carlos Rojas Palma (carlos.rojas.palma@sckcen.be), Elaine Rua R. Rochedo (elaine@ird.gov.br), Jacques Lochard (lochard@cepn.asso.fr), Eduard Lazo (lazo@nea.fr) and Juan Kunst (jkunst@cae.arn.gov.ar).

(180) The session produced recommendations that can be summarized in the following points:

- New focus on later and recovery phase issues and approaches
- Need for a clear conceptual framework
- Economic impact assessment is key
- Start planning and preparations now
- Stakeholder engagement is essential
- General enlargement of types of stakeholders involved
- Keep away from “scientific jargon”
- Optimization is a central issue
- Stakeholder engagement is the key to successful decisions
- Topical tools being developed
- Multi-criteria assessment is important
- Self-protection actions are key, but need framework (monitoring, health surveillance, education)
- Post-accident management and decision support systems and approaches are being actively studied.
- Commonalities of Post-Accident Protection Management

- Broad distribution of impacts and effects
- Individual-level of attention is necessary
- Involvement of the affected individuals in their own protection improves resultsCommonalities of Decision Support
- Topical tools" are an important support for decision making in emergency situations
- Tools must be developed well in advance in order to be useful
- Topical information provided to decision makers must be digested and clear

2.2.5. ICRP Jubilee

(181) IRPA12 provided a nice occasion to celebrate the 80th birthday of the ICRP, and what better than to do it with an ad hoc conference on the history of the organization that provide for the international paradigm on radiation protection. It was done with a keynote lecture of Prof. Roger Clarke, former ICRP Chairman and currently Member Emeritus. Prof. Clarke's paper, which was co-authored with the ICRP Scientific secretary, Jack Valentin, was entitled *The 80th Anniversary of the International Commission on Radiological Protection*: The evolution of its policies through 80 years, became a comprehensive tour of the creation and consolidation of the ICRP radiation protection paradigm. He concluded that in the 80 years of its existence, the Commission has sought to utilize the best scientific data in preparing recommendations that address the practical needs of the profession. The basis of that protection policy has changed as the scientific data have emerged and as the uses of radiation have broadened. In recent years the Commission has adopted a more open policy in the development of its policies, publications and recommendations. This involvement of the profession has been beneficial to all parties and may be expected to continue into the future.

2.2.6. Concluding the Paradigm

(182) The Concluding Plenary session III provided the opportunity to wrap up the field of radiation protection paradigm. Chaired by A. Sugier (France), K. Mrabit (Morocco), R. Czarwinski (Germany), W. Stern (USA), grasped the essentials of the rich technical sessions.

(183) Obviously, discussions on the new ICRP recommendations and their applicability, and on their influence in the current international radiation protection paradigm, were the centre of this field of IRPA12. The Chairperson regarded the motto of the Congress, strengthening radiological protection worldwide, to be in synchrony with one of the ICRP objectives in its recent Publication ICRP 103, in her words: *Similar procedures are used for deciding on the extent and level of protective actions, regardless of exposure situation*. Moreover, she recalled that the ICRP…*is of the opinion that the implementation of protection for what has until now been categorized as interventions could be enhanced by increasing the attention to these common features*. Namely, she expects that the traditional radiation protection paradigm will evolve into one for which a similar procedure be used regardless of the exposure situations, a procedure characterized by optimization plus source related restrictions. She also underlined a number of future challenges for ICRP, among them: follow-up of scientific advancements -particularly on alpha emitters and cancer risk-; tissue reactions and other non-cancer effects of radiation (as presented in the first part of IRPA12) the implementation of the recommendations in ICRP Publication 103, as basis for the revised BSS; developing specific recommendations for emergency and existing exposure situations and for NORMs and radon exposures; developing a practical framework for the protection of the environment; reinforcing the dialogue with experts, professionals and regulators; and enhancing radiation safety culture in the medical field.

(184) On developing a *radiation protection framework* it was noted the fundamental importance of , training and staffing. Effective radiation protection will only be ensured by an adequate number of competent persons at the appropriate levels. Important to develop and maintain national capability to meet radiation protection needs, addressing initial training at all levels for all personnel; and maintaining competence. For building competence, mixing national, regional and international resources will bring greater effectiveness and accelerate implementation of international standards and recommendations and promote better sharing of knowledge and experience. Sustainability must be the objective and knowledge management must be addressed to ensure retention of expertise. In sum, for developing radiation protection infrastructure the initial focus should be on education and training of the Regulatory Body. There was a special round table on this subject and its key issues, challenges and conclusions are reported elsewhere.

(185) There continues to be an increasing recognition of the importance of, and interest in, safety and security of radioactive source. Of the papers submitted, there was an almost equal representation between safety and security issues. Safety and security concerns are also a global responsibility. Accidents or the potential malicious misuse of radioactive material can affect any country and all countries must work together to ensure that sources are managed safely and securely.

(186) Orphaned radioactive sources continue to represent a large safety and security risk due to their uncontrolled nature. It is important that efforts to detect and remediate these sources, as well as prepare for any related emergency situations continue to be developed. More synergies and integration between safety and security. Safety Fundamentals SF-1 explicitly mention that safety measures and security measures must be designed and implemented in an integrated manner.

(187) While acknowledging important achievements of the world community in the field of radiological security, IRPA12 noted that there remains much work to do in many countries. The international radiation protection community has a leading role to play in meeting this challenge.

(188) The topic of *developing protection policies, criteria, methods and culture* was dominated by the following basic question: Who can take actions to protect from radiation, where their empowerment comes from and what knowledge they need to act appropriately? …and to the answer that is being given in nuclear energy activities approaches to seek social consensus building and to gain the public trust and confidence (stakeholder involvement).

(189) A renewed interest was shown for *the protection of the public and the environment*. It is of interest to mention that there is some evolving work in environmental monitoring and techniques derived from improvements in instrumentation and software or requirements in decommissioning of installations including the legacy of old uranium mines.

(190) *Radiation protection of environment* (non-human species) is progressing at national and international level. Nevertheless it was noted that the radiological protection of the environment is not an urgent or important issue in developing countries, which obviously have other priorities. The Congress shown that many safety criteria and guides on this topic are being developed. There have been important development of methodologies and tools to assess the

protection of animals and plants, pointing up the presentation of the tool developed within the European Project ERICA.

(191) In *occupational radiation protection* it is to be noted that except for medical applications the occupational exposure related to manmade sources have decreased. In the medical field, interventional procedures were identified as a critical occupational protection issue for the medical practitioners. The estimated collective dose due to occupational exposure involving natural sources is about 8 times higher than in other occupations (with high average individual effective dose and large number of workers, the largest component being from mining). An important issue for practical occupational radiation protection was the development and application of dose constraints; many good examples for design and operation phases were presented at IRPA12. It was also noted that a prerequisite for the application of the principle of optimization of occupational radiation protection is information exchange on methods for dose reduction through networking

(192) The UNSCEAR 2008 data on *medical exposures* are alarming. The justification of medical exposure continues to be a challenge: quantitative assessment of detriment versus benefits? In any case, the increase of patient doses is important and requires attention. Medical imaging has become the largest controllable source of radiation exposure. Moreover, many accidents have been reported in the medical area. How to communicate with patient and public and a scale for rating were identified as important issues. Improving the radiation protection of patients requires engagement of all involved parties to strengthen cooperation. Error reporting systems are required and should be both graded and harmonized. Reducing dose in computed tomography is important and can be achieved by tailoring the protocols for the level of acceptable noise according to the clinical indication and the size of the patient. Diagnostic reference levels (DRL's) should be used appropriately as a tool for optimization after engagement by professional bodies, noting that there is a demand to reduce them. It was recalled again the importance of training, which_should be undertaken before the transition from film/screen to digital imaging. The main aim should be to broaden and share the knowledge of radiation protection to professionals involved.

In the *emergency planning* area it was noted a new focus on malicious acts. Mass casualty events may overwhelm national capabilities of a country with advanced resources – depends on number of casualties. The Polonium 210 incident in London was a good example described at IRPA12; it was the most relevant radiation emergency in the past several years, implying the need to triage thousands of people and assess levels of Po intake for hundreds.

(193) Many new emergency-related support tools were presented: e.g., the ARGOS CBRN decision support system, and the MOIRA system for assessment of alternate rehabilitation strategies for lakes and rivers. It was recognized that this tools must be developed well in advance to be effective. For the after event, it was recognized that there is a new focus on the recovery phase: stakeholder engagement and communication with the public were found to be essential for success: International cooperation and harmonization was recognized as essential, but there was some frustration for the little work presented in this area. Also, there were few presentations on lessons learned, except some big exercises, e.g., Sweden's TOPOFF.

(194) In the area of *medical response in emergencies*, exciting new developments in treating radiation injuries were presented, such as mesenchymal stem cell injection, particularly in France and Japan. There are also new methods for triage using cytogenetic procedures. It was noted however that there are a lack of international criteria on range of issues, such as

decontamination and decorporation. International assistance in medical response may be needed and pre-established arrangements are essential. No every country has developed capabilities in highly specialized treatment of radiation injuries and therefore arrangements for regional assistance should be in place. There are many legal issues related to medical response in emergencies that have to be resolved in advance in order to facilitate availability of medical data in emergency and afterwards and the transportation of patients to assisting country.

(195) The enduring lesson is that consequences will depend dramatically on steps taken to prepare for accident or attack. Arrangements must be in places that include clear authorities and responsibilities among relevant organizations. Criteria and policies for implementation of protective actions must be prepared in advance. Lack of preparation has led decision makers to make mistakes. Actions must be developed in collaboration with public and stakeholders to ensure their support IN ADVANCE. Serious efforts to accelerate international cooperation are urgently necessary. States must recognize that they may NEED assistance, eliminating the 'donor/recipient' mentality).

(196) In closing, a number of countries reported on the implementation of radiation protection programs and national dose distributions and trends. There was a clear need for radiation protection support to developing countries.

2.3. RADIATION SAFETY IN PRACTICE

(197) This field was developed under the motto *towards a practical implementation of radiation protection principles* and covered the areas of radiation safety in nuclear installations, in non-ionizing radiation applications, in medicine, in natural occurring radioactive materials (NORMs) and industry and, in other applications and practices. Three special technical sessions covered the special topics of networking in radiation protection, legal implication of radiation protection and, stakeholder engagement in practice.

2.3.1. Background: *Radiation Safety in Practice*

(198) The Background Plenary Session III on *Radiation Safety in Practice* featured speakers from all intergovernmental organizations involved in the setting of radiation safety standards, which addressed special issues and challenges in relation to radiation safety in practice.

2.3.1.1.Towards an International Radiation Safety Regime.

(199) The role of the IAEA for constructing an international radiation safety regime was presented by E. Amaral (Brazil) Director of NSRW at the IAEA Department of Nuclear Safety and Security, *Radiation Safety in Practice: Towards an International Safety Regime*. It was recalled that the IAEA Statute establishes that the IAEA is "To establish or adopt… [in consultation with…] standards of safety for the protection of health and minimization of danger to life and property…and to provide for the application of these standards". The history of the International Basic Safety Standards (BSS) is long, and the BSS are well established internationally.

(200) The Chernobyl accident impacted on the IAEA programme on safety. Since Chernobyl, there was an international awareness on the need for global institutional mechanism on nuclear and radiation safety. The IAEA Department of Nuclear Safety was created and a formalization of IAEA safety standards development was introduced together with a strengthening of provisions for the safety standards application.

(201) The current BSS review process was presented and, in particular, the conclusions of a number of round tables on specific issues organized by the IAEA were submitted to IRPA12:

- The Round Table on Medical Exposures concluded that: medical exposure still overwhelmingly most significant; stakeholders should remain vigilant; it is essential a close interaction between radiation regulatory body, health authorities and labour authorities; and, information and guidance needs to reach all relevant facilities.
- The Round Table on Denial of Shipment concluded: there is a need to work together – industry, member states and the IAEA; industry needs to report evidence; need effective communication with constituents; interdependency between countries noted – mutual support important; empowerment of those seeking to solve the problem; and, energizing governments to recognise problem and support solutions.
- The Round Table on Upsurge in the uranium mining and production industry concluded: regional approaches to common problems in remediation and developing regulatory control and monitoring systems in Africa, Asia and South America; cooperative approaches with other organizations such as the World Bank, European Bank for Reconstruction and Development *(*EBRD*)* , Organization for Security and Co- Operation in Europe (OSCE) , and the United Nations Development Programme (UNDP); the promotion of the concept of lifecycle planning at an early stage of a uranium mining project; resurrection of the UPSAT peer review programme coordinated by the IAEA; and, in the future, the development of international networks of regulators and operators will play a key role in spreading the principles of Best Practice to uranium producers across the world.

(202) The IAEA concluding remarks were as follows: Currently there is now a single IAEA Fundamentals for Safety and a new structure for safety standards is being designed. There is no room to implement separately radiation, waste, transport and nuclear safety". Integration at all levels is crucial for improvement of safety and of credibility on nuclear energy and application of ionizing radiation, but practitioners at the national level are the one who can ensure radiation protection standards are met, particularly in the revival of nuclear energy, uranium mining and development of new technologies in the medical area.

2.3.1.2.The Inter-Agency Committee on Radiation Safety

(203) Extremely important for building an international safety regime, and in particular for the revision of the BSS, is the Inter-Agency Committee on Radiation Safety, IACRS. This was presented by IACRS Chair, Renate Czarwinski (Germany-IAEA), in collaboration with D. Byron (USA-FAO), Z. Carr (Kazakhstan-WHO) , M. Crick (UK-UNSCEAR), A. Janssens (Belgium-EC), P. Jimenez (Spain-PAHO) , E. Lazo (USA-NEA) , S. Niu (China-ILO), "*An effective tool for harmonization"*. It was recalled that in 1990, an important step towards international harmonization of radiation protection and safety took place: the IACRS was constituted as a forum for consultation on and collaboration in radiation safety matters between international organizations. IACRS role is to promote consistency and co-ordination of policies

with respect to areas of common interest in radiation protection and safety, such as: applying principles, criteria and standards and transferring them into regulatory terms; coordinating research and development; advancing capacity building including education and training; promoting widespread information and sharing of knowledge; facilitating the transfer of new technology; and, providing services. It is a forum for the exchange of information between the agencies/organizations on their respective activities with view to ensuring as far as possible the harmonization of their respective plans and activities related to radiation safety, in order to avoid unnecessary duplication of radiation safety standards and recommendations. It is constituted by the following UN Agencies/organizations: UNSCEAR, IAEA, ILO, WHO, PAHO and FAO. Other intergovernmental Agencies/organizations involved are: NEA/OECD and the European Commission. Observer organizations are: ICRP, ICRU, IEC, IRPA, and ISO.

(204) An important work of IACRS was the setting for the development of the current BSS (SS115) published in 1996 -jointly sponsored by six organizations. Other common work were the Safety Requirements entitled Arrangements for Preparedness for a Nuclear or Radiological Emergency published in 2002 - jointly sponsored by seven int. organizations, the Safety Requirements for Geological Disposal of Radioactive Waste published in 2006 - jointly sponsored by two int. organizations, and the Fundamental Safety Principles (SF-1) published in 2006 jointly sponsored by nine int. organizations. Co-sponsorship of safety standards strengthen the safety standards in that it is expected that each of the cosponsors uses the safety standards as a basis for their work and in the advice to their Member States. It leads to the expectation that each of the cosponsoring organizations would be fully integrated into the development of the safety standards and into any further review and revision of a safety standard that they had already co-sponsored and that the co-sponsoring organizations will exchange information in relation the need for the development, or review and revision of safety standards, and on their experience in the application of the safety standards. The future is clear: international agencies/organizations must provide consistent advice and assistance to the various governmental agencies of their Member States. To achieve this, they will need to develop: broad agreement, through discussions among IACRS member organisations, concerning the consistent interpretations of the precautionary principle as it applies to specific cases (e.g. radon, worker protection, environmental protection, etc.) to facilitate its harmonious implementation; and effective networking processes and procedures to help to assure consistent and coherent international approaches to RP issues.

2.3.1.3.Emerging Challenges in the Management of Medical Exposures

(205) The views from PAHO (Pan American Health Organization), WHO, EC, IAEA on emerging challenges in the management of medical exposures were presented by Pablo Jiménez (Spain) from PAHO. The basic facts were presented as follows: medical exposure is by far the largest radiation source other than natural background; the availability and use of medical radiation facilities varies widely around the world, in some industrialized countries medical exposure is already the largest source of exposure, medical exposure is different from other uses of radiation: too little or too much dose is bad in both diagnosis and therapy, there is minimally trained staff causing unsafe radiation conditions for patients, and medical exposure is the less regulated type of exposure. The challenges are multiple: technological, regulatory application of the international standards, justification, optimization, and dose limitation. The main technological issues are: the worldwide introduction of complex radiotherapy techniques, the use of CT and PET/CT for clinical and also for screening purposes, image guided intervention procedures, development of hybrid imaging modalities, and change in the pattern of usage :

children & young, dose trends per procedure. The country status is relevant for the application of the BSS – for example, each country has different needs for harmonization. On justification, the issues are many: generic justification: health authorities and medical professional societies, individual justification: referring and radiological medical practitioner, particular attention to pregnant, breast-feeding and paediatric patients, opportunistic screening: health authorities should be able control and influence the process through policies and assure that patients are informed about benefits, risks and limitations. On optimization of protection the issues identified were: calibration of equipments and performing the clinical dosimetry by a medical physicist, implementing a QA program under the supervision of a medical physicist, and performing QC tests at the time of acceptance & commissioning, periodically thereafter and after any major maintenance that could affect patient safety. On dose limitation it was recalled that dose limits do not apply to medical exposures. However, there is need for the establishment of diagnostic reference levels as dynamic values which are tools for optimization (not "limits") and dose constraints (not "limits") for carers and comforters as well as for volunteers in biomedical research, all in consultation between health authorities, medical professional societies and the regulatory body.

2.3.1.4.Emerging Challenges in the Management of Occupational Exposures

(206) The emerging challenges in the management of occupational exposures were presented by Shengli Niu (China) of the International Labour Organization. The ILO is a tripartite organization with worker and employer representatives taking part in its work on equal status with those of governments. The number of the ILO member countries now stands at 181. In 1969 the ILO was awarded the Nobel Peace Prize. Its mandate is to promote social justice and internationally recognized human and labour rights. The promotion of social justice as a fundamental value prominently includes workers' protection. The protection of the worker against sickness, disease and injury arising out of employment is one of the tasks assigned to the ILO in the words of the Preamble of its Constitution. Four strategic objectives of ILO were described as follows: fundamental principles and rights at work and international labour standards; employment and income opportunities; social protection and social security; and social dialogue and tipcarts. The areas of improvement listed in the Preamble of the ILO Constitution include: regulation of the hours of work including the establishment of a maximum working day and week; regulation of labour supply, prevention of unemployment and provision of an adequate living wage; protection of the worker against sickness, disease and injury arising out of his employment; protection of children, young persons and women; provision for old age and injury, protection of the interests of workers when employed in countries other than their own; recognition of the principle of equal remuneration for work of equal value; recognition of the principle of freedom of association; organization of vocational and technical education, and other measures.

(207) Standard-setting, including radiation protection standards, is one of the ILO’s major means of action to improve conditions of life and work worldwide. ILO standards are Conventions and Recommendations adopted by the International Labour Conference, which between 1919 and 2008 adopted 188 Conventions and 199 Recommendations, many of them related to occupational safety and health. Convention (No. 115) and Recommendation (No. 114) concern with the protection of workers against ionizing radiations; they were adopted in June 1960 at the 44th Session of the International Labour Conference. Convention (No. 115) applies to all activities involving exposure of workers to ionizing radiations in the course of their work and provides that each Member of the ILO who ratifies it shall give effect to its provisions by

means of laws or regulations, codes of practice or other appropriate methods. The Convention (No. 115) and Recommendation (No. 114) lay down basic principles and establish a fundamental framework for radiation protection of workers. They also contain provisions concerning the protective measures to be taken, the monitoring of radiation and the medical supervision of workers.

(208) In addition to the BSS, the relevant standards concerning the radiation protection of workers is the ILO Code of Practice on Radiation Protection of Workers (Ionizing Radiation). ILO is fully engaged in the inter-Agency cooperation for revision of the BSS and ensure employers' and workers' participation in the process. The main issues identified include: pregnant workers (e.g., difference in dose limits for woman and foetus), genetic susceptibility, gender susceptibility, exposure of the eye lens, exposure to radon and progeny, definition of occupationally exposed workers, quality management, classification of areas (more practical guidance on how to define these areas was requested), occupational exposures of air crews, occupational issues in the decommissioning of older nuclear facilities that may not have been designed for ease of decommissioning, an increasing need to manage disused radioactive sources and a challenge for greater international co-operation, the consideration of radiation protection as an integral part of sound and effective health and safety management system that should not be considered in isolation, the need to maintain and develop expertise and competence in the field of radiation protection and particularly the need to encourage young people to follow a career in this discipline, the need to develop and improve methodologies for dose assessment which meet the requirements including greater development of electronic dosimeters and the continued refinement of internal dose models, a greater use in learning lessons from 'events' in terms of operational learning experience, the implementation of standards in developing countries, the radiation exposure control of workers of multinationals, maintaining the safety of migrant workers in developed countries, the harmonization of standards and interagency initiatives to increase the basic level of safety for the workers through for example the 'Action Plan for Occupational Radiation Protection'. In conclusion, there is a full menu for future practical works in occupational radiation protection.

2.3.1.5.Emerging Challenges in the Management of Public and Emergency Exposure

(209) The emerging challenges in the management of public and emergency exposure were presented by Hans Riotte (Germany – OECD/NEA) on behalf of EC, FAO, IAEA, OECD/NEA, and WHO. The evolution of the radiation protection system since the ICRP foundation in 1928 can be summarized indicating that it experienced a continuum of incremental enhancement incorporating scientific developments, social values and experience. The key challenges will be in terms of managing public and emergency exposures. For that, it is convenient to recall two old definitions related to radiation protection: it is not only a matter for science, but it is a problem of philosophy, and morality, and the utmost wisdom; and the establishment of maximum permissible radiation levels is a non scientific task, which however must be based primarily on scientific knowledge and judgment. Thus, the nature of radiological protection is the search for the most appropriate level of protection under the prevailing circumstances, implying assessment of risks and protection options, and judgment in decision-making.

(210) Key generic challenges are: balance between harmonized approaches and case specific solutions; applying the precautionary principle requires increased transparency and stakeholder engagement, and citizen vigilance, as a check and balance to governmental and regulatory decisions, is increasing.

(211) The public exposure challenges include: structures and procedures for optimum engagement with stakeholders (transparency of process, role of actors, trust in institutions), integration of emerging science (e.g., bystander effects; cardiovascular diseases, new epidemiological evidence -radon), and management of radon exposure (focus on high-end or average of concentrations?, new reference levels?, programmes for synergies of radon and smoking?, global approach to indoor air quality?, focus on specific groups at risk?).

(212) The emergency exposure challenges include: implementing new ICRP 103 approach, broadening range of emergency situations (e.g. RDDs), stakeholder involvement in planning and late phase consequence management, objectives and processes for recovery, integrated approach to consequence management, and the impact of economics on decision-making.

(213) In order to address these challenges international organizations, building on their specific strengths, should continue to work together on: BSS development, radon exposure management, stakeholder engagement studies, international emergency exercises, international standards, and international Action Plans. Although national structures and approaches differ, the identification of commonalities and good practice can efficiently facilitate the development of harmonized national and international solutions.

2.3.2. Radiation Safety in Nuclear Installations

(214) This area of knowledge addressed the nuclear fuel cycle industry views on the following topics: *radiation safety in nuclear reactors and other fuel-cycle facilities* including current radiation protection performance and its supporting robust track records, radiation protection policies and policy-making evolution, international policy developments (risk from low-dose of ionising radiation: scientific development/knowledge and key implications on public risk perception and on public policy making and environmental protection), radiation protection areas for improvements (e.g. programs, technologies, culture, etc.), perspectives on nuclear energy development, the radiation protection system for practices: the success of keeping it simple and flexible, clearance and exemption, global consistency of radiation safety standards, intervention –improved guidance for decision-making out of normal regime, worldwide industry radiation protection cooperation, staffing, education and training in the nuclear industry, and stakeholder involvement: industry practical experiences; *decommissioning and restoration* including radiation protection issues on site decommissioning, restoration and post-decommissioning, and stakeholders involvement; and *radioactive waste management* including liquid and gaseous discharges treatment, solid waste management and disposal (very low level radioactive wastes, low and intermediate level radioactive wastes, long-lived radioactive wastes, high level radioactive wastes), and stakeholders involvement.

2.3.2.1.Radiation Safety in Nuclear Reactors and Other Nuclear-Fuel Cycle Facilities

(215) Topical Sessions TS III.1.1 were Eduardo Díaz (ediaz1@ciudad.com.ar), Sylvain Saint-Pierre (saintpierre@world-nuclear.org, Dominique Minière (dominique.miniere@edf.fr), and Alejandro Leciñana (alecinan@conuarfae.com) and those of Topical Sessions TS III.1.2 were Hideki Toyomatsu (miyazaki.shinichiro@e5.kepco.co.jp), Saint-Pierre, (saintpierre@world-nuclear.org),Alberto Andino (aandino@conuarfae.com), Ralph Andersen (rla@nei.org) and Analía Saavedra (asaavedr@sede.arn.gov.ar).

(216) These sessions. which were organized in cooperation with the World Nuclear Association, covered radiation safety in nuclear reactors and other nuclear-fuel cycle facilities. They benefited from an excellent participation from senior industry executives, The participation included Mr. Alerto Andino, Director and CEO, CONUAR (Argentina), Dr. Filho Tranjan, President, INB (Brazil), Mr. Hideki Toyomatsu, Executive Office, Kepco (Japan) and Mr. Dominique Minière, Deputy Senior VP, EdF (France). Their main reflections and conclusions are summarized in the 'concluding' section of this part.

2.3.2.2.Radiation Safety in Decommissioning and Restoration

(217) The Topical Session TS III.1.3 was *Radiation Safety in Decommissioning & Restoration*. The session officers were Roger Coates (coates.roger@tiscali.co.uk), N. Zoubek (norbert.zoubek@sanofi-aventis.com), Borislava Batandjieva (borislava.batandjieva@chello.at), Natalya Shandala (Shandala@srcibph.ru) and Roberto Añasco (anasco@cnea.gov.ar).

(218) The session underlined that there are many types of facilities worldwide, which are nowadays under decommissioning process, including nuclear power plants, research reactors, nuclear fuel cycle facilities (from mining to the fuel treatment), research facilities and installations (accelerators, medical installations, laboratories), and waste management facilities.

(219) Decommissioning is a young and growing field and from the beginning planning is a key point to have success. As it is an interdisciplinary activity, requires a multi industrial team and good expertise.

(220) The stakeholders and the regulatory authority must be involved in "preparing" the preliminary papers in order to solve all the problems during the process. Transition from an operational facility to decommissioning is not an easy change because the change of "culture".

(221) Clear objective will let organize all the secondary activities and make the best recommendation over reuse or not the field for future nuclear activities. Nowadays IAEA´s publications have been developed to cover all radiological Safety aspects. Systematic approach to ALARA and sharing experience, and the international cooperation get more and more important in the future.

2.3.2.2.Radiation Safety in Radioactive Waste Management

(222) The Topical Session TS III.1.4. was on *Radiation Safety in Radioactive Waste Management*. The session officers were Piero Risoluti (piero.risoluti@casaccia.enea.it, David Allard (djallard@state.pa.us), Jean Christophe Niel (Jean-christophe.niel@asn.fr), Pedro Carboneras (pcam@enresa.es), and Elsa Piumetti (epiumett@cae.arn.gov.ar).

(223) The session featured experiences and proposals of both the operators and the regulators. Many paper were presented from countries that currently find themselves under the "strengthening-the-national-infrastructure-and-regulator-framework" phase and from countries with regulatory bodies and regulatory framework both consolidated. Operators showed their experiences in the management of radioactive wastes, including disposal, their future projects an the profits and advances; covering the spectrum of installations which goes from the nuclear medicine to the NPPs.

(224) In general, all participants joined in and concluded in the radioactive waste characterization as a fundamental process to optimize the options for the "disposal" and the "long term storage". In relation to this topic, mathematic models were presented for the radioactive waste characterization and its application to specific installations / processes. It is worth to mention the presentation of pieces of research work about new ideas and technologies applicable to the radioactive waste characterization as well as to the enhancement of the radioactive inventory of certain radioactive residues types.

(225) Finally, it is important to indicate that everyone brought out the need to work all together towards a harmonization in the "national policy and the corresponding strategies", taking into account the very long times that the radioactive wastes management implies and therefore involves the future generations. Despite all efforts (that could be seen in this session) by the international community, a number of issues remain over which international consensus is yet to be achieve.

2.3.3. Radiation Safety in Non Ionizing Radiation Applications

(226) The original intention of the organizers of IRPA12 was to present a Congress dedicated to both ionizing and non-ionizing radiation with a wide coverage of both ionizing an non-ionizing radiation protection. Experts and authorities of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) were invited to join the Programme committee at this effect, and they did it with the financial help of SAR. However, surprisingly, ICNIRP decided to continue to hold a separate workshop from the IRPA Congresses as it did in the past.

(227) Notwithstanding the above inconveniences, IRPA12 continued to offer the planned technical sessions on non-ionizing radiation protection where individual contributions were presented, the various topics discussed and conclusions reached. The officers in charge of session II. 2.1. were Agnette Peralta (apperalta@co.doh.gov.ph, Altair Souza de Assis (altair@vm.uff.br; altairsouzadeassis@gmail.com), John Swanson (john.swanson@ngtgroup.com) and Patricia Arnera (parnera@ing.unlp.edu.ar) and Claudio Muñoz (cmmunoz@itba.edu.ar), and of sessions II2.2.,3. and 4. were Paolo Vecchia (vecchia@iss.infn.it), Víctor Cruz Ornetta (vcruz@inictel.gob.pe) and Jorge Skvarca (jorgesk@hotmail.com) and Claudio Muñoz (cmmunoz@itba.edu.ar).

(228) The following topics were addressed at these sessions: *power frequency electric and magnetic fields* including public exposures from power frequency fields – power lines, delivery cabling and domestic wiring, occupational exposures from power frequency and other ELF fields, welding, smelting, induction, measurements and computational modeling of interaction of ELF fields with people, measures to control and, where relevant, reduce ELF exposures, risk analysis, communication and management of ELF and health, and development of technical standards and exposure guidelines on ELF; *mobile telecommunications*, including public and occupational exposures from mobile phones, base stations, emergency radio systems etc, measurements and computational modelling of interaction of RF fields with people, measures to control and, where relevant, reduce RF exposures, risk analysis, communication and management of radio-frequencies and health, development of technical standards and exposure guidelines on radio-frequencies; *optical radiation and ultrasound* including public and occupational exposures from ultraviolet radiation devices (e.g., sun-beds), and public and occupational exposures from lasers and other high intensity lights and lighting systems, use of lasers and other high intensity light sources in medicine and for cosmetic purposes, public and

occupation exposures from infrared emitting devices, infrared heaters and saunas, measurements and computational modelling of interaction of optical radiation with people, occupational, diagnostic and therapeutic exposures to ultrasound, measurements and computational modelling of interaction of ultrasound with people, measures to control and, where relevant, reduce optical radiation exposures, risk analysis, communication and management of optical radiation and health, development of technical standards and exposure guidelines on optical radiation, development of technical standards and exposure guidelines on ultrasound; and, *emerging EMF technologies* including occupational, patient and volunteer exposures from magnetic resonance imaging (MRI), public and occupational exposure to wireless communication devices (body-worn transmitters, WiFi, baby alarms, etc.), public and occupational exposure to electronic personal identification, electronic articles surveillance, radiofrequency identification and metal detection devices, measurements and computational modelling of interaction of fields from emerging, technology devices with people, measures to control and, where relevant, reduce EMF exposures, risk analysis, communication and management of emerging EMF technologies and health, and development of technical standards and exposure guidelines on emerging EMF technologies.

(229) In addition, the customary ICNIRP report was presented at IRPA 12.

2.3.4. Radiation Safety in Medicine

(230) This area of knowledge addressed radiation safety in *diagnostic radiology, interventional radiology, nuclear medicine* and *radiotherapy*. In each of this sub-areas, the following topics were considered: design, shielding and monitoring of new medical radiation facilities, including PET/CT facilities, nuclear medicine department, therapeutic nuclear medicine facilities (wards, theatres and holding tanks), and radiotherapy facilities (including particle therapy); assessment and monitoring of patient dose in diagnostic and interventional radiology, computed tomography, diagnostic and therapeutic nuclear medicine, pet/ct, radiotherapy (including particle therapy), and paediatrics; addressing the issue of optimization, including optimization protection taking account of dose and diagnostic outcome, quality assurance, health screening (e.g. ct "health-checks", breast screening, colon screening, osteoporosis screening), benefit versus risk to research subjects, dealing with pregnancy and potential pregnancy issues; lessons learnt from incidents, near-misses and accidents; and, education and training.

2.3.4.1.Radiation Safety in Diagnostic Radiology

(231) The officers of session TS III 3 1 on *radiation safety in diagnostic radiology* were Michel Bourguignon (Michel.BOURGUIGNON@asn.fr), C. Milu (cmilu@ispb.ro), Caridad Borras (cariborras@starpower.net) Ruby Fong (Ruby.Fong@bartsandthelondon.nhs.uk) and Alfredo Buzzi (alfredo.buzzi@diagnosticomedico.com).
(232) This Topical Session covered, and conventional diagnostic radiology and computed tomography. The main topics covered were: quality control; measurement (methods, analysis, devices); phantoms and software development; Monte Carlo simulation on *Voxel* phantoms; dose audits at local, national, regional levels, all showing large variations; mean doses, which were largely falling within international reference doses; paediatric doses in computed tomography, which in some cases similar to adult doses!; proposals for establishment of DRLs for adult and children; methods for analysis and audit image quality; technology changes, such

as faster film-screen (FS) combination; computed radiography (CR); direct digital radiography (DDR)/flat panel; and fluoroscopy.

(233) In summary, it was concluded that:

- Dose evaluation and DRLs are effective optimization tools
- It is important to evaluate Image Quality (IQ) and establish optimized dose-IQ relationship
- The sequence survey-training-resurvey can be used as a model of optimization
- There is need to develop optimized scan protocols for paediatric patients
- Use DLP instead of tube loading for CT shielding calculation
- Use of voxel phantoms for dose evaluation where available

2.3.4.2.Radiation Safety in Interventional Radiology

(234) The officers of the Topical Session on *Radiation Safety in Interventional Radiology,* were Claire Cousins (dpd24@cam.ac.uk), Ariel Duran (aduran@hc.edu.uy), Eliseo Vañó (eliseov@med.ucm.es), Robert Corbett (rhcorbett@btopenworld.com) and Amalia Descalzo (adescalzo@arnet.com.ar).

(235) The sessions concluded that the practice is safe and highly beneficial to patients, but the levels of radiation are among the highest used in medical imaging and therefore a number of recommendations were made, as follows:

- ICRP recommendations should be followed in order to protect properly the patients undergoing interventional radiology.
- Medical doctors employing fluoroscopically-guided procedures need to be trained and certified in for this practice.
- X-ray systems used for interventional radiology should be submitted to a strict acceptance and commissioning process.
- Industry should continue to implement dose saving options for interventional systems and improve standardization and archiving dosimetry data.
- Occupational dosimetry should be improved.
- Patient dose surveys and the use of reference levels should be extended, including paediatrics

2.3.4.3.Radiation Safety in Nuclear Medicine

(236) The officers of Topical Session TS III.3.3 on *Radiation Safety in Nuclear Medicine*, were Bangül Günalp (bgunalp@yahoo.com), Michael Stabin (michael.g.stabin@vanderbilt.edu), Mario Marengo (mario.marengo@aosp.bo.it), Alfred Hefner (alfred.hefner@arcs.ac.at) and Silvia Vazquez (svazquez@fleni.org.ar).

(237) The session reached few but important conclusions, as follows:

- High cause of concern are the occupational exposure doses of PET facilities
- Issue of concern is the lack of clear guidelines for the design of PET/CT installations
- Some references on patient doses from Nuclear Medicine exams
- Great importance on the dosimetric calculation using anthropomorphic phantoms with high fidelity reproduction of patient characteristics (*voxel* phantoms)

2.3.4.4.Radiation Safety in Radiotherapy

(238) The officers of Topical Session TS III.3.4, on *Radiation Safety in Radiotherapy*, were Pablo Jiménez (jimenezp@paho.org), Maria Helena da Hora Maréchal (mhelena@cnen.gov.br), Albert Lisbona (a-lisbona@nantes.fnclcc.fr), Pedro Ortiz (P.Ortiz-Lopez@iaea.org) and Norma Acosta (nacosta@fuesmen.edu.ar).

(239) This session featured a total of 50 papers (both oral and as a poster). Most of them were related to optimization in treatment planning, beam calibration and characterization, and radiation shielding. Other issues presented were on radiotherapy technology, treatment delivery and verification, and proactive safety assessment for avoiding accidental exposures.

(240) Several cases of Monte Carlo simulations of dose distributions and special new phantoms for quality control of complex treatments were presented. Other specific methods for validation of dose verification or estimation patient doses and distribution in common treatment situations were also presented.

(241) Comparison of different methods for determination of absorbed dose to water in reference conditions and in irregular fields was analyzed in several papers. These methods included the use of different ionization chambers, development of algorithms, postal audits, and measurements with bipolar phototransistors.

(242) The occupational exposure was estimated in several types of facilities including proton and particle radiotherapy facilities. Estimation of neutron doses and instruments for neutron measurements were also presented.

(243) The evaluation of compliance with appropriate manufacturing standards of ^{60}Co units and the specifications of an Electrostatic-Quadrupole accelerator facility for Boron Neutron Capture Therapy were presented. An innovative dosimeter was proposed for on-line in vivo quality assurance consisting in an Optically Stimulated Luminiscence detector.

(244) A proactive safety assessment to avoid accidental exposures for treatment with accelerators was presented. This approach allows systematic identification of and anticipation to all potential causes and help establishing priorities in terms of QA.

(245) It was concluded that new highly conformational RT demands new challenges such as dose escalation, reduced margins, steep gradients or high accuracy in terms of dose calculation, delivering and verification. Tools such as inverse planning or Monte Carlo simulations are needed for those techniques to validate its safety. In addition, since radiation therapy is the practice where the radiation dose intentionally applied to human beings is the highest, the application of the requirements for QA must be more exigent to assure radiation safety.

2.3.5. Radiation Safety for NORMs

(246) The congress provided an extensive coverage of problems associated with naturally occurring radioactive materials in industry, including on the following NORMs-related topics: natural versus «artificial» radiation; exclusion and exemption for natural occurring radioactive materials; framework for work activities and use of raw materials; jurisdiction at local and national level; case studies including, mining and processing of metal ores, phosphate industry, oil and gas industry with its sub-product of radioactive scales, coal production of energy and use

of fly ashes, building materials, production of mineral sands, titanium and rare earths industries, zirconium industry, and thorium; and application of international standards.

(247) The session was divided into four topic areas: TS III 4.1 NORM Uranium Mining and Processing, TS III 4.2 NORM Other Minerals Mining and Processing, TS III 4.3 NORM in Oil and Gas Industries, TS III 4.4 NORM and Radon Issues in Building, which will be presented separately hereinafter. Papers presented in these Topical Sessions covered a wide selection of the many situations where exposures to NORM have been identified. In general papers could be classified under one of three topics. Firstly there were papers that reviewed exposures from NORM in variety of situations reflecting the growing awareness of the wide spread nature of NORM exposures. The second category concentrated on measurement methods of assessing levels of NORM and NORM exposures and modeling doses to humans. The third category was the management and regulation of NORM.

(248) Papers reviewing NORM industries showed a wide variety of NORM industries covering areas such as uranium, rear earth minerals, coal, gas and oil industries as well as phosphate industries and mineral processing industries. In these industries NROM can concentrate in products, by -products and residues. Resulting exposures might be low doses to large populations or larger dose to a smaller number of people. Occupational exposures are often significant in many NORM industries.

(249) The measurement of activity or activity concentration levels in NORM materials can often be very difficult due to the fact that many NORM radionuclides are part of long radioactive decay chains. Often industrial processes separate different nuclides causing disequilibrium. Some of the radionuclides of most interest such as: radium, radon, thoron, ^{210}Pb and ^{210}Po are difficult to measure. When modeling exposure pathways there are lots of assumptions made which are to cover a wide variety of situations. Assessing doses to individuals requires the development of metabolic models for internal exposure.

(250) Because of the variability of sources and exposures there is no one simple solution to the management of NORM. A wide variety of regulatory instruments required which will be based on a graded approach which would incorporate Exclusion, Exemption, Clearance, Notification, Registration and Licensing. Under the new system if radiation protection outlined in ICRP 103, NORM exposures should be managed as Planned or Existing Exposure Situations. The application of dose constraints or reference levels as part of the optimization process is required.

2.3.5.1.Radiation Safety in Uranium Mining and Processing

(251) The officers of the Topical Session TS III.4.1., on *Radiation Safety s in Uranium Mining and Processing,* were Philippe Bosquet (philippe.bosquet@areva.com), Fernando Carvalho, (fernando.carvalho@itn.pt), Peter Waggitt (P.Waggitt@iaea.org), Antonio Oliveira (oliveira@abacc.org.br) and Gabriela Gnoni (ggnoni@cae.arn.gov.ar).

(252) This session featured 7 oral presentations and 3 posters presentation and coming from 9 countries. These included techniques for the monitoring and surveillance of uranium and its decay products at uranium mines, the environmental impact of uranium mining and milling, the radiological impact on workers and the development of regulatory policy for uranium mining. Important themes and conclusions could be drawn from the papers.

(253) The uranium industry is undergoing a renaissance. This has led to a rapid expansion of operations and highlighted a shortage of trained and experienced radiation protection professionals. There was a strong recognition that this situation can not be put right overnight. There is a need for development of uranium mining regulations and radiation protection procedures in many countries experiencing an expansion of uranium mining. A culture of productive interaction between regulatory and operators should be developed. All parties need to work to achieve high levels of excellence in the management of radiation health, safety, waste and the environment. A strong safety culture should be based on internationally shared principles and "best practices standards" and is particularly needed in emerging uranium producing countries.

(254) Social acceptance will depend on proper management and public education is also required to allay unnecessary concerns regarding uranium mining. International organizations (IAEA, WNA, ICRP, IRPA, NEA) have an important role to play in disseminating guidance and information.

(255) In summary:

- As the uranium industry is undergoing a renaissance, proper radiation safety procedures and regulations are needed
- There is shortage of trained and experienced radiation Safety professionals associated with the mining industry that cannot be overcome overnight.
- Public education on these issues should be increased.
- Full interaction between regulators and operators must be stressed.
- All parties directly involved in uranium mining and processing strive to achieve the highest levels of excellence in the management of radiation, health and safety, waste and the environment applicable to sites throughout the world. A strong safety culture based on a commitment to common, internationally shared guiding principles is sustained.
- These principles hold special relevance for emerging uranium producing countries that do not yet have fully developed regulations.
- "Best practices standards" need to be introduced.
- Social acceptance of this industry will depend on the proper management of these principles.
- The role of international organizations (i.e., IAEA, WNA, ICRP, and IRPA) was highlighted.

2.3.5.2.Radiation Safety in other Minerals Mining and Processing

(256) The officers of Topical Session TS III.4.2., on *Radiation Safety in other Minerals Mining and Processing*, were Peter Waggitt (P.Waggitt@iaea.org), Julian Hilton (aleffoffice1@aol.com), Peter Burns (Peter.Burns@arpansa.gov.au), John Selby (John.selby@rbm.co.za) and Marcela Medici (mmedici@cae.arn.gov.ar).

(257) This session featured 4 Oral Presentations and 16 posters presentations. A wide variety of industries generate waste streams or product steams that are enhanced in NORM. Examples of industries covered in this session were: thorium in rare earth minerals, phosphate industries, the coal industry, scale on water pipes and areas of elevated background radiation. Several papers gave comprehensive reviews of NORM industries in various countries to document the scale and scope of the problem. NORM industries usually produce large volumes of low activity material which has the potential to give rise to chronic low level exposures often over

many years. Papers were also presented on methods of modelling the distribution of NORM and evaluations of exposures from NORM and estimation of dose.

(258) Following the publication of ICRP 103 it is clear that the system of radiation protection includes the management of NORM either as planned exposure situations or as existing exposure situations. In applying these recommendations regulatory instruments and management tools need to be flexible to handle wide variety of situations. Application of the optimisation principle is very applicable in the case of NORM. Legacy sites and decommissioning were discussed in several papers.

(259) The main conclusions can be summarized as follows:

- Need to define the limits of regulations
- Need to talk about a graded approach
- Need to encourage flexible regulation to set site specific and local conditions
- Need to use evidence based on realistic scenarios
- It was stressed the need of stakeholders involvement
- It was stressed the need to encourage interchange of staff between industry operators and regulators to improve training in NORM industry
- A number of situations with unacceptable doses were identified but the conclusion was that they can be easily handled
- The assessment of occupational exposures at two NORM industries resulted that the higher doses corresponded to areas with very low occupational factors

2.3.5.3.Radiation Safety in Oil and Gas Industries

(260) The officers of Topical Session III.4.3. on *Radiation Safety in Oil and Gas Industries*, were Antonio Oliveira (oliveira@abacc.org.br), Rafat M Nassar (rafat.nassar@aramco.com), Ruth Mc Burney (rmcburney@crcpd.org) and Analía Canoba (acanoba@cae.arn.gov.ar).

(261) Several papers reported on countrywide surveys with the aim of getting a picture of the scope and scale of the problem. There were reviews of NORM in various Brazilian facilities and of oil fields in equatorial regions of South America. Papers reported on the development of safety manuals, management strategies and regulatory frameworks in other countries including Saudi Arabia and Belgium.

(262) Particular problems identified were scales and sludges on pipes and in pumps and tanks. Radon was also identified as a problem in many situations. Several papers were presented on measurements techniques and the assessment of dose from NORM exposures. There were also several papers on decommissioning of old plant and facilities.

(263) Papers on surveys in oil fields show large volumes of scales and sludges with activity concentrations that give dose rates that range from background to 150mSv/h, with one report of a pump giving 400mSv/h. Very high levels of radon gas, 400kBq/m^3, were reported in a propane gas stream. Several papers concentrated on the disposal of NORM wastes and the decomissioning of equipment and installations which have been contaminated by NORM.

(264) Papers were also presented on the occupational health and safety problems associated with maintainence of pipes and equipment while others concentrated on the development of measurement techniques for assessing levels of NORM. Measurements of radium isotopes were

used to assess Th/U ratios in geological formations a paper was presented on the use of liquid scintillitation techniques for the measurement of ^{222}Rn, ^{228}Ra, ^{226}Ra, ^{210}Pb and ^{210}Po.

(265) It was concluded that the NORM management strategy in these industries shall be defined, with cleaning or maintenance of contaminated components requiring special precautions. It was also noted the need of disposal sites for NORM wastes from these industries. And in relation to the decommissioning of installations it was noted the large amount of scales and sledges with contaminate with NORMs that the industry produces. In this regard, the upcoming challenges are occupational and disposal aspects, in particular the need of a permanent solution to the waste problem. Protective measures are needed to reduce occupational doses. There is also a need of defining the adequate way for storage of wastes and of development and research for reducing waste volumes.

2.3.5.4.Radiation Safety for Radon Issues in Buildings

(266) The officers of Topical Session TS III.4.4, on *Radiation Safety in NORM and radon issues in buildings*, were Geoff Webb (geoffrey.webb@physics.org), Serena Risica (serena.risica@iss.it), Gustavo Haquin (gustavo@soreq.gov.il), Luis Quindós Poncela(quindosl@unican.es), and Gabriela Gnoni (ggnoni@cae.arn.gov.ar).

(267) This session was characterized by the presentation of a large number of papers on a wide variety of topics which in itself is a reflection of the ubiquitous nature of NORM. These papers covered instrumentation (4); measurements and surveys (2); modelling (2); risk assessment (3); regulation (7); and, building materials (13). They fell generally into four different topics surveys and dose measurements of a variety of situations, measurement and modeling if the magnitude of exposures from NORM. The management of risks, in particular those from wastes and residues, and the regulation of NORM.

(268) Building materials, and their radon emanation, are one of the most wide spread source of exposure to NORM. The issues discussed were: measurements techniques, including measurements in buildings materials, in homes and workplaces of radon and thoron; measurements programmes to characterize radionuclide concentrations; dose assessment; regulatory regimes to control exposure; disposal of TENORM wastes; the dilemma of reducing individual doses or collective doses; need to improve knowledge. Similar issues were raised at the Technical Session III 5 3 on *Radon and the public*.

2.3.6. Other Applications and Practices

(269) This area of knowledge addressed the following topics: *transport of radioactive materials* (which featured an special round table, see separate title) including, regulations, package design, package approval, package operation and maintenance, radiation protection programme, emergency response, management system and quality assurance, security and education and training; *industrial, research applications and security screening* including industrial applications, isotope production and processing, accelerators for industrial use (new materials, sterilization, etc.), isotopic tracers in industrial processes, industrial instrumentation with radioactive sources (automatic process controllers, gauging), non-destructive testing (gammagraphy, radiography, neutrography, etc.), moisture and density measurement in soils and other applications, research applications of radiation, and application of radiation for security and customs purposes (human screening, baggage screening, cargo screening, new

technologies); *radon and the public*, including radon risk assessment, radon risk communication., exposure guidelines and action levels, radon concentration measurements and techniques, and mitigation techniques & cost effectiveness of mitigation actions; and, *radiation safety in flights and space* including assessment of air crew external dose, computational methods, development in instrumentation and methods (calibration procedures, irradiation facilities, uncertainties, harmonisation of procedures for determining individual dose intercomparisons, and standardization), regulatory frame and legal contexts in air crew radiation protection, space dosimetry methods, and radiological support during space missions.

2.3.6.1.Radiation Safety in Transport of Radioactive Materials

(270) The Topical Session TS III.5.1., on *Radiation Safety in Transport of Radioactive Materials*, featured a round table on this topic, fort the first time at IRPA Congresses. The session participants were Richard Rawl (rawlrr@ornl.gov), Jorge López Vietri (jlvietri@sede.arn.gov.ar), Mario Mallaupoma Gutierrez (mmallaupomag@yahoo.es), William Wilkinson (wl.wilkinson@talk21.com) and Nancy Capadona (ncapadon@sede.arn.gov.ar).The presenters and participants that offered comments and questions reflected four common themes that are prevalent today in the transport of radioactive materials: *safety record*, *increase in shipments*, *denial and delay of shipments* and, *security.*

(271) *Safety record:* There is an excellent safety record over the last 50 years with no deaths or serious injuries from the radioactive nature of the material being transported. Some of the credit for this is attributable to the strength of the IAEA Transport Regulations, the resulting robust package designs that must be used for high activity materials, and consistent adoption of the regulations by countries and international organizations.

(272) *Increase in shipments:* With the expected expansion of nuclear power and increases in the availability of nuclear medicine applications, shipments of radioactive material will continue to increase over the foreseeable future. These shipments highlight the benefits that nuclear technology brings to society and necessity for transportation that supports the realization of these benefits.

(273) *Denial and delay of shipments:* Whenever a shipment is refused or delayed, particularly for short lived medical isotopes, there is a corresponding denial of benefit to the intended recipient, sometimes with corresponding adverse economic and security impacts. The IAEA, countries, and regional organizations have begun addressing this problem through dialog and identification of actions to improve the situation. The Montevideo Group in South America has initiated a reporting system to identify specific instances and help focus corrective actions where they are most beneficial. Additional efforts are planned for the international community to identify how it can interact with carriers to improve their knowledge about these shipments and their willingness to accept them.

(274) *Security:* Security during transport is a key issue in today's political environment. However, security requirements for radioactive material that are more stringent that those that carriers normally meet for other dangerous good could make the denial of shipment situation worse. A balance is needed in security requirements to ensure that the materials are adequately protected during transport without being disruptive or burdensome to the carriers' operations.

2.3.6.2.Radiation Safety in Industrial and Research Applications & Security Screening

(275) The officers of Topical Session III.5.2., on *Radiation Safety in Industrial and Research Applications & Security Screening*, were Augustin Janssens (augustin.janssens@ec.europa.eu), Nobuyuki Sugiura (nsugiura@kindai.ac.jp), Josilto de Aquino (josilto@cnen.gov.br),Donald Cool (Donald.Cool@nrc.gov), and Lida Borello (lborello@afip.gov.ar). This session featured thirty-two papers, three of them were selected for oral presentation and the main ideas discussed are summarized in the following paragraphs.

(276) The multiple beneficial uses of ionizing radiation in industry, security and other applications. A method was presented for producing molybdenum-99 and iodine-131 from low enriched uranium targets, with a description of the radiation safety benefits achieved with this new method, including the reduction of nuclear wastes and of the total iodine emissions. The increasing investment on the use of non-intrusive means of detection at customs and, as a consequence, the need of a qualified person in the radiation safety area, was highlighted. The role of the radiation safety officer within customs was discussed, as well as the difficulties of this position, and the benefits that the collaboration of the officer can bring towards the implementation of safety culture. It were also presented the regulatory and radiation safety issues taken into consideration in the licensing of a mobile security screening device which employs backscatter X-ray technology .

(277) The issue of security screening was considered a relevant topic of this session, mainly due to the growing security concerns worldwide leading to the introduction of new screening technologies using ionizing radiation, which are capable of detecting hidden weapons, explosives, illicit drugs as well as people smuggling. The US ISCORS Guidance for Security Screening of Humans utilizing ionizing radiation was presented. The EU requirements with regard to medical and non-medical imaging, focusing on radiation Safety issues regarding the use of radiation for security screening were summarized. The Proposed Security Screening Requirements for the revision of the BSS were also presented.

(278) During the general discussion period, questions on the justification of security screening were raised. The main conclusions are related to the benefits on the use of ionizing radiation in industrial and research applications as well as in security screening. However, as this use also entails risks, the principles of justification of the practice, optimization and application of dose limits should be taken into account.

2.3.6.3.Radiation Safety in Flights and Space

(279) The Congress featured an special Topical Session TS III.5.3 on Radon and the public. The session officers were Jean Luc Godet (jean-luc.godet@asn.fr), Franz Joseph Maringer (franz-josef.maringer@bev.gv.at), Douglas Chambers (dchambers@senes.ca), Karla Petrova (Karla.Petrova@sujb.cz) and Mariela Czerniczyniec(mczernic@cae.arn.gov.ar). For the conclusions see those on NORMs.

2.3.6.4.Radiation Safety in Flights and Space

(280) The officers of Topical session TS III.5.4, on *radiation safety in flights and space*, were Toshiso Kosako (kosako@nuclear.jp), Ulrich Straube (ulrich.straube@esa.int), Frantisek Spurny (spurny@ujf.cas.cz), and Jorge Carelli (jcarelli@cae.arn.gov.ar).

(281) This session started with a presentation on policy on this controversial subject area. A consolidated explanation of cosmic ray radiation safety was presented, including galactic cosmic ray performance. Then, a special lecture was presented by Mr. H. Lubbe (Germany) from the International Federation of Air Line Pilots Associations (IFALPA). In 2003, IFALPA policy of cosmic radiation was decided and the structure of a guideline was presented. Doses in jet air flights are followed by several countries and were discussed. Discussions also centred on dosimetric aspects, biological effect, and dose calculation, concluding that fostering of information exchange with pilots and other cabin crews should be encouraged. On the doses in space flight, issues of dosimetry were lively discussed. Measurements with TLDs for space station of low orbit space flight were presented and discussed based on the real applications. The medical and biological aspects were examined. Mars missions and their requirements for a special consideration of shield among other issues were also discussed.

2.3.7. Networking in Radiation Safety

(282) The special technical Session S.T.1 (a round table) addressed the high-in-the-international-agenda issue of *networking in radiation safety*. During the nineties and later on, as an answer to the evolution of socio political demand, and thanks to the technological communication means, a new generation of radiation safety networks has grown up. They are set up on different geographical bases from worldwide networks to very local ones; they sometimes cover a specific topic (training for example) or a specific domain (cardiology for example), they are more often multi-topic and multi-sectorial; they always rely on communication and exchanges through direct contacts, most often complemented by emails, web sites and forums.

(283) From the discussion at the session on networking came that: the keywords dealing with the success of these networks are personal links and communication, sharing information, enthusiasm, flexibility, collective efficiency, making use of native languages; the keywords corresponding to the limits of the networks are limited resources, risk of duplication, problems of confidentiality; international organisations and regulatory bodies need stakeholder networks as a decentralised complement to their actions, but the initiatives have to some from the stakeholders (regions, operators, regulators, medical associations, and in general professionals); and, local stakeholders need networks as a tool of mutual help on practical issues which give them more legitimacy in their own institutions

(284) It should not be reasonable to envisage a single network of networks covering everything. However, it would be sensible to avoid duplications; thus the future is open not only to the emergence of new networks and new types of networks everywhere, but also to the spontaneous establishment of adapted links between the networks and creating then several networks of networks at all levels both geographical, topical and sectorial.

2.3.9. Legal Implications of Radiation Protection

(285) The Special Technical Session STS.2 addressed, for the first time in IRPA Congresses, the *legal implications of radiation protection*. At a very lively round table organized in close collaboration with the Legal office of NEA/OECD, presentations and discussions focused on three of the most important challenges facing the international radiation protection community today.

(286) There was a clear recognition of the need for both precision of harmonization in the application of radiation protection standards in order to provide greater legal certainty to regulators, operators, lawyers and the public. There was also a clear recognition of the value of comprehensive stakeholder participation in the decision making process of regulatory bodies and of the need to develop more unified and consistent legal obligations on a global skill for compensating nuclear damages should it occur. Participants considered this session to be very constructive and expressed strong support for continuing including legal issues in future congresses. It was finally agreed that cooperation between lawyers, scientists and governments on these issues would result in benefits to everyone.

2.3.10 Stakeholders

(287) The controversial issue of stakeholders were addressed in two sessions, and follows:

- An Special Technical Session addressed the issue of *stakeholder engagement in practice.*
- An Background Plenary Session addressed the issue of *Stakeholder Involvement In Decision-Making* and also the *IRPA guiding principles* in this area.

2.3.10.1 Stakeholder Engagement In Practice

(288) The Special Technical Session STS3, addressed the issue of *stakeholder engagement in practice*. The session was chaired by Juan Carlos Lentijo (jcll@csn.es) and featured a as a keynote lecture Rick Jones (j3e08@msn.com). The rapporteur was T. Schneider (Schneider@cepn.asso.fr) and the technical secretary Gabriel Terigi (gterigi@sede,arn.gov.ar).

(289) The Congress emphasized that this time this controversial issue was dedicated to the application of the concept ‘in practice’. It was nevertheless articulated with the reflection initiated since IRPA 11 on the "Guiding Principles for RP professionals on Stakeholder Engagement". IRPA12 shown a growing concern all over the world with the application of stakeholders in real world situations, with papers and interventions from France, Italy, Latvia, Norway, Portugal, Spain, UK, EU, Argentina, Brazil, India, and Japan and engagements by international organizations such as OECD-NEA and WHO. The main fields of application were identified as: environmental issues associated with nuclear installations, post-accidental situations, occupational exposure, and medical exposure: patients. Significantly, it was not recognized an issue by the non-ionizing radiation presentations!

(290) Many environmental issues relate to discharges of nuclear installations, and in particular to the diffusion of information on environmental issues associated with discharges. They included: establishing dialogue meeting for sharing information and concern; developing pluralistic expertise for assessing environmental and impacts; involvement of local stakeholders on environmental monitoring results; and, identifying the indicators for the assessment of the impact on Biota. Other environmental issues obviously related to radioactive waste management. They included developing multi-attribute approach for exchanging information, feed-backing experience on difficulties in national debate; involving local stakeholders to address the issue of intergenerational transfer of protection; elaborating multi-level consensuses; and preparing decommissionning activities with stakeholders .

(291) In the post-accidental management are a number of issues were identified, including: addressing agricultural and environmental issues in case of an emergency situation (the INEX

exercise); addressing radioecological sensitivity of territories with multi-attribute approaches; involving local stakeholders in the monitoring and elaboration of self-help actions; and involving stakeholders in preparedness of post-accidental management. In the occupational exposure area the issues identifies included developing networking and ALARA approaches. Public information and elaboration and diffusion on radon was considered a central issue and well as local community engagement for managing radon in dwelling. There were also issues related to medical exposure of patients including involving patients, professionals and organization in decision-making and developing international partnerships to promote public health. Finally, IRPA12 also identified many transversal issues, including: developing of a radiation protection culture; IRPA society initiatives to promote radiation protection culture through dialogue with different stakeholders; involving local communities to promote radiation protection culture through a global approach; and, addressing the articulation between science and values with the stakeholders

(292) The session favoured diffusion and dissemination of approaches and exchange of experiences on stakeholder engagement, which is an increasing practice, and it was a step further based on the IRPA guiding principles (see hereinafter). It also identified needs for further developments, such as tools and framework for stakeholder engagement, and training. The conclusions of the session can be summarized in three clear points:

- Stakeholder involvement is a real issue. In modern societies, people (both individuals and groups) want to participate in a more direct way in those decisions that affect their environment, their health, in essence … their life.
- Stakeholder engagement in practice is an effective tool to improve the decision making processes, getting better and more sustainable decisions.
- There are a number of real experiences in this area that have been presented, related to a variety of different fields (environmental issues associated with nuclear installations, post-accidental situations, occupational exposure, radon in dwellings, medical exposure of patients, NIR, etc). However, more guidance is welcomed on how to conduct the processes and, in this sense, the IRPA Guiding Principles mark a significant step further.

2.3.10.2. Stakeholder Involvement In Decision-Making and *IRPA guiding principles*

(293) The Background Session IV addressed the issue of *Stakeholder Involvement In Decision-Making*, and also the *IRPA guiding principles*. It was chaired by the President of the Board of Directors of the Argentine Nuclear Regulatory Authority, Dr. Raul Racana, and featured presentations by the Directeur Général of France's IRSN, Jacques Repussard and Tony Bandle (UK SRP).

(294) Mr. Repussard referred to IRSN experience on the issue. The French law on nuclear safety (2006) requires the existence of a stakeholder committee for each nuclear plant. This proved to be a holistic approach to foster and sustain public confidence, transparency and openness and cultural awareness in the public. The IRSN's experience has identified the main features that are necessary for the implementation:, leadership, pragmatism in implementation, cultural change within the institution itself, and investment in education and in research. The benefits have been notable: a « sense of mission » boost, a strive for world class excellence. The concluding experience was summarized as follows: In times of challenge, the best insurance that there will be people out there to interact with in a positive way, people who will trust and support us.

(295) Mr. Bandle presented the IRPA *Guiding Principles Stakeholder Engagement in Decision Aiding in Radiological Protection,* which were summarized as follows: collectively develop objectives for the stakeholder engagement process, based on a shared understanding of issues and boundaries; develop a culture which values a shared language and understanding, and favours collective learning; respect and value the expression of different perspectives; ensure a regular feedback mechanism is in place to inform and improve current and future stakeholder engagement processes; and apply the IRPA Code of Ethics in their actions within these processes to the best of their knowledge

(296) There are professional reasons that require these principles. Involving stakeholders appropriately whether they be other professionals or artisans like doctors, engineers, technicians and ecologists, or the workers, local community or general public, should be an integral part of the radiological protection processes of justification and optimization. Justification is about weighing up benefits against costs; in things that affect people lives, their health, their wealth and their well-being, or their environment, why not involve them? Optimization is about weighing up options. Where these options affect people or their environment, why not involve them? Attention to both of these fundamental principles of radiation protection in the context of stakeholder involvement leads to solutions which are more widely agreed and owned and are therefore more sustainable. This set of principles are not the output from academic studies or a wish list draw up by idealists, they represent the distillation of a huge amount of real life experience and lessons learnt the hard way, fought over and debated by a representative group of radiation protection professionals, and validated by actual stakeholders and with reference to authoritative research. The guiding principles are intended to aid members of IRPA Associate Societies in promoting the participation of all relevant parties in the process of reaching decisions involving radiological protection which may impact on the well being and quality of life of workers and members of the public, and on the environment. In promoting this approach, radiological protection professionals will aim to develop trust and credibility throughout the decision making process in order to improve the sustainability of any final decisions. IRPA12 attendees were asked to endeavour to make the IRPA principles a day-to-day reality.

2.3.11. Concluding radiation safety in practice

(297) The Concluding Plenary Session III was the last technical session of the Congress and the opportunity for winding up the rich sessions dealing with radiation safety in practice. It was chaired by the Director General of NEA/OECD, Luis Echavarri (NEA/OECD), and the Chairman of the Argentine Atomic Energy Commission, Norma Boero and featured summaries presented by: Sylvain Saint Pierre (UK/WNA), on radiation safety in nuclear installations; (Rodolfo Touzet, Argentina) on non-ionizing radiation applications (NIRs); Pablo Jiménez, (Spain / PAHO), on radiation safety in medicine, Peter Burns (Australia) on radiation safety with naturally occurring radioactive materials (NORMs) in industry; and (Gustavo Massera (Argentina) on radiation safety in other applications and practices.

(298) As far as the nuclear industry is concerned, it was emphasized that the dominant safety feature is a global movement toward nuclear renaissance and an extended introduction of nuclear power generation. 31 countries and regions have introduced nuclear power generation and over 20 countries are planning to build or will build new nuclear power plants in future. Thus, substantial nuclear developments are foreseen around the world over the coming decades. These developments closely relate to the world challenge on energy and environment• Operators from France, Japan and USA have all highlighted their practical contributions. IRPA12 also heard from Argentina and Brazil.

(299) The long and solid track record of radiation protection in the nuclear industry is an excellent basis for expansion• Collective doses and individual doses have been steadily reduced over the years (…and this precedes the notion of dose constraints!) For instance, the efforts by EdF and contractors have reduced collective radiation exposure by a factor of four per reactor in nearly 15 years (From 2.44 man Sv in 1991 to 0.63 man Sv in 2007). In support of a nuclear energy global expansion, all operators are committed to strengthened radiation protection. But there are key areas for improvements and offering global opportunities, for instance: a greater harmonization of the global safety regime; fully integrate radiation protection as part of this regime; further developments and integration of safety culture in radiation protection; design and implement practical improvements for highest exposed jobs and for general working conditions; sharing "Best Practices" through industry cooperation; and improving public communication about radiation & radiation safety, including the reporting of radiation protection incidents. Future challenges include radiation protection workforce and skills renewal, attraction and stability, education and training programs, and stewardship for emerging nuclear energy countries, extended radiation protection practices to all relevant professions, and a more balance and complete coverage of public health policies for the control of exposure. (300) Other key points include: emerging nuclear fuel cycle countries (mines, conversion, enrichment, etc.) anticipate radiation protection challenges, radiation protection for new build (improvements already integrated in currently offered new nuclear power reactorsuality management systems (QMS) applied to integrated safety, and safety culture are best drivers for sustaining excellent RP performance. Dose constraints (DC) were seen as the only one of the flexible tools of Optimization: it was considered that DC cannot restrict Optimization, because this would be counterproductive; DC should be flexible and part of an iterative process.

(301) IAEA set of waste safety requirements and safety guides, which were presented at IRPA12, offer a good opportunity for solving the waste management conundrum of public acceptance. IRPA12 offered an opportunity to see solutions of practical problems by describing waste management aspects for diverse sources: a modular reactor (PBMR), the largest research accelerator (CERN), borehole disposal, and a low-level (LLW) waste disposal site (UK). Several papers covered radioactive waste management plans (general or national). Two issuesLLW were flagged as requiring special attention: environmental regulations for radioactive discharges tend to be excessive (huge cost versus tiny dose reduction) and how much of a country's resources should be used? Exclusion, exemption and clearance continue to be a controversial issue. Clean-up is important and so is a good sense of proportion and a transparent methodology (cost-dose-risk benefits).

(302) A comprehensive methodology for dealing with uncertainties in context of clearance levels, which is consistent with ICRP Publication 104, has been adopted by the Japan regulatory body and could serve as a basis for an international agreed approach on this difficult issue. Other main points on waste management to be highlighted include: progress has been made in NORM waste management, countries without nuclear energy programs have also progressed in waste management programs, and IAEA has been helpful, there is a lot of technological knowledge for the characterization of wastes as part of waste management programs, stakeholder involvement is important in support of decision-making as part of waste management sitting process .

(303) On *decommissioning and restoration,* IRPA12 recalled thatnd-state should be discussed upfront: vacant field or various types of site reuse, e.g. industrial, commercial, leisure. Decommissioning is increasingly important. Early planning and priority process are both key.

Characterization is a necessary step for planning and undertaking decommissioning. The radiation protection organization is relevant, e.g. transition from operation to decommissioning where contractors need to be fully included Waste management infrastructures and routes should be adapted. Although site-specific context prevails, a common approach to decommissioning increases credibility, e.g. IAEA safety guides. Systematic approach to ALARA should be an integral part of decommissioning with monitoring and control. Experience sharing mechanisms (e.g. international cooperation) already exist and need to be further developed.

(304) As far as *radiation safety in activities involving non-ionizing radiations*, it was underlined that for the first time the subject of non-ionizing radiation was developed in full an IRPA Congress in addition to the customary ICNIR report the original aim was to include fully all the aspects of the epistemology of radiation and the biological effects, the paradigm of radiation protection on the regulatory view, and the practice of radiation protection on the use of plans and methodologies to control radiation fields. However, due to changes made in the program and especially because of the elimination of the ICNIRP workshop, doubts were flagged on the success of the initial project. In order to compensate for the problems created by this situation, particularly to the Latin-American attendees of IRPA12, the SAR organized parallel to the Congress a local NIR workshop, in Spanish, which was attended by about 200 people. Notwithstanding all the difficulties, there were a significant number of presentations on NIRs, about 60, and a good number of attendees at the technical sessions and refresher courses and at the related plenary. They covered the originally intended areas, as can be seen hereinafter.

(305) A new stochastic model of carcinogenesis induced by ionizing radiation and the concept of breaking barrier cell mechanisms considers breaking the barrier mechanisms of a cell as key feature of carcinogenesis. The barrier mechanisms (e.g., antioxidant defence, repair, apoptosis) represent the complex of cell responses to primary cell damages caused by exogenous and endogenous factors. This approach can be applied for ionizing or non-ionizing radiation and indicates the advantages to develop studies together between ionizing and non-ionizing radiation. A similar analysis can be done with the presentation on modelling living cells as signals. On the paradigm of radiation protection for NIRs, it was underlined the use of the precautionary principle in health protection policies regarding electromagnetic fields, and the general diagnosis on non-ionizing radiation 2007 fields. Also the practice of radiation protection against NIRs, particularly on the use of plans and methodologies to control radiation fields, was covered. It was mentioned in particular the application of computational dosimetry studies to assess electromagnetic fields exposure in the vicinity of transmission lines and power substations . In sum, what could have been a frustration ended reasonably well covered.

(306) As far as *radiation safety in medicine* is concerned, IRPA12 dedicated a lot of attention to the growing radiation protection problem: protection of patients undergoing radiation medicine procedures.

(307) The main conclusions on radiation safety in the practice of diagnostic radiology can be summarized as follows: dose evaluation and DRLs are effective optimization tools; it is important to evaluate image quality (IQ) and establish optimized dose/IQ relationship; the sequence survey-training-resurvey can be used as a model of optimization; there is need to develop optimized scan protocols for paediatric patients; it should be used DLP instead of tube

loading for CT shielding calculation; and, *voxel* phantoms should be used for dose evaluation where available.

(308) *Radiation safety in interventional radiology* was given a particular emphasis. The main topics treated were: occupational issues, patient dosimetry and technical issues. The occupational issues are: no regulation or harmonization of use double dosimetry but real time dosimeters can be useful; need to carry out dose assessments at different parts of the body such extremity doses, especially fingers, knees and gonads; and lack of use of lead aprons by some personnel and of regular checking of its quality. The patient doses issues are: reference levels should be established where possible and regular dose assessments should be made, but paediatric levels are still needed as adult dose settings should not be used for paediatrics; and, use criteria for advance identification of high skin doses. The technical issues are: flat plate detectors led to higher doses; ECG modulation can be useful in DSA/CTA; grid controlled fluoroscopy was found to provide no significant dose saving. In sum, the conclusions for protection in interventional radiology were: interventional radiology is safe and highly beneficial to patients, but the levels of radiation are among the highest used in medical imaging. And therefore the specific ICRP recommendations should be closely followed; medical doctors employing fluoroscopically-guided procedures need to be trained and certified in radiation protection for this practice; x-ray systems used for interventional radiology should be submitted to a strict acceptance and commissioning process; the industry should continue to implement dose saving options for interventional systems and improve standardization and archiving dosimetry data; occupational dosimetry should be improved; and patient dose surveys and the use of reference levels should be extended, including paediatrics.

(309) As far as *radiation safety in radiotherapy*, the practice that has caused most accidental harm, the main thematic areas that were indentified in IRPA12 are: optimization in treatment planning; beam calibration and characterization; radiation shielding; radiotherapy technology; treatment delivery and verification; proactive safety assessment; several Monte Carlo simulations of dose distributions and special new phantoms for QC of complex treatments; comparison of different methods for determination of absorbed dose to water in reference and no reference conditions, including the use of different ion chambers and other detectors, the development of ad hoc algorithms, and postal audits; specific methods for validation of dose verification or for estimation of patient doses and distribution in common treatment situations; occupational exposure estimations for types of facilities, including proton and heavy particle radiotherapy facilities; estimation of neutron doses and instruments for neutron measurements; evaluation of compliance with appropriate manufacturing standards of different equipments; and, probabilistic safety assessment (PSA) to avoid accidental exposures for treatment with accelerators. The conclusions can be summarized as follows: new highly conformational radiotherapy demands new challenges such as dose escalation, reduced margins, steep gradients or high accuracy in terms of dose calculation, delivering and verification; tools such as inverse planning or Monte Carlo simulations are needed for those techniques to validate its safety; and, since radiation therapy is the practice where the radiation dose intentionally applied to human beings is the highest, the application of the requirements for quality assurance must be more exigent to assure radiation safety. In brief: new and rapidly evolving technologies raise new issues; the implementation of QA programs is essential to assure radiation safety; qualified personnel is needed; health professionals needs to be properly and regularly trained in radiation protection; and, implementation of appropriate regulations is essential, involving the participation of health authorities and medical professionals societies, and ensuring

harmonization and better coordination among multiple stakeholders –a regulatory body for this area may mean more than one body each having different responsibilities.

(310) IRPA12 also dedicated a lot of attention to the radiation safety in another practice having a large radiological impact, *NORMs in industry*, where the common issues were: regulatory policy; environmental impact of uranium mining and milling and radiological impact on workers and on the public.

(311) The conclusions for NORMs in the uranium mining and processing can be summarized as follows: as uranium industry is undergoing a renaissance, updated radiation protection procedures and regulations are urgently needed; shortage of trained and experienced radiation protection professionals cannot be produced overnight; public education on the issue is required; interaction between regulators and operators must be stressed; all parties need to work to achieve high levels of excellence in the management of radiation health, safety, waste and the environment; strong safety culture should be based on internationally shared principles, which are particularly needed for emerging uranium producing countries; "best practices standards" need to be introduced; social acceptance will require proper management; and international organizations (e.g., IAEA, WNA, ICRP, IRPA) have to play an important role.

(312) On NORMs in other minerals mining and processing, the following issues were addressed: thorium in rare earths ; phosphates; coal; country reviews; models for evaluation; elevated background; and scale on water pipes. It is clear that a wide variety of industries produce NORMs, usually large volumes of low activity material, and several countries have undertaken comprehensive reviews for measurement of NORMs and dose estimation. It was re-emphasized that the system of radiation protection includes NORMs, but regulatory instruments and management tools need to be flexible to handle wide variety of situations. Legacy sites and decommissioning is an open issue for the immediate future.

(313) On *NORMs in oil and gas industries,* the main issued were: countrywide surveys, pipes scales and sludges, measurement techniques; decommissioning and the radon problem. The surveys in oil fields have shown large amount of scales and sludges (dose rates up to 150 μSv/h [400 μSv/h in a pump], 400kBq/m^3 ^{of} radon gas in propane stream). The main issues are: maintenance of pipes and equipment, disposal of NORMs wastes and decomissioning of installations. Measurement challenges are liquid scintillation for ^{222}Rn, ^{228,} ^{226}Ra, ^{210}Pb and ^{210} Po, identification of radium isotopes, assessing Th/U in geological formations, and dating scales and contaminated soils.

(314) On *radiation safety for NORMs and radon issues in buildings*, IRPA12 featured a large number of papers on a wide variety off issues such as: measurements and modelling, regulation, surveys and dose measurements, management of risks and waste, radon build up in workplaces, radioactivity in building materials, radioactivity on tobacco (smoked at building ambiances), measurement and modelling in a variety of situation, and regulation and management of materials

(315) The conclusions for the area of NORMs in industry can be summarized as follows:

- The first challenge is to know what's out there: there is wide variety of NORMs industries (uranium, rear earths, coal, oil, gas, phosphates, mineral processing and others) and NORMs can concentrate in products, by-products and residues; there are exposures to large populations with small doses, exposures to small populations with larger doses and

occupational exposures and the challenge is how to measure it; there are difficult measurement situations, measurement of low activity or activity concentration, long decay chains and disequilibrium, hard to measure radium, radon, thoron, Pb 210, Po210; modelling exposure pathways with a lot of assumptions and averages are adopted for widely varying situations; assessing doses to individuals with large uncertainties, particularly for internal exposure.

- The second challenge is what to do about it: there is no one solution to the management of NORMs; wide variety of regulatory instruments required; graded approach including exclusion, exemption, clearance, notification, registration, licensing; managed as planned or existing exposure situations; dose constraints or reference levels are not clear; numbers of people exposed and magnitude of exposures should be optimised within dose bands; flexibility is required!

(316) Many of the conclusions about *radiation safety for NORMs and radon issues in buildings* are applicable to the controversial issue of protection of the public against radon exposures where major challenges continue to be: measurement and dose assessment in, air, soil and water, dwellings caves and spas; measurement techniques; and regulatory aspects, including reference levels. The WHO sponsored international radon project is a good start for reducing the population disease burden due to radon in homes, involving participation of more than 30 countries and including awareness, risk communication, measurement, cost and effectiveness of control, and remediation; it proposed a controversial reference level < 400 Bq/m3. The factors affecting cost effectiveness and health benefits of remediation programs are suitability of short-term measurements, seasonal correction factors, remediation at several story dwellings, and impact of smoking cessation programmes.

(317) On *radiation safety on industrial, research applications and security screening* there was noted the wide range of applications. (Transport has been treated under a separate title). The main issues identified were sampling and measurements, operational protection, detection systems, improving imaging, licensing issues and security screening.

(318) On *radiation safety measures for crews in commercial airlines* the main issues were: studies of biological indicators for assessing risk in air crews; programmes for calculating dose for given flight routes for personal use; involvement of airline pilots, and concern on new composite material being employed in aircraft manufacture.

(319) On *radiation safety in space*, the main issues continue to be: space dosimetry and specific radiation science, feasibility of operational radiation protection for astronauts, particularly protection in prolonged space mission, and on board measurement in space stations

(320) On *radiation safety in transport* it was concluded for transport that it is globally accepted evidence that risk from transport operations are small, but the increasing denials from carriers is a main issue of concern; there is a need to revert the situation in part caused by fears and may even be by the low economic significance to the carrier. For the issue of radon is clear that much progress in measuring and assessment has been achieved but it is necessary to strengthen actions for awareness and risk communication; the efficiency of remedial actions seem to be very low yet. Screening for security reasons that may involve exposure of persons is an increasing activity that seems to be in many cases ahead of regulatory response for adequate protection. Radiation environment in space and biological consequences compared to current exposure of workers may require implementing a specific radiation protection framework.

3. EPILOGUE

3.1. EPISTEMOLOGY OF OUR KNOWLEDGE

(321) It is apparent that IRPA12 has demonstrated the strong scientific basis on which radiation protection is founded. The physical sciences used to characterize radiation exposure have reached an exquisite sophistication and the biological sciences used to estimate radiation health effects are in frank evolution.

(322) In fact IRPA12 has shown how much has advanced our understanding of the effects of radiation exposure. It seems that radiation protection specialists had been somehow arrogant in implying simplicity for what was supposed to be far from simple. The final outcome of an exposure situation could perhaps be simplified in a simple nominal number, aimed at quantifying radiation risk, but the biological mechanisms leading to this outcome have shown to be extremely sophisticated and complex.

(323) We have come far from the simple target model that was our preferred paradigm as nearby as in IRPA10, just a decade ago. IRPA12 has been plenty of papers presenting the complexity of nature: by-standards effects, genomic instability, adaptive responses, abscopal effects, clastogenic plasma factors, etc, etc, etc. A new universe is developing showing the intricacy between the interaction of radiation with the cell structure and the cellular outcome. IRPA12 has show clearly how much we know about this complicated phenomena, perhaps much more than for the interaction with cells by other pollutants, but IRPA12 has also shown how much we do not know. Our ignorance seems to be the greater as we move from cell damage to its final expression as health effects.

(324) We know with certainty that high-doses may induce enough cell killing to produce serious health damage to tissues and IRPA12has provided an enormous amount of information on new techniques diagnosing these effects, including a large number of new biological dosimetry techniques, as well as information on pathological techniques for treating these so-called ‘deterministic effects’. However, IRPA12 established that we do not have enough information for attributing to low-level radiation exposure a given incidence of health effects with certainty, but the Congress made also clear that, following low-level radiation exposure, detrimental health effects may occur with a high level of plausibility and this is the reason why we need radiation protection requirements even at such low doses. It seems for me obvious that it is on this dilemma of attributing or not health effects at low doses, which we know are highly plausible to occur, is were our efforts should concentrate in the future. This will be a major challenge for IRPA13. And I presume that biology will help us but will be unable to solve the conundrum.

(325) Sievert lecturer’s Dr. Streffer shown skepticism on the possibility that in the time up to IRPA13 we would be able to find in the short time a biological marker that can identify with absolute certainty radiation-damage. While I hope to be wrong, I share Dr. Streffer’s disbelief.

(326) Therefore, the estimation of radiation risk for radiation protection purposes will have to continue to be based on radio-epidemiological studies. IRPA12 have been informed of many

epidemiological studies that are under way at the moment. Between now and IRPA13 many results will be available, others will have to wait for IRPA14. Meanwhile we will have to rely on the solid epidemiological evidence we have at the moment, which have been just recently compiled and informed to the UN General Assembly by UNSCEAR and reported at IRPA12.

(327) It seems to me that the detriment-adjusted nominal risk factor of 5% per Sievert for low-radiation doses, which is derived from the available epidemiological evidence, will continue to provide the basis for radiation protection and low doses for the time to come to IRPA13 and beyond.

3.2. OUR PARADIGMATIC RADIATION PROTECTION MODEL

(328) Based on all the above science, radiation protection will continue to rest on the paradigm that we have been able to construct and which is used worldwide. Universal agreement on a protection model against a given pollutant is completely uncommon in our diverse world. The radiation protection community should feel very proud to have been able to reach such universal agreement and it, I submit, should be very grateful to the work of ICRP for helping us in this endeavour. The ICRP is an exceptional NGO, which would be impossible to build up today. But in 1928 the world of science was perhaps simpler, lest polluted by politics, and thank to that we have ICRP today. IRPA12 was proud to host the ICRP jubilee, 80 years of a rich history so well described by one of its main actors: Professor Roger Clarke, who summarized nearly a century of radiation protection progress. IRPA12 was a unique opportunity for expressing the radiation protection community gratitude, not only to Professor Clarke, but also to Jack Valentin –who after many years of intensive work of Secretary of ICRP and editor of its Annals retired after the Congress.

(329) The background session on the paradigm was particularly illustrative. IRPA12 has provided one of the first opportunities for discussing the evolving international radiation safety regime before such a large and professionally qualified audience –and the discussion was done by all its actors, the international organizations that conform the Inter-Agency Committee on Radiation Safety, and moreover was chaired by the people that will at the end have the last word in the establishment of international standards, the chairmen of the radiation safety committee and the commission of safety standards of the IAEA. Jack Valentin (Sweden), used his usual clarity and good humour for informing IRPA12 on the new ICRP recommendations in ICRP Publication 103, and on the subtle changes that the radiation protection paradigm is enduring. The new ICRP recommendations will be the basis for the undergoing revision of the international radiation safety standards. This was the dominant issue of the second main field of this Congress: the radiation protection paradigm.

(330) We learned very important issues in this session. Firstly and fundamentally that something important occurred in 2006: the approval by Governments and publication by the IAEA of a unified and single set of Safety Fundamentals at the top of the pyramid of international safety standards. That document includes 10 principles, which are common to the entire relevant safety field: the so-called nuclear safety, radiation safety, water safety and transport safety, an artificial separation that represent more a confused history that a real severance in safety. That means that all safety requirements within the system will derive logically, in a top down approach, from the agreed ten principles. It will, in particular, be the case of the new BSS being prepared. Then relevant safety guides containing should-type obligations will derive from the safety requirements. More globally, that means that we must

consider radiation protection as a primary part of an integrated safety regime. Radiation protection should not and will not loss its specificity, but its paradigm, rules, partners, etc. must take into account their belonging to a larger concept, the concept of an integrated safety regime that covers all type of exposure situations, actual and potential, and all type of installations since the modest diagnostic equipments to the sophisticated nuclear power plants.

(331) This vision may have a large number of consequences. For instance: firstly, the Inter-Agency Committee on Radiation Safety should consider to enlarge its scope into a full integrated international safety regime; secondly, the revision of the BSS must take into account the concept of integrated safety regime; and, thirdly, the integrated safety regime should recognize the role of the BSS as the ultimate Topical basis for protecting people against radiation exposure, be this actual or potential exposure. Dr. Lacoste, one of the chairmen of this session, provided a recommendation that I personally share very much: a possible topic for the forthcoming IRPA13 could be: “Towards an international safety regime”.

3.3. THE BOTTOM LINE: RADIATION SAFETY

(332) IRPA12 clearly demonstrated that radiation protection is clearly ingrained in the practitioners employing ionizing radiation. From the required infrastructures to the specificities of the protection of the public, workers and patients, including the special arrangements for emergencies and response, are high in the agenda for all practitioners.

(333) However, or better, notwithstanding, there is a dominant issue that this time was specially discussed at a round table of IRPA12: I refer to the very much emphasized topic of education and training. Because without educated and trained people all our theories on an international safety regime would be just that: conjecture and speculation but not real. I am very happy of the large step forward provided by IRPA12 in this area. The initiative of the IAEA to create regional training canters providing postgraduate education and training in radiation safety is more than welcomed. In Argentina we are off course proud that our country has been the first one selected for providing officially such service. The post graduate course here has a history of more than a quarter of a century and many radiation protection officials in Latino-America have been trained here.

(334) It is also clear that there are huge differences among practitioners on the state of implementation. The nuclear industry seems to be well ahead of the other in that respect; well regulated and following the international paradigm, it has reached superb levels of radiation protection excellence. Medicine is re-noticing the problems that gave birth to radiation protection in the first place, discovering new ones, and attacking them expeditiously. Other industries, such as the NORMs industries, have just realized that they have a problem and are struggling to solve it.

(335) In any case, I remained convinced that the radiation protection practitioners in nuclear, medical and other activities making use of radiation, are fully engaged withthe progress reached by the fast growing global radiation safety regime being build up by relevant national and intergovernmental organizations.

3.4. CLOSING REFLECTIONS

(336) In my view the IRPA12 Congress was up to its self-imposed challenge: *strengthening radiation protection worldwide*. This was the result of many factors: the massive concurrence of experts from all over the world; the quality of their interactions, discussions and reflections; and, the robustness and global reach of their findings and conclusions.

(337) Conversely, I feel that IRPA itself was not up to the expectations of this wide audience. The short-sighted approaches undertaken by the North-Atlantic radiation protection societies at IRPA General Assembly *de facto* excluded the rest of the radiation protection profession from the leadership of its *alma mater*.

(338) Hopefully, the next four years –which undoubtedly will bring new progress to our discipline– will also provide space for introspective reflection on this unacceptable discrimination: Glasgow could be the place for changing attitudes and IRPA could genuinely search not only for *strengthening radiation protection worldwide*, as the IRPA 12 Congress did, but also for *strengthening a worldwide leadership for the radiation protection profession*.

(339) I have great expectations for and look forward to IRPA13 in Glasgow, Scotland!