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EUROPEAN JOINT PROGRAMME FOR THE INTEGRATION OF RADIATION PROTECTION RESEARCH
CONCERT

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D 2.2 Joint research needs and priorities addressing radiation protection research relevant for medical use of radiation and communication/risk perception in radiation protection field

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Abstract

This deliverable consists of two separate sections addressing the research needs and priorities of radiation protection research in two research areas: the first section is relevant for medical use of ionising radiation, and the second section addresses the issues related to communication and risk perception, reflecting the outputs of CONCERT Tasks 2.5 and 2.6, respectively.

Strategic Research Agenda for Medical use of ionising radiation (CONCERT Task 2.5):

Taking into account the changing funding situation and the importance of radiation protection research in the field of medical applications, the five European medical associations dealing with ionising radiation (EANM, EFOMP, EFRS, ESR and ESTRO) decided to build a common strategic research agenda (SRA), described in this document (Update November 2nd 2015). The mission of this SRA is to achieve the following objectives:

- Ensure an adequate level of information exchange between the signatories in the fields of joint interest within the scope of the Memorandum of Understanding (MoU) between the medical associations and MELODI and EURADOS;
- Identify gaps of joint interest in existing SRAs with respect to RTD needs for improving radiation protection in the medical field, or for improving the effectiveness/exposure ratio of medical protocols based on the use of ionising radiations, so as to optimise the SRA contents and avoid duplication of efforts;
- Identify research areas of joint interest where progress may benefit from contributions from signatory organisations, or the members thereof, e.g. some low dose effects or dosimetry research projects may benefit from contributions in a clinical environment, conversely, some medical protocol research may benefit from advanced dosimetry or radiobiology developments;
- Develop joint documents to support the elaboration of RTD calls in the framework of the Horizon 2020 programme, both in the EURATOM/Fission and in the Health programme;
- Optimise and coordinate the dissemination of scientific knowledge resulting from research, particularly through education and training actions.

The SRA highlights various topics of research in the five main areas:

- Measurement and quantification in the field of medical applications of ionising radiation
- Normal tissue reactions, radiation-induced morbidity and long-term health problems
- Optimisation of radiation exposure and harmonisation of practices
- Justification of the use of ionising radiation in medical practice
- Infrastructure for quality assurance

It is emphasized that the translation of research results into routine clinical use is of the utmost importance and that education and training needs to be strongly supported. To inform the preparation of the first CONCERT call, a statement of priorities from the draft medical SRA addressing the above five main areas was provided by the Task 2.5 Working Group of CONCERT in September 2015.

Creating a Strategic Research Agenda for Social Sciences and humanities in Radiation Protection (Task 2.6):

This document outlines the rationale to integrate social sciences and humanities in radiation protection research as specified for Task 2.6. It then summarises the results from a first discussion exercise carried out in the field of risk communication and risk perception in consultation with the European technical platforms involved in radiation protection research. Subsequently, it focuses on needs and expectations of different stakeholders regarding risk communication and risk perception research of relevance for the radiation protection domain. The latter includes results synthesized both from pre-CONCERT activities, as well as activities conducted in the framework of CONCERT Task 2.6 at an early stage of the project. At this stage, the consideration of research needs covers Task 2.6.2 (Risk communication and risk perception), whereas research needs related to ethics and justification (Task 2.6.1) and safety culture (Task 2.6.3) are addressed only preliminarily.

Both the consultation exercise with the platforms and the more detailed analysis of research needs connected to risk perception and risk communication provide important input for the development of the forthcoming Strategic Research Agenda for Social Sciences and Humanities Research in radiation protection research. The analysis carried out substantiates the need for transdisciplinary approaches in radiation protection research. Specifically, for risk communication and risk perception research, there is a high interest in such topics within the radiation protection community. A general conclusion is that risk communication in modern society should be seen as an important form of stakeholder engagement that enables dialogue rather than simple provision of information. Future research should address this issue and integrate stakeholder engagement in all areas of research and innovation connected to radiation protection.

The future development of the SSH Strategic Research Agenda should also intensively address other fields of SSH, such as ethics and safety culture. Furthermore, after the first reflection exercises with the platforms, the outcomes should be compared by a joint forum of all platforms, in order to highlight the most relevant priority areas where SSH can contribute to RP research. The work on Task 2.6 will intensively continue in direction of a proposal for joint SSH, which will be presented and broadly discussed within a research community at the RICOMET 2016 conference in co-organisation of the following EC projects related to the field and strategic research agenda: CONCERT, EAGLE, PLATENSO and OPERRA. The Conference will be held in Bucharest from 1st to 3rd of June 2016. The conference will be an opportunity for extensive discussions and exchange on trans disciplinary research and practice related to radiation protection, strategic research agenda for social sciences and humanities, socio-economic and ethical challenges, stakeholder engagement, governance, communication about ionizing radiation (in emergency management, low doses, communicating uncertainty, ethics, mass media communication, public understanding, research needs …) The conference will involve an international level of different stakeholders, from experts, media representatives, researchers, project partners, EU officials, NGOs to representatives of inform civil society.

After the RICOMET 2016 conference, the Task 2.6 members will work on a final proposal of the SSH, present it at the Radiation Protection Week in Oxford in September 2016 and discuss it with the European platforms: MELODI, NERIS, EURADOS and ALLIANCE.

Contents

Section 1: Medical use of ionising radiation

Common Strategic Research Agenda for Radiation Protection in Medicine

by the

European Medical Associations representing Ionising Radiation Applications in Medicine

European Association of Nuclear Medicine (EANM)
European Federation of Organisations in Medical Physics (EFOMP)
European Federation of Radiographer Societies (EFRS)
European Society of Radiology (ESR)
European Society for Radiotherapy and Oncology (ESTRO)

Last update: November 2nd 2015

Preamble

Reflecting the changing funding strategies for research projects within Europe and the goal of jointly improving medical care by sustainable research efforts, the following medical associations involved in the application of ionising radiation, namely,

European Association of Nuclear Medicine (EANM)
The EANM is the umbrella organisation representing nuclear medicine in Europe and represents 40 National Member Societies, approximately 3.200 individual members and around 30.000 professionals working in Nuclear Medicine in Europe. EANM aims to advance science and education in nuclear medicine for the benefit of public health, relating to the diagnosis, treatment, research and prevention of diseases through the use of unsealed radioactive substances and the properties of stable nuclides in medicine, throughout Europe.

European Federation of Organisations in Medical Physics (EFOMP)
The EFOMP serves as an umbrella organisation representing 35 national member and affiliated organisations of more than 7,000 physicists and engineers working in the field of medical physics in Europe. EFOMP aims to harmonise and advance medical physics both in its professional clinical and scientific expression throughout Europe by bringing about and maintaining systematic exchange of professional and scientific information, through the formulation of common policies, and by promoting education and training programmes.

European Federation of Radiographer Societies (EFRS)
The EFRS is the non-profit umbrella organisation representing 35 professional societies and 45 educational institutions representing over 100,000 radiographers across Europe. The aims of the EFRS are to represent, promote and develop the profession of radiography in Europe, across medical imaging, nuclear medicine and radiotherapy areas of radiography practice.

European Society of Radiology (ESR)
The ESR is a non-profit organisation representing the general interests of radiology in Europe. The aims of ESR are to serve the healthcare needs of the general public through the support of science, teaching and research and the quality of service in the field of radiology as well as the promotion and coordination of the scientific, philanthropic, intellectual and professional activities of radiology in all European countries. The ESR has over 62,000 individual members as well as 59 institutional member societies of which 44 national radiology societies and 15 European Radiological Subspecialty Societies and European Allied Sciences Societies.

European Society for Radiotherapy and Oncology (ESTRO)
The ESTRO is a non-profit scientific organisation representing radiation oncologists, medical physicists, radiobiologists and radiation therapists with over 5,000 members both within and outside Europe. ESTRO aims to foster the role of radiation oncology in order to improve patient care in the multimodality treatment of cancer by promoting innovation, research, and dissemination of science through its congresses, special meetings, educational courses and publications.

Decided that it was necessary and would be helpful to develop a corresponding common medical strategic research agenda (Medical SRA) to overcome current and future deficits and to be a constructive partner in European radiation protection research. To this end, research areas of interest have been jointly identified and agreed upon in this common SRA endorsed by the medical societies.

The effort of the medical societies in developing an SRA for the medical application of ionising radiation complements the efforts of other European platforms such as MELODI, EURADOS, ALLIANCE, and NERIS, which have developed or are developing their own SRAs in the fields of general low-dose research, dosimetry, radioecology and emergency preparedness, respectively.

In a memorandum of understanding (MoU) that the medical associations, MELODI and EURADOS signed in 2014, it was decided to cooperate in order to promote the integration and the efficiency of European radiation protection research, to maintain and use a common European infrastructure for this research, as well as to bring forward scientific education and training in the field of radiation protection for medical applications of ionising radiations.

The mission is to achieve the following objectives:

- Ensure an adequate level of information exchange between the signatories in the fields of joint interest within the scope of the MoU;
- Identify gaps of joint interest in existing SRAs with respect to RTD needs for improving radiation protection in the medical field, or for improving the effectiveness/exposure ratio of medical protocols based on the use of ionising radiations, so as to optimise the SRA contents and avoid duplication of efforts;
- Identify research areas of joint interest where progress may benefit from contributions from signatory organisations, or the members thereof, e.g. some low dose effects or dosimetry research projects may benefit from contributions in a clinical environment, conversely, some medical protocol research may benefit from advanced dosimetry or radiobiology developments;
- Develop joint documents to support the elaboration of RTD calls in the framework of the Horizon 2020 programme, both in the EURATOM/Fission and in the Health programme;
- Optimise and coordinate the dissemination of scientific knowledge resulting from research, particularly through education and training actions.

The stakeholders are involved through a formal consultation process that has been initiated, is ongoing, and will be reflected in future updates of the SRA presented here.

1. Summary

Reflecting the change of funding strategies for research projects within Europe, and the goal of jointly improving medical care by sustainable research efforts, the medical associations involved in the application of ionising radiation have identified research areas of interest and agreed upon these in this common strategic research agenda (SRA) endorsed by the medical associations.

The research that is seen to be necessary and most urgent for effective medical care, under the best harmonised practice, and efficient in terms of radiation protection can be summarised to the following five main topics:

1. Measurement and quantification in the field of medical applications of ionising radiation
2. Normal tissue reactions, radiation-induced morbidity and long-term health problems
3. Optimisation of radiation exposure and harmonisation of practices
4. Justification of the use of ionising radiation in medical practice
5. Infrastructures for quality assurance

The subtopics defined for each topic describe the specific research aspects that are identified as areas of great importance regarding research for establishing optimal radiation protection in the field of medical applications. These descriptions can be found in Chapter 3 of this document.

It is important to highlight that the approach to improve the use of ionising radiation in medicine by pure fundamental research would lack impact and influence unless having immediate consequences for and being translatable to everyday clinical practice. It is also important that the results of the research are not only translatable but really translated into daily routines. Therefore it is essential that the research is undertaken in a concise manner by persons educated and trained for good medical practice. The results have to be evaluated in clinical practice and have to be made public in a way that it is easy to access (results and implementation guidelines available on the internet) and to implement the methodologies developed. It is also essential that the same level of importance is placed on educating the staff working in the field to guarantee a direct clinical impact and to ensure high-level, standardised medical care and related radiation protection fully exploiting and profiting from all research conducted with regard to radiation protection in the medical field throughout Europe. This aspect of the SRA is reflected in Chapter 4.

2. Background

During the last 5 to 10 years the structure of research funding by the European Commission (EC) has gradually changed. The intention is to bring together all interested parties to facilitate European research projects in the field of radiation protection research and *“setting-up a European umbrella structure for radiation protection research call administration”.* To this end, strategic research agendas (SRAs) have been developed or are currently under development.

Therefore, a medical SRA in view of the applications of ionising radiation in the medical field is especially important, since the medical use of ionising radiation is the largest man-made source of exposure to the human population. The advantages of such SRAs include:

- Providing guidance on/help to identify the most relevant and urgent research topics in the fields they cover
- Demonstrating the importance of research areas to the stakeholders
- Justifying research expenditure in defined areas

- Facilitating discussions with other members of the scientific community in the field of radiation protection
- Determining important topics and influencing research calls of the EC, OPERRA and CONCERT.

Since medical applications are among the most important contributors to exposure of the population in Europe to ionising radiation, for medical radiation protection research to be effective, it is critical that the results of the research projects are directly transferred into clinical practice i.e. translational research.

This SRA is foreseen as the cornerstone for a common platform or alliance of the European medical associations dealing with topics related to the use of ionising radiation. This platform will be called **Common Approach to Radiation Protection in Medicine** (**CARPE-M**) and its implementation will be discussed directly after the setup of this SRA.

3. Research Topics

3.1 Measurement and quantification in the field of medical applications of ionising radiation

A key priority for radiation protection research in radiation oncology, nuclear medicine and also interventional and diagnostic applications of ionising radiation is to improve techniques and methods for measurement and quantification. The research approaches will need to be multidisciplinary and innovative. The key research questions in measurement and quantification research are:

3.1.1 Characterisation of exposure

The basic quantity for the characterisation of exposure is absorbed dose, so where ever possible dose measurements or calculations / calibrations should be stated in terms of absorbed dose. One of the main challenges for future research is the pronounced anatomical heterogeneity of (absorbed) doses within and between critical organs in all areas of medical uses of radiation. This needs to be supplemented by optimization of models and model parameters to translate absorbed doses into equivalent, organ, biologically effective doses or any other, indirect dose entities. Accurate and precise measurements with known margins of uncertainty are a prerequisite for the adequate implementation of dosimetric techniques into medical practice and medical routines, specifically for different types (qualities) of radiation and levels of spatial resolution. Therefore, the following issues need to be addressed in research:

- Calibration of dosimeters for medical applications is currently performed using secondary standards non-specific to the radiation fields used in medical application of ionising radiation leading to undefined measurement uncertainties. Therefore, exact measurements require calibration against radiation fields specific to medical applications.
- There is a limited availability of dosimeters for use inside the human body, this implies, that currently simulations of radiation transport and deposition are necessary, e.g. using Monte-Carlo (MC) methods and normalise them to measured quantities.

- Real-time measurement of doses is relevant to reduce doses to staff. Therefore, the development of specific dosimeters is required; allowing real-time monitoring for example of eye structures and extremity/finger doses from interventional radiology/cardiology and nuclear medicine. The existing dosimeters are either not for online measurements or they suffer from technological limitations in terms of highest dose rates as in pulsed radiation fields or size or practicability.
- Non-uniform spatial (3D) and temporarily varying (4D) dose distributions can lead to differences of up to several orders of magnitude in local dose distributions. Therefore, micro-dosimetric measurement devices and techniques for use within and between cells, the anatomical structures of organs and the human body are necessary, e.g. for dosimetric use with regard to individual structures in the eye, the brain and the heart, and also other organs depending on the basis of future research results.
- Different types of radiation (photons, electrons, protons, heavy ions, secondary neutrons) are used for and/or associated with medical purposes. Correct determination of doses to and dose-distributions within patients on different levels of spatial resolution is necessary depending on the required purpose in terms of radiobiological questions or optimisation of procedures. Also mixed fields and energy spectra need to be taken into account for reliable measurements and calculations of dose-distributions.
- Knowledge on track structure and/or micro-dosimetry of internal emitters (alpha, beta, Auger) is a prerequisite to predict the associated biological effects. Therefore, computational methods need to be further developed and connected to the results of corresponding research on measurements and calibration procedures (see above).
- Development of updated or alternative quantities and concepts for describing the anatomical dose distributions within organs, tissues and the body as the basis for predicting health effects, rather than mean absorbed doses (e.g. dose averaged over an organ) or dose volume histograms.
- Methodologies have to be developed for determination and description measurement and calculation of doses outside the planning target volume (PTV) for radiation therapy - the peripheral dose. This is urgently required to build and optimize prediction models for secondary tumours, but also tissue effects, to enable comparison of different techniques and/or technologies.

This research would be a prerequisite for the accurate and precise evaluation of the dose as the basis for better radiation protection of the patient and medical personnel as explained below.

3.1.2 Individual dosimetry

Individualised patient dose assessment methods e.g. by adjusted phantoms for measurements, size specific conversion factors, dose measurements taking into account imaging parameters shielding etc. are needed to allow for accurate patient dose estimation and risk assessment. Many dose distributions will depend on individual patient constitution (e.g. size, weight, shape, age and biological factors such as the distribution and kinetics of radioactive markers or susceptibility to different therapeutic procedures). Therefore, the following dosimetric procedures need to be addressed in research:

- Development of computational methods for dose distribution calculations based on patient-specific and equipment-specific characteristics for all medical procedures using ionising radiation, including for example CT, interventional and nuclear medicine procedures as well as radiotherapeutic procedures avoiding different dose indicators for different types of procedures in order to get comparable meaningful information about organ doses of individuals.

- Development of optimal measurement protocols in nuclear medicine for accurate estimation of absorbed doses using patient-specific and equipment-specific characteristics. Refinement, validation and implementation of new biokinetic models for dosimetry in molecular radiotherapy using for example physiologically-based pharmacokinetic (PBPK) models for the individual assessment of biokinetics, including uncertainty budgets.
- Development of methods to estimate or measure the actual delivered radiation dose in radiotherapy.
- Development of a unique dose indicator that describes the absorbed dose to organs in order to perform risk assessment.

This research would be essential for accurate and precise determination and evaluation of indication-, therapy-, and/or subgroup-specific doses and therefore risks of radiation-induced morbidities of individual patients and thus to a per-patient basis for better radiation protection of patients and medical personnel.

3.1.3 Quality metrics for diagnostic imaging and therapy

For the use of quantitative imaging approaches, standardised protocols for each clinical indication and/or specific disease common clinical indication need to be developed. Therefore, the following issues need to be addressed in research:

- Development of dosimetric and image quality metrics to fully assess the impact of novel detector technologies (e.g. low- or lowest-noise as well as energy resolving detectors), as well as of image reconstruction methods available for reducing radiation exposure to the patients is needed. To this end, research is needed on which requirements (system stability, noise reduction, influence of individual patient characteristics, reconstruction parameters) have to be met for quantitative imaging to yield reliable and reproducible results.
- Measuring methods (e.g. standardisation of phantoms, reading protocols, etc.) need to be improved or developed and standardised to address the improvements in medical technology as well as to meet new methods e.g. particle therapy or new molecular imaging technologies.
- There is an increasing need also for quality metrics of treatment plans to allow an easier quality assurance as well as comparability of methods used in radiation therapy and to allow a more standardized research regarding clinical treatment outcomes.
- The concepts and the use of diagnostic reference levels (DRLs) and achievable dose levels (ADLs) have to be redefined to meet the requirements of organ specific dose distributions or critical organ structures doses.

This research enables the translation of quantitative techniques to widespread clinical use for the benefit of the patient. In addition, this research is also a prerequisite for the harmonisation of practices and quality assurance.

3.1.4 Sources and influences of uncertainty

Uncertainties need to be determined for all techniques described above, be it measurements or computations. Many components independently contribute to the uncertainty in the determination and reporting of medical applications as well in the performing of a medical application as well as in its characterisation. It is of utmost importance to develop methods to assess the contributions of different stages in the chain of medical interventions to be able to define the relevant points of optimisation, which means putting effort into those parts of a medical application scheme where there is the highest benefit. Therefore, the following issues need to be addressed in research:

- Quantification of the influence and sensitivity of different parameters (technique dependent, system dependent, patient dependent, medical staff dependent).
- Development of methodologies for classifying different influencing parameters and to build a system that allows the optimisation of medical applications of ionising radiation for individual patients or methods.

Knowledge of the integral uncertainty and its components is key to identifying the most relevant steps, to allow for prioritisation and targeted optimisation and thus making more effective use of clinical and research resources.

3.2 Normal tissue reactions, radiation-induced morbidity and long-term health problems

A key priority for radiation protection research in radiation oncology, nuclear medicine and also interventional and diagnostic applications of ionising radiation is to improve health risk estimates. The corresponding research approaches will need to be multidisciplinary and innovative. The key research questions in tissue reactions and biological risk research are:

3.2.1 Exposure-associated cancer risk: dose, dose-distribution-, and dose-rate dependence

Knowledge of the dose dependence of the radiation induction of primary or secondary cancers, in particular in relation to dose inhomogeneities and dose rate is of major importance in order to optimise therapeutic efficiency and reduce unwanted side-effects. In radiation oncology, this refers to high doses within the planning target volume (PTV) as well as to out-of-PTV doses, e.g. low to moderate doses, in particular in intensity-modulated and image-guided radiotherapy, but also in brachytherapy and molecular (radionuclide) radiotherapy. It also needs to include other, additional treatment modalities, particularly chemo- and biologically-targeted therapy. Diagnostic procedures must also be considered, especially in view of interventional or fluoroscopic procedures or nuclear medical imaging techniques and those applied in preparation for treatment.

3.2.2 Non-cancer effects in various tissues and radiobiology-based effect models for individual morbidity endpoints

Radiation-induced morbidity (cancer and non-cancer diseases and disorders) may be observed early or late (occurring after 3 months to 5 years after radiation exposure), not only in the tissues and organs exposed to high doses. Also, very late health effects (occurring after more than 5 years to many decades after exposure) may not only be observed in high dose radiotherapy (>5 up to 50 Gy) but also in the intermediate (0.5 to 5 Gy) or in the low dose (<0.5 Gy) ranges. Examples of these very late occurring normal tissue morbidities, which may be induced by localized radiation exposure outside the planning target volume of radiotherapy or by repeated interventional procedures are: cardiovascular or cerebrovascular diseases, functional or structural damage to various eye structures, various delayed, persistent immunological changes, progressive microvascular injuries, but also late and very late developmental and functional detriments after radiation exposures in diagnostic procedures and paediatric radiotherapy and many more radiation-associated health disorders. The contribution of other treatment modalities, particularly chemo- and biologically-targeted therapy, to the development of particularly very late side effects is currently poorly understood and needs also to be considered along with any diagnostic procedures, especially for interventional or fluoroscopic and nuclear medicine procedures and those applied in preparation for treatment.

Current morbidity risk models and normal tissue complication probability (NTCP) models are largely empirical or based on hypothetical data-fitting models of assumed processes of damage development and lack the evidence of a mechanistic basis. Moreover, they do not consider the influence of the position of the doses within one organ, or the interaction of dose distributions in “corresponding” organs, such as lung and heart, or the effect of additional treatments, such as chemotherapy. These factors, however, must be included to get appropriate estimates for the patterns of risk of any individual patient with regard to modern techniques in radiotherapy, nuclear medicine and radiological diagnosis.

3.2.3 Individual patient-related radiation sensitivity and early biomarkers of response and morbidity

The individual sensitivity of patients may be considered in the choice of specific diagnostic procedures and/or therapeutic strategies. This can be based on intrinsic factors (age, gender, genomics, proteomics) of their tumours or different normal tissues, but also on concomitant diseases impacting on general or specific normal tissue tolerance, lifestyle (e.g. reduced lung/liver tolerance due to smoking and alcohol consumption) or previous/parallel treatments.

Patients with a high risk for a certain, severe, morbidity symptom may require a change in dose distribution, in treatment strategy or follow-up protocols may need to be adjusted to the individual morbidity risk pattern based on early biomarker expression. In a number of tumours, biological factors affecting radiosensitivity, i.e. predictive factors, such as local hypoxia, tumour heterogeneity or viral infections, were identified. Such investigations need to be extended, and may also consider the early response of the tumour to a specific treatment. Imaging biomarkers of tumour radiosensitivity are needed in this context, as well as biomarkers of morbidity which can be identified before or early in the treatment phase may help in the selection of the adequate treatment of the individual patient. These have so far been rarely studied. However, patients with a high risk for a certain, severe, morbidity symptom may require a change in dose distribution, in treatment strategy or follow-up protocols may need to be adjusted to the individual morbidity risk pattern based on early biomarker expression.

3.2.4 Radiobiological mechanism of radiation-induced side-effects and protective strategies

The radiobiological molecular mechanisms of radiation-induced morbidities in normal tissues and organs are very complex and vary between different signs and symptoms of morbidity in the same organ and between different organs. Also the tumour responses to therapeutic exposure to ionising radiation, including radiotherapy using hadrons, are currently largely unknown. The radiobiological molecular mechanisms are even more complex after combined radiotherapy and chemo- or biologically-targeted treatment strategies. These mechanisms need to be clarified for specific clinical morbidity endpoints in order to develop specific strategies for protection, mitigation or management of the clinical consequences of exposure. They are even more important for medical radiation procedures in paediatric patients given the evidence showing that the complexity and severity of morbidities and developmental injury and the risks of therapy-induced malignant diseases are particularly high after radiotherapy (in almost all instances in combination with chemotherapy!).

Similarly, novel strategies for improving the diagnostic and/or therapeutic efficacy for the application of ionising radiation may be based on the synergistic combination with upcoming technologies like for example combinations with high intensity focused ultrasound and biology-based approaches relying on tumour genomics, proteomics or metabolomics including local enhancement of drug delivery.

Both the protective and sensitising strategies need to be established and validated in preclinical as well as in subsequent clinical studies. These investigations need to focus on the efficacy of the novel approaches and also on their selectivity for the respective target tissue to guarantee a therapeutic gain.

3.3 Optimisation of radiation exposure and harmonisation of practices

According to the European Basic Safety Standard (BSS), the radiation protection of individuals subject to public or occupational exposure must be optimised with the aim of keeping the magnitude of individual doses, the likelihood of exposure and the number of individuals exposed as low as reasonably achievable (ALARA) taking into account the current state of technical knowledge, economic and societal factors. The optimisation of the protection of individuals subject to medical exposure should be consistent with the medical purpose of the exposure.

The EU Directive on patients' rights in cross-border healthcare (2011/24/EU) calls for a concerted strategy in terms of harmonisation of clinical practices, meeting patients' expectations of the highest quality healthcare, including when they seek treatment away from home.

According to the literature, high variability of mean effective doses or organ doses of patients across Europe persists across all medical ionising radiation procedures, even across single countries, hospitals or even on the department level, despite technological developments facilitating reductions in patient dose, thus highlighting the importance of harmonisation of ionising radiation procedures and the development of new and more efficient optimisation methods including evaluation criteria. For this optimisation, there needs to be a general definition what is an acceptable level of quality, what kind of optimisation should be performed and what is the optimal level. With the main goal of maximising the clinical outputs of the procedures while minimising the exposure of patients and staff, the key research questions are:

3.3.1 Patient-tailored diagnosis and treatment

The comprehensive tailoring of imaging and therapeutic procedures in terms of the clinical question, anthropometric and physiological parameters of each patient especially children and lesion-specific characteristics is a key challenge that is largely still not addressed properly. Furthermore, imaging is essential to patient-tailored therapy planning, therapy monitoring and follow-up of disease, as well as targeting non-invasive or minimally invasive treatments, especially with the rise of theranostics (combination of diagnostic and therapeutic procedures to optimise treatment).

For the reasons given in the above, research in view of reducing radiation exposure to the patients by individually tailoring their diagnosis and treatment needs to be conducted with regard to the following currently unresolved issues:

- Development of quantitative imaging biomarkers for each common clinical indication and/or specific disease/organ, and their standardisation with regard to required image quality in conjunction with related radiation exposure
- Recent advances in imaging using specific radiotracers will provide additional tools for better characterisation of a lesion at the molecular level. This will provide an insight of lesion heterogeneity and targeting, with perspectives in guiding biopsy of lesions, prediction of treatment response and image guided therapy.
- For optimal treatment prescription in targeted radiotherapy the knowledge of the dose-response relationship is essential. In targeted radiotherapy, patient-specific dosimetry is essential for both the prediction of the adverse events of a treatment and of the tumour response.
- Research on the requirements that have to be met for quantitative imaging to yield reliable and reproducible results, e.g. in view of system stability, image reconstruction techniques, influence of individual patient characteristics and applied radiation exposure
- Development of approaches for low-dose time-resolved volumetric imaging (4D), e.g. of blood flow or volume distribution (perfusion) as well as organ-motion dependent imaging, especially in view of therapy planning and treatment response imaging.
- Development of body-mass index (BMI) specific image acquisition protocols and specific dose-reduction algorithms for obese patients, since obese patients require higher than average radiation doses and exploitation of techniques normally used for radiation exposure reduction to achieve diagnostic image quality
- Development of approaches for low-dose treatment-response and follow-up imaging solely focussing on the detection of "change" (relative to a standardised baseline acquired at higher radiation exposure) providing reliable diagnostic assessment, e.g. through development of standardised disease- or treatment-specific imaging protocols especially for those patients frequently imaged
- Research for identifying underlying relationships between demographic, disease-related, and 'omics' biodata and image and treatment data for fully developing personalized medicine in order to offer the best medical diagnostics and treatment associated with the lowest possible dose to each individual patient

The benefit of this research could be to develop systems for diagnosis and treatment allowing for more efficient treatment techniques. These would then also be more economic. This research could also provide further insights into disease processes of individual patients and therefore foster precision medicine.

3.3.2 Full exploitation and improvement of technology and techniques

Despite the potential for the exponential growth in the technological features of medical imaging equipment to decrease patient doses, such benefits are not always realised in daily clinical practice.

Therefore research on development, improvement, clinical applicability and full clinical exploitation of (new) technology and techniques for offering diagnosis and treatment delivery associated with the lowest technically possible radiation exposure to the patients is required. In this context, currently the following topics need to be addressed by research:

- low-dose (CT) imaging enabled by low tube potentials and current-time products in view of its clinical applicability, indication, standardisation as well as its potential diagnostic and technical limitations
- novel image reconstruction techniques enabling low- or lowest-dose image acquisitions, with regard to their routine clinical applicability and their limitations in view of ensuring diagnostic accuracy and reliability
- novel detector technology in medical imaging in view of its clinical applicability and potentially associated technical limitations
- diffraction enhanced imaging and other newly developed approaches
- further development, implementation and application of patient- and disease-adapted techniques and protocols of combined modalities as for example SPECT/CT, PET/CT, PET/MRI and LINAC-MRI
- optimization of image guidance procedures in radiotherapy
- strategies for a reduction in peripheral doses in radiotherapy, e.g. by defining indications for ion therapy
- research for and production of novel radionuclides and radiopharmaceuticals for either improving diagnostic and therapeutic outcome or reducing associated exposure
- data-crawling and mining approaches based on large-scale data contained in imaging and treatment biobanks, e.g. for extracting indication-specific acquisition or treatment protocol parameters along with associated patient exposure data for the purposes of diagnosis and treatment optimisation, standardisation and harmonisation (e.g. by definition of European DRLs) as well as for extraction of higher-order patterns of disease, its diagnostics and treatment along with associated doses, and the possible interrelation of this data e.g. to genomic data (radiogenomics).

While research with regard to technology development may remain basic research institutions- and even more manufacturer-driven and controlled, though requiring and relying on input and feedback from medical research and routine clinical applications, research on clinical applicability, improvement and full exploitation of technology and techniques enabling radiation exposure reduction is driven by and requires active medical research in the fields of radiological diagnosis and radiopharmaceutical and -therapeutic treatment. There needs to be an emphasis on the close link between technology developments at research institutions and especially at manufacturers sides and the clinical research facilities with feedback options and especially to define a process to consolidate the achievements in terms of harmonisation.

Any optimisation in medical imaging techniques, including dose reduction strategies, must be evaluated thoroughly in terms of the resulting image quality. In determining whether an image is diagnostic or fit for purpose it is important to take into account not only the physical measurements of image quality (e.g. signal to noise ratio (SNR), modulation transfer function (MTF), and detector quantum efficiency (DQE)) but also to include psychophysical methods (e.g. contrast detail assessment and spatial resolution assessment), and clinical, diagnostic performance approaches such as visual grading analysis (VGA), receiver operating characteristic (ROC), and psychometric scales. The current variability, absence of validated approaches and guidelines represents a significant barrier to effective optimisation research. The 1996 European Guidelines on Quality Criteria for Diagnostic Radiographic Images (European Commission, 1996) aimed to provide some assistance with image quality assessment but these were very limited, have deficiencies, were never validated and are now dated. There is thus an urgent need for establishment of robust, validated approaches to facilitate this critical aspect of optimisation research.

Technologically meaningful developments must be performed with respect to the possible output for patient, staff and public in various levels of maturity in terms of the status as product lines and its applications in the medical environment.

In this context, multi-professional engagement together with educational institutions and equipment manufacturers will facilitate the required development of strategies for the harmonisation of ionising radiation procedures and standards of practice, since several studies have highlighted the heterogeneous use of technology and the unanticipated patient and staff dose increases. This is of particular importance in paediatric populations as well as for patient cohorts requiring multiple consecutive diagnostic, radiopharmaceutical, or -therapeutic procedures.

3.3.3 Clinical and dose structured reporting

Clinical reporting

Medical imaging procedure workflow involves several steps, ending with a clinical report. Currently, medical imaging reports are often presented with little or no structure to the text. This can present difficulties in understanding the content of the report both for referring physicians and patients. The development of a structured reporting system will improve the clinical outcome of a medical imaging procedure, by focusing on the essential message, in a harmonised way, thus facilitating the communication process along the clinical pathway of the patient.

There are many advantages of such reports, including improved follow-up for returning or chronic patients, easy retrieval of pertinent information enabling clinical and translational research, integration of the information in imaging biobanks, and automated translation.

Another related issue is the lack of a centralised medical databank on imaging procedures for each individual patient on a national and European level, often leading to unnecessary repeated diagnostic procedures and hence unnecessary radiation exposure. Harmonisation of clinical reports could facilitate the development of such a centralised medical registry at a European level. Also, a centralised dose data collection algorithm for therapeutic procedures would allow for improved analyses of dose-effect relationships for adverse events, including stochastic radiation sequelae.

Dose reporting

Structured dose reporting in radiation diagnostics and therapy (or documentation of administered activities in nuclear medicine) is a growing area of focus and will benefit all professions directly involved in the ionising radiation procedures and patients undergoing such procedures in the years to come. However, the adequate specification of dose distributions has not been addressed yet in research and clinical practice sufficiently.

In radiation oncology, structured dose reporting needs to address absorbed doses in organs at risk and/or their subvolumes relevant for adverse event endpoints. The latter need to be specified and their scaling to be defined. Moreover, anatomy-related dose distributions in the irradiated volume and in the periphery, at least down to the 1 % isodose, need to be reported or re-constructable from the documented treatment information and then specifically related to potential radiation sequelae.

The main benefits would be:

- To establish a model for providing information – in radiation diagnostics and nuclear medicine - about patient dose exposure in an easily accessible way e.g. by integrating visual scales for the referring physicians to understand the level of exposure, and
- to facilitate the rapid determination of local, national and European diagnostic reference levels (DRLs).
- To facilitate establishment – in radiation oncology – of dose response relationships for adverse events in organs at risk as well as for stochastic radiation effects both close to the PTV and in the periphery of the patient.

Structured dose reporting in radiation diagnostics (or documentation of administered activities in nuclear medicine) is an essential tool for the harmonisation of the dose management systems and the comparison of doses, creating a comprehensive, common language for health professionals. Structured dose reporting in radiotherapy is essential to establish firm dose-effect relationships for adverse deterministic and stochastic events.

3.3.4 Protection of staff, patients, carers, and general public

Aside from the optimisation of protocols and procedures, their standardisation and their personalisation, it is most important to optimise radiation protection using existing radiation protection measures. To optimise radiation protection in terms of applicability and best benefit for staff and patients, the establishment of key indicators of safety and quality in radiation protection is essential according to the general ALARA principle discussed before. The primary goal of the development of safety programmes is to reduce morbidity risks from excessive exposure to ionising radiation for specific procedures and population e.g. interventional radiology and the paediatric population. Another focus is on cost-benefit analysis of the implementation of radiation protection devices and safety programmes. Neither proven criteria of cost nor proven criteria of benefit have been established so far. Research must explore both external and internal radiation exposure and their associated protection measures.

3.4 Justification of the use of ionising radiation in medical practice

The principle of justification is one of the key pillars of radiation protection underlined in the recently revised European BSS Directive. This principle focuses on weighing the benefits versus the risks. Further important elements are patient communication, as the basis for shared decision-making including the patient rights for influencing the decision, as well as the appropriateness of the radiological procedure with respect to the clinical setting. The key research questions in research into the justification of the use of ionising radiation in medical practice are:

3.4.1 Risk / benefit assessment and communication

While the clinical benefit of a diagnostic or interventional imaging procedure is assumed to be established, an estimation of the risk related to effective dose exposure for a given patient is a difficult step because the current estimations are for a general population. The current uncertainties in this area make the establishment of a reliable risk / benefit assessment virtually impossible.

Therefore there is the urgent need for research aimed at a risk estimation for an individual patient. However, it is unclear how this can be implemented for the stochastic mechanisms based on epidemiologic data. Increased risk factors for organs /specific patient groups or patient-parameter based changes on optimal imaging procedure setups may however be investigated. For the development of such a research programme for diagnostic imaging and interventional procedures, reference to a centralised repository of imaging data would be an important resource for data mining and the following risk assessment (see sections 3.5.1 and 3.5.2).

The proposed research will have a direct benefit for the patient in general and especially in the context of screening methods based on the use of ionising radiation.

Most new therapeutic radiation technologies are clinically introduced to reduce exposure to healthy tissue. In the near future, an increasing number of cancer patients will be treated with particles (e.g. protons and carbon ions). Although particle therapy will result in lower dose levels to many critical structures as compared to the currently used photon-based technologies, the consequences in terms of reduction of late and very late side effects remains to be determined and have to be weighed against the higher costs.

In the context of the current drive for patient empowerment and involvement in the decision-making process, the development and subsequent evaluation of novel tools for patient communication have become necessary. Some professional organisations such as the ACR, RSNA, ESR and national/clinical societies have developed communication guidelines and platforms for diagnostic imaging, however, a unified approach regarding methodology and content is currently missing.

The proposed research work will aim to develop a European evidence-based electronic communication platform focusing on all types of diagnostic imaging using current information technology that is endorsed by the relevant professional organisations, patient organisations and other relevant stakeholders. The European platform will be designed in a way to allow for localisation and adaptation to the national / regional settings. The establishment of such a system has to be based on the successful completion of the cost benefit research activities outlined above.

3.4.2 Improvement of use of evidence-based guidelines

Clinical imaging guidelines especially in view of the referral process are intended to help physicians decide when an imaging study would be useful and identify the most appropriate examination for a particular patient. In recent years, imaging guidelines in view of the referral process received much attention from the radiation protection community and international organisations given the increasing number of medical imaging procedures and studies that have shown that about 30% of the imaging procedures performed in Europe were found to be inappropriate. The recently revised European BSS Directive requires that clinical imaging guidelines are available in all EU member states.

In 2011, the European Commission awarded a European tender project to assess the availability and implementation of clinical imaging guidelines in EU member states. One of the key conclusions was the recommendation that the awareness and use of clinical imaging guidelines in Europe need to be improved and that novel approaches are needed to achieve this.

The proposed research work must identify and develop methods to improve the use of clinical imaging guidelines in Europe especially in view of the referral process at large e.g. through incentives, regulatory requirements, IT tools, etc. The research work is related to a key priority in medical radiation protection as outlined among others in the Bonn Call for action and must be relevant for all diagnostic applications of ionising radiation. To define the proposed methods, an evaluation and impact assessment of the use of currently existing European and national guidelines must be performed with an emphasis on evaluating the usability of the guidelines and their impact on daily clinical practice.

The outcome of the proposed research work should be a European recommendation paper on how to improve the dissemination, integration into the clinical workflow and use at large of clinical imaging guidelines in view of the referral process. In addition methodologies and guidelines for adoption/localisation/adaptation of the guidelines need to be proposed.

The recommendation paper shall serve as guidance for professional societies and policy-makers in Europe.

3.5 Infrastructure for quality assurance

To perform investigations on tissue reactions, optimisation procedures as well as risk and benefit evaluations it is important to rely on optimal, quality assured data, which are gathered under defined conditions, and which are necessary to various reasons including legal questions pertaining/specific to the research to be performed. In addition, the clinical system of medical applications of ionising radiation has to be standardised and evaluated about its effectiveness in radiation protection.

3.5.1 Data coding, collection and management

It is crucial for the future of medical imaging in Europe to develop a European medical imaging coding system (EMICS) including radiology and nuclear medicine imaging procedures. EMICS should apply to all medical procedures based on ionising radiation, giving policy makers and healthcare providers an objective and clear view, on a procedure-level basis, at national and EU levels. This would be a fundamental tool for future studies such as population dose studies and or e.g. parameter dependent image quality studies. According to the recently published Dose DataMed 2 report, *"in order to compare x-ray examination frequency data between countries, and to assign typical effective dose values to examinations, it is crucial that an "X-ray examination" is defined and counted in a consistent way".* Therefore, the development of EMICS, based on an alphanumerical code structure, must be facilitated and must be integrated in all HIS / RIS systems.

EMICS would also support the harmonisation of the "language" for medical imaging and therapy across Europe giving healthcare providers a powerful tool for the future planning of health systems at local, regional, national and European levels. This should be extended to the acquisition of data on the long-term consequences of radiation exposure, diagnostic or therapeutic, potentially in combination with other therapeutic procedures, to allow structured long-term follow-up, assessment and documentation of treatment-related morbidity and the possibility to relate morbidity to anatomical dose distribution. Requirements and structures, along with administrative characteristics, including data protection issues, need to be defined. Such data management structures will provide a basis for epidemiological investigations into relevant medical questions. Data should be collected throughout Europe according to this standard using defined mandatory and where possible additional data regarding exposure and if possible image quality as well as certain patient specific data.

3.5.2 Comprehensive medical database / imaging biobank

Biobanks are repositories for the storage and retrieval of biological samples of a large number of subjects. A major goal of biobanks is the organised collection of biological material and associated information to spread access among scientist requiring this information. Extending this concept to medical imaging and especially to radiation protection is needed in order to collect radiation protection metrics and to allow for long-term follow-up for specific cohorts, which will be called a comprehensive medical database or imaging biobank. It might be important for various reasons:

Importance for dose collection: The concepts and the use of DRLs and achievable dose levels (ADLs) have to be redefined to meet the requirements of organ specific dose distributions or critical organ

structures doses as mentioned in 3.1. Large scale (national, regional) patient inter and intra organ dose distribution monitoring is necessary for the purpose of definition, optimisation and periodic assessment of DRLs and ADLs. This aim can be achieved by developing large scale archives and automatic data analysis using the recently developed standards allowing sending and archiving of dose information.
The development of automatic methods for phantom image quality assessment (and patient image quality assessment) together with the use of advanced IT technologies (e.g. large scale archives, data mining methods, expert system technique) is required for supporting users in the optimisation process.

Importance for long-term follow up of cohorts:

There is clear evidence that radiotherapy may cause, in organs and tissues close to the PTV but also in organs in the periphery, an increased risk for late and very late side effects that are clinically relevant and have a major impact on quality of life. Although there is an increasing awareness of radiation-induced very late side effects, the infrastructure to systematically collect relevant data to get more insight in the factors that contribute to these risks is largely lacking.

The proposed research work should involve the development of a structure for a European imaging biobank infrastructure integrated with a European radiation oncology biobank infrastructure.

3.5.3 Developing key performance indicators for quality and safety

Key performance indicators (KPIs) have been successfully introduced as a performance measurement in many areas of healthcare in line with the EU Agenda on Quality of Health Care and Patient Safety put forward by the EC DG SANTE. Currently there is no recognised gold standard in the fields of medical imaging or radiation therapy. A general concept of performance indicators for imaging and radiation therapy is thus needed and should also include indicators for the safety of patients and of procedures and how to maintain safety standards, according to the optimisation and justification processes.

The proposed research work will consist in the establishment of KPIs for the quality achieved regarding specific medical procedures and in general terms of radiation protection and harmonisation at the European level. For integration into the workflow, pilot studies in dedicated centres and impact assessment before dissemination are envisaged.

3.5.4 Audit systems

Clinical audit is a tool designed to improve the quality of patient care, experience and outcome through formal review of systems, pathways and outcome of care against defined standards, and the implementation of change based on the results. Audit cannot be carried out without a pre-set standard against which performance can be assessed.

As laid down in the revised European BSS Directive, Member States shall ensure that clinical audits are carried out in accordance with national procedures. Clinical audit is a relatively new concept in radiation protection. It seeks to improve the quality and outcome of patient care through structured review of medical radiological practices, procedures and results, whereby these are examined against agreed standards for good medical radiological procedures, with modification of practices, where appropriate, and the application of new standards if necessary.

In October 2009, the EC published guidelines relating to clinical audits for radiological practice, including all investigations and therapies involving ionising radiation. In spite of this document, clinical audit is still clearly underdeveloped in Europe.

To address this shortcoming, the proposed research "must aim at developing" an easy-to-use, cost and time effective European clinical audit tool taking into account existing initiatives from professional organisations. The tool will facilitate implementation of the relevant requirements in the European BSS Directive, and could potentially provide the basis for future European accreditation processes based on quality and safety.

3.5.5 Education and training metrics

There is a strong demand for new education and training models in medical radiation protection due to the rapid development of medical techniques based on ionising radiation, growth of hospitals and the continuous need to produce competent health professionals. The major challenge is addressing the variety of professions and professionals, with different knowledge background, different needs, but all working towards the same objective: patient and staff safety.

To achieve that objective it is necessary to establish a harmonised and sustainable safety culture in radiation protection amongst health professionals through specific oriented education and training courses. External assessment of the quality of education or training provision is needed (ICRP reference) and should be provided by a European accreditation body.

It is important to develop through research:

- a metric system to measure the knowledge, skills and competences outcomes from education and training in radiation protection for the different health professions involved in ionising radiation procedures;
- an assessment system to measure:
  - the impact of the implementation of a continuous professional development model for education and training in radiation protection;
  - the type of needs for education and training, considering the installation of new equipment and/or new procedures.

There is a need to create a European certification system for education and training in radiation protection, based on the development of standards of proficiency for health professionals, as an instrument to guarantee safety procedures to European citizens, through harmonization of practice through education and training.

4 Education and training

As highlighted in the recent EC Radiation Protection No. 175 *'Guidelines on radiation protection education and training of medical professionals in the European Union'* there is a continuing, and growing need for high quality education and training in the field to ensure the radiation protection of patients, staff and the public. This education and training must be accessible and delivered at an appropriate level for all professionals working in the field of medical ionising radiation as well as those utilising the services provided by medical ionising radiation professionals. EC Radiation Protection No. 175 came about as an outcome of the MEDRAPET project and describes education and training in radiation protection using the European qualifications framework (EQF), knowledge, skills and competence (KSC) structure and European credit transfer system (ECTS).

It is essential that any research in the area of medical ionising radiation is translated into clinical practice in order to ensure that patients and staff see the direct benefits of this research. As highlighted in sections 3.3 and 3.4 of this SRA, there is evidence that this translational research often fails due to the absence of parallel education and training programmes. High quality education and training programmes will raise awareness of ongoing EU research projects and initiatives and ensure their uptake into clinical practice at local, national and European levels. Separately, there has been an identified need to also develop high quality education and training specifically for researchers to help strengthen the medical ionising radiation research community.

Education and training may consist of traditional, face to face lectures and practical sessions but should also focus on becoming more clinically-focused and case-based. Online, or e-learning, approaches to the delivery of content at all levels utilising mobile devices is a key consideration, which includes the development of dedicated appropriate e-learning tools, e.g. facilitated by a multidisciplinary European e-learning platform.

Education of staff

In the former chapters necessary and relevant topics for research related to the optimal use of ionising radiation and radiation protection in medical applications have been explained. Also, measures have been mentioned how these optimisation have to be implemented throughout European by means of standardisation and harmonisation. However, it is obviously not sufficient just to define methods for harmonisation but this has to be reflected within the education of the staff.

This education needs to reflect the basic aspects of

- radiation physics,
- radiation biology,
- radiation protection,
- radiation communication, and
- specific parts for the procedures / areas that are supposed to be covered by the staff.

Therefore, within this SRA it is proposed to develop a standardised education rule describing topics that have to be covered. In addition there is a need for securing the highest level of knowledge transported reflecting state-of-the art technology as well as standardisation and harmonisation efforts. Finally, establishment of a European certification approved by the medical associations issuing this SRA should also be covered, not only after the completion of initial training, but also throughout the whole professional life of each professional.

Education of researchers

To provide valuable research dealing with these identified relevant topics with potential impact, it is important to perform well-founded and structured research along certain lines. In order to do so, it is also necessary to train researchers in performing research according to the best practice. That especially holds true for research working with humans or biological material, but also with any data related to humans. There has to be a standardised training structure also reflecting the actual state-of-the-art for research procedures with the goal of fostering the efficiency of projects reflecting the research topics identified above especially in terms of optimal patient care and radiation protection.
In this respect it is important to deal with best practice

- regarding literature work and citation practice
- statistical power of investigations
- uncertainty budget calculation of measurements and calculations/simulations
- clear hypothesis driven project definition
- pre-research feasibility estimates of proposed outcomes.

List of abbreviations

ACR	American College of Radiology
ADLs	Achievable Dose Levels
ALARA	As Low As Reasonably Achievable
ALLIANCE	European Radioecology Alliance
BMI	Body-Mass Index
BSS	Basic Safety Standard
CARPE-M	Common Approach to Radiation Protection in Medicine
CT	Computed Tomography
CONCERT	European Joint Programme for the Integration of Radiation Protection Research
DE	Dual-Energy
DRLs	Diagnostic Reference Levels
EANM	European Association of Nuclear Medicine
EC	European Commission
ECTS	European Credit Transfer System
EFOMP	European Federation of Organisations in Medical Physics
EFRS	European Federation of Radiographer Societies
EMICS	European Medical Imaging Coding System
EQF	European Qualifications Framework
ESR	European Society of Radiology
ESTRO	European Society for Radiotherapy and Oncology
EU	European Union
EURADOS	European Radiation Dosimetry Group
HIS	Hospital Information System
IR	Interventional Radiology
IT	Information Technology
KPIs	Key Performance Indicators
KSC	Knowledge, Skills and Competence
LINAC	Linear Accelerator
MC	Monte Carlo
MEDRAPET	Medical Exposures Directive's Requirements on Radiation Protection Training of Medical Professionals in the EU
MELODI	Multidisciplinary European Low Dose Initiative
MRI	Magnetic Resonance Imaging
NERIS	European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery
NTCP	Normal Tissue Complication Probability
OPERRA	Open Project for European Radiation Research Area
PBPK	Physiologically-based Pharmacokinetic
PET	Positron Emission Tomography
PTV	Planning Target Volume
RIS	Radiology Information System
RSNA	Radiological Society of North America
SPECT	Single Photon Emission Computed Tomography
SRA	Strategic Research Agenda
TCP	Tumour Control Probability

Statement of priorities from the draft medical Strategic Research Agenda

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Note:

These priority topics presented here were selected by taking one (in some cases a combination of several) from each of the sections of the medical SRA. They all have high priority for the advancement of radiation safety in medicine. The first two have a direct relationship with the priority topics of MELODI and EURADOS, and could be incorporated into these topics in an appropriate way.

VS 07/09/2015

Priority title	**Individualised patient dosimetry for medical use of radiation**
Priority description	Individualised patient dose assessment methods are needed to allow for accurate patient dose estimation and risk assessment. Many dose distributions depend on individual patient constitution (e.g. size, weight, shape, age and biological factors such as the distribution and kinetics of radioactive markers or susceptibility to different therapeutic procedures). Therefore, the following need to be addressed in research: • Development of computational methods for dose distribution calculations based on patient-specific and equipment-specific characteristics for all medical procedures using ionising radiation, including for example CT, interventional and nuclear medicine procedures, as well as radiotherapeutic procedures taking account of different dose indicators for different types of procedures to get comparable meaningful information about normal tissue doses of individuals. • Development of optimal dose measurement protocols in nuclear medicine for accurate estimation of normal tissue absorbed doses (mean organ doses and 3D distributions) using validated quantitative imaging and dose calculation methods. Refinement, validation and implementation of new biokinetic models for dosimetry in molecular radiotherapy using for example physiologically-based pharmacokinetic (PBPK) models for the individual assessment of biokinetics, including uncertainty budgets. • Development of dose-based indicators of risk-related intra-organ dose distributions avoiding or replacing mean organ dose or effective dose as indicators • Determination of all aspects of the absorbed radiation critical to risk evaluation, such as dose-rate, dose inhomogeneity, charged particle energy spectra, etc. • Evaluation of the uncertainties of dose estimates, including investigation of the influence and sensitivity of different parameters (technique dependent, system dependent, patient dependent, medical staff dependent).
European relevance	Individualised dosimetry is fundamental both to individual patient safety and to research on radiation risk. Clinically it will enable the use of procedures optimised to individual patients, giving greater safety and effectiveness. For research, epidemiological cohorts that include accurate individual doses will give more information on patient risk and basic radiobiology.
Multidisciplinarity; Reference to the strategic research agendas (SRA)	This topic is taken from Section 3.1.2 of the medical SRA. EURADOS priorities 2 and 5 address aspects of this topic MELODI Statement Priority 1 proposes use of cohorts for which individual dosimetry will be essential. COUNCIL DIRECTIVE 2013/59/EURATOM (BSS) Article 56 (1) requires individual planning and verification of doses for radiotherapy. This is currently not performed in the majority of therapeutic applications in nuclear medicine.
Impact: decreased uncertainty	Currently dosimetry for diagnostic procedures is generally population-based, critical organ dosimetry for nuclear medicine therapy is generally not performed in daily clinical routine (except for some specialised treatments/centres) , and in external beam therapy doses are not calculated beyond a high-dose margin around the treatment volume. Decrease in uncertainty will be significant.
Impact: increased radiation protection	Individualised dosimetry has the potential to lead to a considerably reduced individual risk from medical procedures. Knowledge of individual risks from medical procedures using radiation will play a major role in improving justification and optimisation.
Impact: increased acceptability	Risk communication and perception will be more credible with individual assessments of known accuracy.
Feasibility	The scientific expertise is available and there are some individual medical research centres already working on the topic. This would benefit from coordination and funding support.
Other justifications	

Priority title	**Individual patient-related radiation sensitivity and early biomarkers of response and morbidity**
Priority description	The individual sensitivity of patients should be taken into account in the choice of specific diagnostic procedures and/or therapeutic strategies. This can be based on intrinsic factors (age, gender, genomics, proteomics) of their different normal or target tissues, but also on concomitant diseases impacting on general or specific normal tissue tolerance, lifestyle (e.g. reduced lung/liver tolerance due to smoking and alcohol consumption) or previous/parallel treatments. The following research is proposed: • Investigation of the incidence of serious short- and long-term normal tissue morbidity in interventional radiology, nuclear medicine therapy, and external beam radiotherapy in relation to the factors listed above, and the dose delivered to the tissue. • Development of biomarkers of individual sensitivity to radiation-induced morbidity which can be identified before or early in the treatment phase so that patients with a high risk for a certain, severe, morbidity symptom may have personally adapted procedures. • Investigation of the molecular, cellular, and tissue mechanisms of radiation-induced morbidities for specific endpoints in order to develop specific strategies for protection, mitigation or management of the clinical consequences of exposure.
European relevance	This topic is primarily of value for the optimisation of diagnostic/therapeutic procedures taking into account individual sensitivity. It will also provide valuable data for basic studies of the factors determining individual radiation sensitivity.
Multidisciplinarity; Reference to the strategic research agendas (SRA)	This topic is taken from Section 3.2.3 of the medical SRA. It could be incorporated into priorities 3, 4 and 5 of MELODI Statement.
Impact: decreased uncertainty	Risks from radiation exposure will be reduced by taking account of sensitising factors.
Impact: increased radiation protection	Greater safety of the medical use of radiation.
Impact: increased acceptability	More objective measures of adverse effects of radiation will lead to great assurance and acceptability.
Feasibility	The first point is quite feasible, depending on collection and analysis of data. The development of biomarkers is always unpredictable.
Other justifications	

Priority title	**Patient-tailored diagnosis and treatment: full exploitation and improvement of technology and techniques with clinical and dose structured reporting**
Priority description	The comprehensive tailoring of imaging and therapeutic procedures in terms of the clinical question, anthropometric and physiological parameters of each patient and especially children and lesion-specific characteristics is a key challenge that still is not addressed properly. Furthermore, imaging is essential to patient-tailored therapy planning, therapy monitoring and follow-up of disease, as well as targeting non-invasive or minimally invasive treatments, especially with the rise of theranostics. The following research is proposed: • Development of a combined strategy using individualised quantitative imaging (incorporating CT, MRI, PET, SPECT, etc.), normal tissue dosimetry, biomarkers, and physiological parameters in order to optimise patient benefit per risk (and cost); • Harmonisation of ionising radiation procedures and the development of new and more efficient optimisation methods including evaluation criteria; • Investigate novel imaging technologies and applications in order to maximise clinical information relative to patient risk • Establish clinical and dose structured reporting in order to facilitate the development of optimal individualised diagnosis/therapy protocols based on multi-centre outcome databases
European relevance	This topic will enable further compliance with COUNCIL DIRECTIVE 2013/59/EURATOM (BSS) Article 56 (Optimisation in medical use)
Multidisciplinarity; Reference to the strategic research agendas (SRA)	This topic is taken from Section 3.3 (Optimisation of radiation exposure and harmonisation of practices) of the medical SRA
Impact: decreased uncertainty	Optimised and harmonised practices will lead to reduced uncertainty in radiation exposure and corresponding risks
Impact: increased radiation protection	Patient-tailored procedures will reduce the risks for individual patients.
Impact: increased acceptability	Risk reduction will give greater assurance to patients.
Feasibility	The proposal contains a mix of application of existing technology and development of new technology. At least 3 years should be allowed to be sure of useful outcomes.
Other justifications	

Priority title	**Improvement of use of evidence-based guidelines for medical imaging procedures: risk-benefit assessment and communication**
Priority description	The principle of justification is one of the key pillars of radiation protection underlined in the recently revised European BSS Directive. This principle focuses on weighing the benefits versus the risks. A further important element is patient communication, taking account of the patient's rights, as a basis for shared decision making on appropriate procedures. The following research is proposed: • Development of individualised risk assessment methods for diagnostic and interventional radiological procedures as part of objective risk-benefit guidelines for clinical practice. • Development and evaluation of novel tools for patient communication of risks and benefits in radiology leading to European guidelines. • An evaluation and impact assessment of the use of currently existing European and national evidence-based guidelines for the decision to use radiological procedures must be performed, with an emphasis on evaluating the usability of the guidelines and their impact on daily clinical practice.
European relevance	This topic will enable further compliance with COUNCIL DIRECTIVE 2013/59/EURATOM (BSS) Article 55 (Justification in medical use) The development of patient risk communication would be of interest to the social sciences and humanities.
Multidisciplinarity; Reference to the strategic research agendas (SRA)	This topic is taken from Section 3.4 of the medical SRA. Patient risk communication and patient's rights will be covered by the social sciences SRA.
Impact: decreased uncertainty	Risks from radiation exposure will be reduced by taking account of an appropriate use of imaging tests
Impact: increased radiation protection	Patient-tailored procedures will reduce the risks for individual patients
Impact: increased acceptability	Risk reduction will give greater assurance to patients.
Feasibility	A mix of sociology, professional and regulatory issues. At least 3 years should be allowed to be sure of useful outcomes
Other justifications	Provide the basis for an EC recommendation

Priority title	**Infrastructure for quality assurance: data coding, collection and management for a comprehensive medical imaging database and biobank**
Priority description	To perform investigations on tissue reactions, optimisation procedures as well as risk and benefit evaluations it is important to rely on quality assured data, which are gathered under defined conditions, and which are necessary for various reasons including legal questions pertaining/specific to the research to be performed. In addition, the clinical system of medical applications of ionising radiation has to be standardised and evaluated about its effectiveness in radiation protection. The following research is proposed: • Develop a European medical imaging coding system (EMICS) including radiology and nuclear medicine imaging procedures. EMICS should apply to all medical procedures involving ionising radiation, giving policy makers and healthcare providers an objective and clear view, on a procedure-level basis, at national and EU levels. • Develop a multi-centre European database and biobank for medical imaging, incorporating a standardised EMICS, personalised dosimetry, and, where possible, biological samples. Investigate the possibility of links to health records to allow patient follow-up. The database would be used for redefinition of diagnostic reference levels (DRLs) and achievable dose levels (ADLs), and provide cohorts for epidemiological studies of the risks of diagnostic radiology, and more general radiation safety.
European relevance	COUNCIL DIRECTIVE 2013/59/EURATOM (BSS) Article 56 (2) requires the regular updating of diagnostic reference levels. The database proposed in this topic has direct relevance for Euratom WP16-17 NFRP-9. It would have wider applications than optimisation of medical use; it would be valuable for basic research into low-dose effects.
Multidisciplinarity; Reference to the strategic research agendas (SRA)	This topic is from Sections 3.5.1 and 3.5.2 of the medical SRA. The proposed database/biobank would be valuable for MELODI priority 1
Impact: decreased uncertainty	Increase of semantic interoperability would be the basis of the establishment of an European biobank, and would allow further of epidemiological studies, and cross talks with other omics biobanks
Impact: increased radiation protection	Benchmarking based on this interoperability would allow the establishment of better and dynamic DRL
Impact: increased acceptability	Need to develop automatic dose recording and management for increasing acceptability
Feasibility	Existing coding systems (RADLEX) and dose recording software are making this project feasible. At least 3 years should be allowed to be sure of useful outcomes
Other justifications	

Section 2: Communication and risk perception

Needs and priorities addressing radiation protection research relevant for communication/risk perception

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Abstract

This document outlines the rationale to integrate social sciences and humanities in radiation protection research as specified for Task 2.6. It then summarises the results from a first discussion exercise carried out in the field of risk communication and risk perception in consultation with the European technical platforms involved in radiation protection research. Subsequently, it focuses on needs and expectations of different stakeholders regarding risk communication and risk perception research of relevance for the radiation protection domain. The latter includes results synthesized both from pre-CONCERT activities, as well as activities conducted in the framework of CONCERT Task 2.6 at an early stage of the project.

Both the consultation exercise with the platforms and the more detailed analysis of research needs connected to risk perception and risk communication provide important input for the development of the forthcoming Strategic Research Agenda for Social Sciences and Humanities Research in radiation protection research. The analysis carried out substantiates the need for transdisciplinary approaches in radiation protection research.

Specifically, for risk communication and risk perception research, there is a high interest in such topics within the radiation protection community. A general conclusion is that risk communication in modern society should be seen as an important form of stakeholder engagement that enables dialogue rather than simple provision of information. Future research should address this issue and integrate stakeholder engagement in all areas of research and innovation connected to radiation protection.

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The context of CONCERT Task 2.6 - Creating a Strategic Research Agenda for Social Sciences and humanities in Radiation Protection

Background rationale

There are three reasons to integrate social sciences and humanities into research that traditionally relies on natural sciences and technology development, and they are all three normative and in that sense also 'ethical'.

The first is that this integration can help to improve the understanding of concrete challenges within specific research fields that have implications for the wider society outside of the research office or laboratory. This is the case with the research fields of concern in CONCERT: research on low dose risk, radioecology, research on emergency preparedness and response, dosimetry, and medical applications. These challenges can be related for instance to the use of specific research hypotheses and methods (modelling, prognosis, etc.), in the sense that one needs to be aware of their potential and limitations for research that aims to inform health and environmental policy. Challenges can also arise from specific ethical issues in which science has a central role and responsibility, for instance the individual sensitivity to radiation or the assessment of health effects for vulnerable groups in post-accident conditions. In practice, the integration of social sciences and humanities should be understood as bringing together natural scientists, engineers, social scientists and researchers in the humanities (e.g. philosophy, history) with the aim to organise a dialogue that would normally not take place within natural sciences and technology development. Such a 'transdisciplinary' dialogue brings together researchers with specific views on the issues at stake who would normally have limited interaction with each other. This would stimulate new research addressing questions of general societal concern that receive insufficient attention in the individual research office or laboratory. Obviously, this kind of dialogues and new research can be organised 'within' the specific natural research fields (research on low dose risk, radioecology, research on emergency preparedness and response, dosimetry), but should preferably take place as a 'meta'-dialogue involving not only these 'technical' research fields, but also researchers from the social sciences and humanities.

The second reason is that integration of social sciences and humanities can render the involvement of stakeholders in research more meaningful and effective. Nowadays it is widely accepted that radiological risk governance in the specific application contexts (medical, nuclear energy) needs to be done with the involvement of stakeholders (the potentially affected and those with specific mandates or specific political or economic interests). From this follows that any research aiming at informing risk governance policies would benefit from the involvement of those stakeholders. While the involvement of stakeholders in research that traditionally relies on natural sciences and technology development works in principle, it would work better if also researchers from the social sciences and the humanities participate. In other words 'inclusive' research first needs to be 'transdisciplinary' in order to make the inclusion of stakeholders meaningful and effective.

As a result of all this – and this is the third reason – improved understanding of concrete research challenges can help that research to become self-reflexive and thus – as an accountability towards society – critical with regard to its own working. In other words, the integration of social sciences and humanities and the involvement of stakeholders can make radiological protection research more aware of:

(1) the social, political, cultural and historical context wherein it operates;
(2) the rationales, possibilities and limitations of its own research methods; and
(3) the relevance and possible interpretations of its own hypotheses.

Obviously that awareness can then inspire what action to take or how communication with the outside world and advice towards policy should be adapted. One can say that the third reason is fulfilled by ‘practicing the first and the second’, and this counts for all kinds of research relevant in this context (research on low dose risk, radioecology, research on emergency preparedness and response, dosimetry). In that sense, the third reason could be understood as practicing a ‘higher’ form of research ethics: the preparedness to foster this ‘double awareness’ (context-awareness and self-awareness) or the preparedness to ‘practice an ethics of reflexivity’ can be seen as an ethical commitment towards society. As a result, that research would in principle be able to inform policy in a more reflexive and thus deliberate way, while it would at the same time be more resilient and resistant against strategic interpretation of its produced knowledge and hypotheses from politics, civil society and the market.

Task 2.6. Aim and approach

Taking into account the previous rationale, the aim of Task 2.6. is to create a Strategic Research Agenda for (the integration of) Social Sciences and Humanities (SSH) in Radiation Protection. In order create that Strategic Research Agenda, an interactive process will be developed with the radiation protection research communities addressed by Tasks 2.1—2.5 (the platforms MELODI, ALLIANCE, NERIS and EURADOS[1]) as well as the organizations dealing with the medical use of ionizing radiations) and the relevant stakeholders. Building on previous experiences gained in different FP7 projects (e.g. OPERRA, EAGLE, PREPARE, NERIS-TP) and experiences gained by the different platforms, Task 2.6 in the CONCERT project will further explore the needs and possibilities to integrate social sciences and humanities in the development and consolidation of European radiation protection research.

The key activities of Task 2.6 are:

- To organise specific meetings among researchers of the platforms involved in CONCERT and researchers from the social sciences and the humanities.
- To identify joint research needs and priorities with regard to specific research challenges that need the integration of social sciences and humanities and the inclusion of stakeholders as described above.
- To prepare the first version of the Strategic Research Agenda for SSH
- To consult key stakeholders on this first version of the SRA.
- To provide input to the Joint Programming (WP3).

For these purposes, the work will be organised in three subtasks around three challenges of risk governance (in either medical or nuclear energy context) that typically need to be informed by transdisciplinary and inclusive research as described above.

1. ethics and justification (2.6.1),
2. risk communication/perception (2.6.2)
3. Safety culture (2.6.3).

This Chapter of the Deliverable 2.2 titled *Research needs and priorities addressing radiation protection research relevant for communication/risk perception* is developed as a preliminary elaboration, that will be

[1] MELODI (Multidisciplinary European Low Dose Initiative)
ALLIANCE (the European Radioecology ALLIANCE)
NERIS (Preparedness for Nuclear and Radiological Emergency Response and Recovery)
EURADOS (the European Radiation Dosimetry Group)

used for development and incorporation in the *Strategic research agenda for Social Sciences and Humanities in Radiation Protection research* in a later stage of the work conducted in Task 2.6.

The next section presents an evaluation of relevant SSH topics for all three Tasks across the CONCERT platforms, ending in some general conclusions about the integration of SSH in CONCERT, and some suggestions about how this might be achieved. It is followed by a special focus on subtask 2.6.2 and the research needs and priorities in risk communication and risk perception.

Integration of Social Sciences and Humanities (SSH) in the CONCERT calls

Responsible Research and Innovation (RRI) implies giving due attention to social and ethical issues, as well as stakeholder and public participation in science, technology and innovation. For instance, the 2012 Interdisciplinary Study (*Benefits and Limitations of Nuclear Fission for a Low Carbon Economy: Defining priorities for Euratom fission research and training, Horizon 2020; 2013)* recommended that future fission "*research needs to respond to societal concerns, including new ways of engaging the public… a holistic approach to the Euratom fission programme is required"* (p.11). Task 2.6 of CONCERT bridges the gap between science and society by suggesting transdisciplinary approaches involving also Social Sciences and Humanities (SSH) in all areas of radiation protection research, and specifically in the CONCERT research calls

CONCERT Task 2.6 argues that research areas like low dose research, radioecology, nuclear and radiological emergencies response and recovery, radiation dosimetry or medical applications of ionising radiation would benefit from such transdisciplinary collaborations between natural scientists, social scientists and ethicists. Integration of Social Sciences and Humanities in radiation protection research projects and research policy would include, among other, enabling different stakeholders to weigh on nuclear research by setting priorities and inputting values.

SSH issues need to be integrated into the technical platforms' priorities. This will be achieved as a result of two activities: 1) Integrating SSH topics into the SRAs produced by the different platforms and 2) Creation of an own SRA gathering SSH priorities in the radiation protection field in a separate strategic document. For some topics, for example in post-accident situations, SSH issues are inseparable and are to some level already integrated within the NERIS SRA. Underlining the links to other platforms is an important mechanism of illustrating the issues that social sciences can contribute to within their lists of research priorities.

The following steps were taken towards integrated research for the first CONCERT call: i) Assignment of SSH contact persons for the platforms, ii) First assessment of needs and opportunities for integration of social sciences in the priorities of the technical platforms iii) Provision of input from an SSH viewpoint on the platforms research topics.

Assignment of contact persons for the technical platforms and the medical organisations

Contact between each platform as well as the medical organisations and assigned 2.6 Task members were established in order to exchange views, knowledge, needs and methods, and improve mutual understanding. The results of the discussions are summarised below.

Results from a first reflection exercise with the European technical platforms involved in radiation protection research

Needs and opportunities for integration of social sciences in EURADOS priorities

(Participants in discussion: i) from Task 2.6: Catrinel Turcanu and Michiel Van Oudheusden, SCK•CEN; ii) from EURADOS: Filip Vanhavere, SCK•CEN)

The discussion was organised around the SRA priorities identified by the EURADOS Platform, to identify the potential way to integrate SSH in these research topics.

EURADOS 1: Quantification of correlations between track structure and radiation damage

The topic addresses fundamental research. Further discussions are needed to clarify potential ways to integrate SSH aspects.

EURADOS 2: Improvement of neutron dosimetry techniques

Social scientists can organise focus group discussions with concerned actors (people exposed, researchers, etc.) about **perception and acceptability** of limitations of current neutron measurement devices or expectations for the new models.

Moreover, an assessment should be made of user **awareness, needs and behaviour of workers** in **different environments**, as well as a reflection on possible implications for safety culture.

EURADOS 3: Quantification of doses after accidental internal contamination

The EURADOS priority 3 recognizes that social sciences and humanities issues are also considered in the **management of an emergency situation** and in the post-accidental frame.

A study of the **perception and communications of risks** and **uncertainties** that come into play could be an important SSH contribution.

Furthermore, **guidelines for communication** of doses to affected people should be developed and cross-national comparisons carried out.

EURADOS 4: Development of accurate and on-line personal dosimetry for workers

Social scientists can contribute, among other, with a study of potential **changes in the behaviour** of individuals using on-line dosemeters and working in various radiation fields.

Furthermore, the observation of **actual use of dosemeters** would bring important insights.

EURADOS 5: Improvement of measurement and combination of out-of-field radiotherapy and imaging doses in photon and particle radiotherapy, for input to epidemiological studies

SSH can elucidate the potential of more accurate measurements and optimised treatment planning systems to increase **awareness** of medical doctors on best therapy modalities. Stakeholder involvement can be facilitated by SSH scientists.

Communication with patients is another aspect where SSH can contribute significantly.

EURADOS 6: Improvement of dosimetry in modern external beam therapy

SSH can contribute with an assessment of how decisions are made in treatment planning: **evaluation of risks and benefits** for the patient.

Furthermore, SSH teams can analyse lessons learned from past accidents and good practice, with focus on understanding the **learning process and** building a collective/shared **learning culture**.

Needs and opportunities for integration of social sciences in ALLIANCE priorities

(Participants in discussion: i) from Task 2.6: Christiane Pölzl-Viol, Martin Steiner, BfS; ii) from ALLIANCE: Jordi Vives I Battle, Hildegarde Vandenhove, SCK-CEN, Martin Steiner, BfS, Deborah Oughton, NMBU)

In radioecology, stakeholder engagement has been done, for example, in the context of the Chernobyl post-emergency land use and the evaluation of the impact of (former) U exploitation (e.g. Limoges, France). However, it has mostly been restricted to dissemination activities through meetings and open workshops with professional groups. The outcome is mainly based on meetings and workshop feedback but not really based on SSH research or common research.
Stakeholder engagement was an important part of both the EC-funded projects ERICA and PROTECT, which held a series of meetings connected to environmental protection with a variety of stakeholders. In addition, a consensus conference was held on protection of the environment from ionising radiation in 2001 in collaboration with IUR. A new consensus seminar will be held in Florida in 2015 that will address societal and ethical aspects of field studies.
At present, radioecology offers a potential for SSH research and interaction in a number of domains:

- Exploring mechanisms to communicate the results of assessments in a credible and objective way to the public, including assumptions, knowledge gaps and resulting uncertainties.
- Increasing trust in the scientific research by addressing knowledge and data gaps that are of concern to society. This includes, for example, explaining the relevance of data uncertainty and data gaps to the assessment process and explaining what is being done to remove knowledge deficiencies.
- Having an open debate on the necessity to use models, e.g. for predictions, and their limitations.
- Involving stakeholders in the discussion on how radioecological research affects the decisions on specific remediation techniques or land use restrictions, e.g. in the case of site remediation.
- Taking into consideration the issues of risk communication when developing decision support tools, especially user interfaces.
- Stimulating discussions about a proper definition of the term 'environment' in the context of radiological protection and the goals of environmental protection against ionising radiation. Radioecology addresses the protection of the environment, but the term 'environment' has not yet been defined properly. There is only a vague idea that the living environment can be represented by a collection of Reference Animals and Plants (RAPs), leaving aside both quantifiable and unquantifiable aspects, e.g. usability and sustainability.
- Restricting the criterion "is the environment protected" not only to the dose to wildlife in relation to certain benchmarks and dose limits, but including the value that mankind assigns to the environment and its usability. Here, it might be interesting to do research on the public reflection and concern regarding the impact of contamination in the abiotic environment.

Ethics of animal laboratory studies and wildlife sampling field work is another potential link between natural and social scientists.

Needs and opportunities for integration of social sciences in medical priorities

(Participants in discussion: i) from Task 2.6: Ilma Choffel de Witte, IRSN; ii) from medical field: Sisko Salomaa, STUK)

For the medical sector stakeholder engagement has been mostly done as part of the dissemination activities through meetings and open workshops with various professional groups. The outcome is mainly based on meetings and workshop feedback but not really based on SSH research or common research.
The level of values applied in ethics and justification cover the health professionals but not yet the patient or layman (the accent was put on stakeholder involvement but not yet on public participation).
Stakeholders involve a broad spectrum of interested parties. For MELODI, international organizations dealing with risk assessment and RP principles were mostly addressed.
Applied research that is closer to radiation protection practices apparently could benefit of a more direct contribution from social sciences whereas the societal impact of basic sciences is translated via the impact of new scientific evidence in RP standards and legislation.
However it may be stated that context dependent research combining SSH and the hard sciences have not really been effectuated as far as the medical radiation protection world is concerned.
It would be advisable to develop an SRA combining natural science and SSH sciences to increase a mutual understanding of the issues at stake and to come to practical solutions or to review already existing success stories.
It would also be helpful for hard scientists especially in the medical field to learn in the form of special dedicated trainings from the soft scientists and vice versa to overcome the mutual communication gap between the medical hard scientists and the lay people.

Needs and opportunities for integration of social sciences in NERIS priorities

(Participants in discussion: i) from Task 2.6: Stéphane Baudé, MUTADIS and Tatjana Duranova, VUJE; ii) from NERIS: Thierry Schneider, CEPN)

The NERIS European platform focuses on preparedness for nuclear and radiological emergency response and recovery. The research priorities defined by the NERIS platform[2] fall into 6 topics: assessment of and communication of uncertainties, robust decision-making, countermeasure strategy preparedness, atmospheric dispersion modelling, and monitoring strategies. Several issues related to risk communication and perception were included in these different research topics.

In the field of assessment and communication of uncertainties, the NERIS platform identified as a research question: how to communicate uncertainty, including legal, social and ethical aspects of this question.

The issue of robust decision-making as identified by NERIS includes 2 sub-issues:

- Structuring the decision processes and the protective strategies at national, regional and local levels with the help of formal decision aid tools, such as multi-criteria analysis and on the basis of feedback from stakeholder processes.
- Development of guidance on the use of DSS in the various phases of an event based on feedback from stakeholder processes and from Fukushima experience in emergency response and recovery.

As regards the first sub-issue, social and human sciences can give input on how to organise multilevel governance frameworks that facilitate stakeholder engagement at multiple levels, how to facilitate

[2] These research priorities are summarised in the "NERIS statement" of August 2015.

stakeholder engagement in the perspective drawn by the Aarhus Convention. Regarding the second sub-issue, social and human sciences can give input on how to use technical tools both to support decisions and to facilitate open-ended debate with and among stakeholders.

The issue of countermeasure strategy preparedness includes:

- Drawing the lessons on the applicability, efficiency and sustainability of countermeasures strategies from the emergency and recovery responses following the Fukushima accident;
- Improving the adequacy of existing decision-making processes and tools at national/regional/local levels to favour the preparedness of efficient countermeasure and recovery strategies;
- Achieving sustainable engagement of local stakeholders in emergency and recovery preparedness and response.

Here, social and human sciences can have an input by working on the social dimensions of efficiency and sustainability of countermeasures, information and participation of local stakeholders in the perspective of the Aarhus Convention, conditions for countermeasures to preserve the capacity of resilience of local and regional communities, conditions for developing a dimension of solidarity between the national community and local communities in countermeasures and recovery strategies.

The issues of atmospheric dispersion modelling and local radio-ecological models give little room for input from social and human sciences.

Finally, the issue of monitoring strategies includes: the optimization of the monitoring strategy in function of the decision support and the integration of different monitoring techniques in one strategy, including new technologies (drones, measurement by the public …)

On this issue, social and human science can address the conditions and means for integrating inputs from experts and from the public in the monitoring strategy and the condition for trustworthy and reliable engagement of both experts and non-experts in this, as well as the issue of how to integrate uncertainty management in these strategies.

Needs and opportunities for integration of social sciences in MELODI priorities

(Summary of activities and suggestions done by Tanja Perko, SCK•CEN and Deborah H. Oughton, NMBU)

MELODI/OPERRA has limited interaction with social sciences, but there have been some initiatives. Besides the workshops mentioned in this report, an OPERRA workshop on Social and Ethical aspects of Health Surveillance was held in October 2015 in Barcelona. Prior to DoReMi, the NOTE project held a workshop on philosophical and ethical issues associated with the non-targeted effect paradigm shift.

The NEA/ICRP has held a series of Science and Values workshops addressing a number of radiation protection issues relevant to MELODI and Low Dose Research. Topics covered have included, amongst others, radiosensitivity, cardiovascular disease, protection of children and low-dose extrapolation.

The following specific ideas were suggested by the participants of the MELODI workshop:

(i) Communication should be a dialogue where social sciences can be of help in order to develop knowhow and practices so that people can make their own choices or decisions,

(ii) Improved participatory practices: people would participate not only to be better informed, but also to act responsibly to find solutions to problems; the scientific community should also communicate about the limits of science, pointing out that science can(not) resolve all questions (epistemology),

(iii) Fear is a primal emotion: It is not only necessary to study risk perception, but also why people are afraid and what the respective role of their social environment is,

(iv) Better evaluation of the ethical basis of risk communication is needed: what kind of communication do we want? It was suggested that we should look at the values that drive us: trustworthiness, honesty, communication on an equal level,

(v) Cross-cultural studies of risk perception are needed in different countries or different sub-populations (e.g. specific regions, also outside Europe) to include societal and culture-specific aspects,

(vi) An important point is the communication of scientific uncertainty. There is a strong need of respective studies with a focus on low dose ionizing radiation,

(vii) Social values in communication to stakeholders should be taken into account, i.e. it is inherently necessary that (natural) scientists take the social values of their partner into account in the communication process.

SSH overview of platforms research priorities for the first CONCERT call

An overview of research priorities identified by all platforms was conducted by 2.6 members in order to suggest how social sciences and humanities could contribute to embed the principles of responsible research and innovation in these research priorities. The integration of SSH for each research priority of the platforms was suggested in form of expected contribution to the priority and SSH methods recommended. This was communicated to the platforms and to the CONCERT MB.

The final research call text proposed by all platforms was overviewed and commented from an SSH point of view. The comments and suggestions were taken into account and the text resulted in a transdisciplinary research involving also social sciences and humanities.

In addition, the following recommendation concerning social sciences and humanities as an integrative activity in the first CONCERT call was suggestion for inclusion in the call's conditions:

"*The need for transdisciplinary research approaches, where 'the social' and 'the technical' are addressed in an integrated way aligns with the Horizon 2020 programme for more open and responsive modes of research and science policy-making, on "Science with and for society" and "responsible research and innovation". Proposals should give due attention to social and ethical issues, including but not limited to the context and the implications of the proposed research outcomes, stakeholder engagement and risk communication. Proposals should make explicit how this will be addressed in the project. It is recommended that consortia foresee transdisciplinary collaboration with Social Sciences and Humanities. In addition, it is recommended that the project includes self-reflection on the justification of the research, and its added value towards society."*

Risk communication and risk perception

Subtask 2.6.2 'Risk communication and risk perception" brings together and engages the radiation protection community, academia from social sciences and humanities and other stakeholders in order to identify new research needs for improved communication practice and mutual understanding of beliefs, views and feelings about radiological risks and benefits, as well as radiation protection. Interaction and trans-disciplinary exchange of practices and needs in all fields of application of ionising radiation is organised in forms of workshops, round tables, reflection groups and questionnaires in different consortium members' countries and outside of consortium countries.

Risk communication was mostly seen in the previous century as a form of technical communication and education whereby the public should be informed about risk estimates. Later on, risk communication was seen as a marketing practice with the aim to persuade people to adopt a certain message. In nowadays societies, risk communication is approached as a socio-centric communication based on public participation, which can help bridging the gaps between stakeholders. The participation of a wide range of stakeholders is the key to avoid possible exclusion of persons or groups who are key participants and the empowerment of stakeholders to understand the ionizing radiation risks and benefits and to have autonomy in the implementation of their personal actions. It is stressed that risk communication should not only be effective, but also ethical, which requires taking moral emotions into consideration. There are moral values at stake, which means that decisions have to be made in a democratic way, after serious debate about values and not merely about numbers. The procedure should be legitimate (requires legitimate procedure for discussing the moral values and emotions associated with risks), it should be ethically justified (ethical deliberation about the values and emotions involved in different messages) and the effects should be adequately addressed.

Stakeholder involvement is of paramount importance to develop effective radiation protection, environmental and health related policies, their implementations and to reach effective consensus around common goals with affected communities in a sustainable and cost-effective manner. Involvement may take the form of sharing information, consulting, conducting dialogues or deliberating on decisions. Through stakeholder involvement, public concerns can be addressed in an open and transparent manner and trust can be built between the different parties. Furthermore, stakeholders may end up developing a kind of ownership of the solutions to be implemented. It is effective if communication and stakeholder involvement are planned at an early stage.

Conflict between stakeholders is common and is often driven by differences in how the research and communication activities’ benefits and risks are distributed, valued, perceived and viewed. This may reflect differences between individuals, groups and authorities in their motivation, values, goals, level of knowledge, interests, their perceptions, beliefs about the objectivity and efficacy. In addition, arguments over the objectivity, validity, credibility and relevance of scientific findings are common in debates related to health effects of radiation, especially related to scientific uncertainty and effects of low doses. The participatory process should lead to effective, democratic, ethical and transparent decisions.

Collection of the research needs and expectations identified in pre-CONCERT actions

Needs and priorities addressing radiation protection research relevant for communication/risk perception were collected by different FP7 projects and events. This report summarises the relevant discussion items and results related to the research in the field of risk communication and risk perception collected at the following events: i) Round table discussion in the context of a MELODI workshop (2013), ii) Workshop in the context of the EAGLE and OPERRA projects (2014), iii) Stakeholder opinion research questionnaire conducted in the context of the OPERRA project (2014) and iv) Reflection dialogues, workshops, round table discussions in the context of the RICOMET conference organised by EAGLE, PREPARE and OPERRA and with the involvement of a broad spectrum of stakeholders from different FP7 projects, NGOs, authorities and other stakeholders (2015).

Round table discussion in the context of the MELODI workshop

A workshop on risk communication and risk perception entitled "*Risk communication and risk perception: How can science help us?"* was organized at the MELODI workshop in the context of the FP7 project OPERRA *(Aerts A., Impens N., Baatout S., Benotmane R., Camps J., Dabin J., et al.- Joint research towards a better radiation protection—highlights of the Fifth MELODI Workshop.- In: Journal of Radiological Protection, 34(2014), p. 931-956)*. The purpose of this workshop was to lay the foundation for a discussion between social, human and natural sciences. The round table discussion was attended by more than 40 participants mainly from the radiation protection community linked in the MELODI platform.
Despite 50 years of extensive research on risk perception and communication, this domain remains largely unexplored in the field of ionizing radiation and its applications. Previous research investigated ionizing radiation risks more as a case study, rather than as a prerequisite for building an intellectual and theoretical capacity, for both scientists and the public at large.
Four interrelated challenges of risk perception and risk communication in the fields of low doses and field of medical use of ionizing radiation were suggested to be discussed at the workshop in order to identify new research topics. First, the issue of technical information and the use of risk estimates; second, the issue of perception and communication related to uncertainty of scientific information; third, the goal of communication by experts and/or authorities (persuasion for acceptance versus information for informed decision-making); and finally, the role of new media and social networks (for instance blogs, Facebook, Linkedin, etc.) in the interpretation of risks from low radiation doses.

Two invited keynote speakers opened the discussion: Britt-Marie Drottz Sjöberg, social psychologist (Norwegian University of Science and Technology, Norway) and Peter Michael Booth, communication practitioner (Hylton Environmental, UK). They pointed out that although widely applied in daily life, radiation is discussed rather narrowly in the society. ICRP clearly defines principles of radiological protection, but leaves the essential element of interaction and communication with society rather underdeveloped. Radiological protection is an extremely complex science and the decisions taken at international and/or state level (not to mention local or individual level) are framed by ambiguous value choices and fraught with problems of uncertainty. The keynote speeches presented a justification why the radiation research community needs to invest more in the R&D of interaction and communication with society and why it needs to promote a transdisciplinary approach integrating natural science, social science and humanities.

After the opening presentations, the participants, 44 researchers from different fields, discussed about the views, attitudes and experiences in the risk perception and risk communication field. They expressed that risk communication and perception related to low doses are a challenge and need to be further investigated, improved and applied.

The discussion captured the various understandings of the concepts related to risks and hazards from the different groups: social scientists, humanities and natural scientists. The focus of the discussion was thereafter about the definitions of risk, hazard, danger or harm from the point of view of the radiation protection society. In addition risk perception concepts as seen by the natural scientists from radiation protection area were discussed and the need to conduct socio-psychological research about this concept was pointed out.

Research topics related to risk perception and risk communication highlighted during the discussion at the MELODI workshop
Use of technical information and risk estimates in risk communication. Perception and communication of uncertainty in scientific information for various publics (lay people, experts, informed civil society).
Perception and communication of risks from low radiation doses Cross-cultural studies of risk perception in different countries and/or specific populations Factors affecting emotions associated to radioactivity and the role of the social environment
Improvement of communication by experts and/or authorities: persuasion versus informed decision-making.
Improved participatory practices in radiation protection R&D Development of know-how and practices enabling informed decision-making for lay citizens, by stakeholder dialogue
The role of new media and social networks (for instance blogs, Facebook, LinkedIn, etc…) in the interpretation of risks from low radiation doses.
Ethical basis of risk communication, e.g. self-reflection on the limits of science from within the radiation-protection scientific community; incorporating social values

Table 1: Research topics and ideas related to risk perception and risk communication highlighted during the discussion at the MELODI workshop

Workshop in the context of the ISEEH Symposium

Questions related to values in risk communication and risk perception were identified as a starting point for a discussion towards identification of the needs for future research related to perception and communication of ionizing radiation risks at the 2nd International Symposium on Ethics of Environmental Health (ISEEH), 15–19 June 2014, Ceske Budejovice, Czech Republic. The workshop was organized in the context of the OPERRA project and linked to the FP7 project EAGLE (Enhancing education, training and communication process for informed behaviours and decision-making related to ionizing radiation risks). The symposium addressed a range of topics including radiation research, toxicology, risk research and bio-monitoring (*Jourdain J., Impens N., Hardeman F., Perko T., Meskens G., Turcanu C., et al.- OPERRA 1st periodic report.- Brussels, Belgium: European Commission, 2015.- 88 p.- (European Commission*)).

The workshop emphasized that the ethical concepts underlying the system of radiation protection have received increasing attention over the last few years, but there seems to be little cross-fertilization with the discussion of related ideas in other areas of environmental health including communication about radiological risks.

Discussion tackled the following questions: Do we analyse and choose these values in our communication about risks? Can we easily identify how our values differ from those of other people? How can we better identify our ethical positions and better shape our communication about risk? Focusing on the workshop session dealing with communication, abroad range of practitioners presented how they structure their communication about ionizing radiation with their stakeholders, in areas touching particularly on radiological protection.

- **Research institute** IRSN (France) presented their Deontology Charter, how it is developed, how it guides activities and how it relates to the IRSN Charter for Openness to Society.

- **Local community organization** STORA (Belgium) presented the duties and activities of responding to local stakeholders' concerns about hosting a category A radioactive waste repository (including environmental health impacts).
- **Researcher** Deborah Oughton (Norway) reflected on the process of identifying mutual and differing values when radiation protections professionals help local people manage their environmental context after radiological accident.
- **Nuclear industry** presented by FUNDACJA FORUM ATOMOWE (Poland) talked **a**bout the assumptions and goals that drove their award-winning Atomic Bus Mobile Laboratory communications campaign.

In addition, a discussion with the audience focused on social value systems in communication about radiological risks – as revealed and compared in the results of an anonymous survey filled out ahead of time by Symposium participants and institutional colleagues.

From the discussion during the workshop it appeared clearly that good communication about ionizing radiation is a matter of well-aligned values, for instance "How safe is safe enough?". We can more easily understand each other and reach decisions when there is some shared agreement about what is important for different stakeholders. When we communicate with stakeholders and different research communities about ionizing radiation risk, we have to be aware of our own underlying values and of those of others, for instance health, feeling of safety, tampering with nature, moral values etc.. More research is needed in the field of these values.

Research topics related to risk perception and risk communication raised during the discussion at ISEEH
Values underlining radiological risk communication. The meaning of independency in risk communication
Development of a mutual-learning process among different stakeholders Narratives related to ionizing radiation in nowadays society.
Review of case studies documenting successful and unsuccessful stakeholder engagement processes in the field of radiation protection. Local knowledge (informed civil society) on ionizing radiation.
Socio-psychological aspects of medical follow-up (e.g. impact on risk perception or the level of satisfaction). Case studies could include nuclear local community – STORA, MONA, Belgium; Sami population, Norway; Chernobyl evacuees
Bridging polarization related to nuclear energy Socio-political research exploring countries' pro- or anti-nuclear stand

Table 2: Research topics and ideas related to risk perception and risk communication highlighted during the discussion at ISEEH

Opinion of the Radiation Protection community collected by the OPERRA project questionnaire

An e-survey carried out with European stakeholders in the framework of the OPERRA project (*Perko, Turcanu & Sirkka (2014): Priorities for radiation protection research: analysis of the OPERRA stakeholder survey - preliminary report prepared for the MELODI Workshop, D4.1.2.*) provided information important for the identification of research needs and priorities addressing radiation protection research relevant for communication and risk perception. The survey was carried out by members of the OPERRA project with assistance from members of the European radiation protection platforms, MELODI, EURADOS, NERIS and ALLIANCE, representing low dose risk, dosimetry, emergency planning and radioecology interests, respectively. The collection of data was carried out between 1/07/2014 and 15/09/2014. The response was encouraging, with 274 completed surveys for analysis from a range of types of respondent, mainly with scientific background and considerable experience in the area. Additionally, some NGO's and a few public respondents filled in the survey. In total the survey gathered 120 responses from members of the from MELODI platform, 119 from EURADOS, 78 from ALLIANCE, 70 from NERIS, 43 submissions from other relevant EC projects and 55 submissions from stakeholders that did not indicate membership to a platform or EC project. Responses were provided by 21 European countries, with some from countries further afield such as the USA, China, Russia and Egypt. Respondents were able to select different research domains of their interest and they responded only in the selected domains, e.g. risk communication and risk perception.

The results of the risk communication and risk perception domain showed (see Figure 1) that:

- 63 respondents out of 88 agreed that support is needed for more research in the field of risk communication and risk perception of low doses.
- 59 respondents also agreed that it would be useful to develop a strategic research agenda for risk communication in radiation protection, while nine respondents did not agree and 19 did not have an opinion.
- 50 respondents agreed or strongly agreed that there is a need for more social science research directed to new mass media, in order to study the influence of this type of communication on the understanding of complex concepts and the perception of radiological risks by lay people.
- Scientific uncertainties related to low doses were recognised by 63 respondents out of 88 as one of the main challenges for efficient risk communication.
- 57 respondents agreed that further research into risk communication would be beneficial to radiation protection, 13 respondents disagreed with the statement and 18 respondents did not have an opinion.

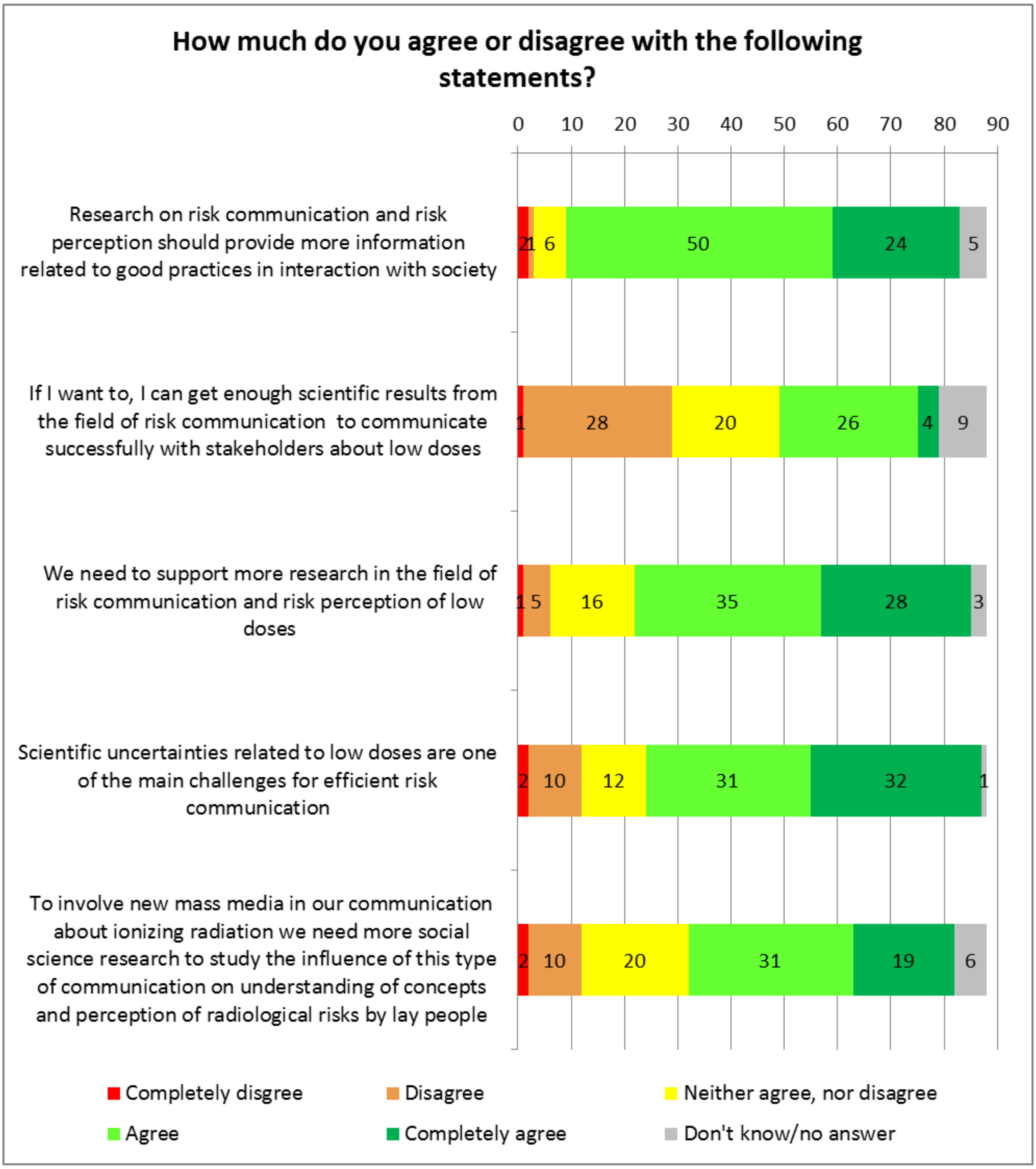

Figure 1: Needs for research on communication and risk perception of low doses of ionising radiation

Overall, a high interest was expressed from the radiation protection community as regards the research on risk perception and communication and more broadly, the need for integration of social sciences and humanities (a transdisciplinary approach).

As shown in Figure 2, the survey highlighted also the need for inclusion of risk communication and risk perception topics in education and training programmes related to radiation protection.

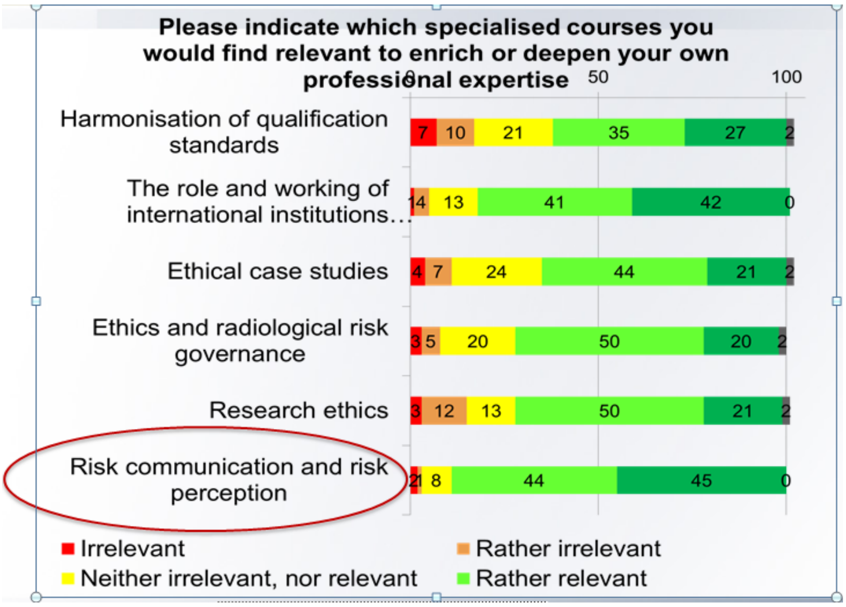

Figure 2: Importance of risk communication and risk perception for education and training

The need to integrate scientists with background in sociology and politics in radiation protection research was particularly stressed for the following challenges:

- Psychological consequences of decisions taken in emergency situations, and risk perception in normal operation;
- Psychological stress is also considered to be an important factor in multiple stressors analysis research;
- Assessment of risk perception of uncertainties and communication about uncertainties;
- Research about what makes the information trustworthy and more effective (e.g. the development and usage of social media in emergency response; communication- cooperation with the public).

The respondents pointed out the need to address stakeholder involvement, local preparedness and communication strategies in the radiation protection research:

- Defining stakeholders and framing problems.
- Stakeholders mapping and collecting lessons learned from past experiences.
- Development of a scientific based guidance on information provision and participation methods of affected population.
- Development of a scientific based guidance and strategies on the contaminated goods management.

Research related to use of social media and networking in emergency preparedness, response and recovery could address the following:

- Analysis of public behaviour response, i.e. understand how the public reacts and which information related to peoples' behaviour can be used by local-national tools to improve response.
- Assessment of the mechanisms by which the public gains information in media and social media.
- Assessment of important factors for social trust in emergency situations.

Research topics related to risk perception and risk communication pointed in the stakeholders' questionnaire
New mass media: i) influence of this type of communication on the understanding of complex concepts and the perception of radiological risks by lay people; ii) use of social media in emergency preparedness and response (public behaviours, mechanisms for acquiring information, drivers of social trust)
Perception of radiation risks in normal operation Communication and perception of scientific uncertainties related to low doses
Psychological consequences of emergency management decisions Use of risk communication to mitigate psychological stress
Factors affecting trustworthiness and effectiveness of information (e.g. development and use of social media in emergency response; communication- cooperation with the public)
Stakeholder involvement, local preparedness and communication strategies in the radiation protection.
Development of education and training materials and programmes including risk communication and risk perception

Table 3: Research topics and ideas related to risk perception and risk communication pointed in the stakeholder's questionnaire

Reflection dialogues, workshops, round table discussions in the context of the RICOMET conference

The RICOMET conference *Risk communication, risk perception and ethics about ionizing radiation* (2015) was organised under the auspices of three FP7 projects: **EAGLE** (Enhancing Education, Training And Communication Processes For Informed Behaviours And Decision-Making Related To Ionizing Radiation Risks), **OPERRA** (Open Project for the European Radiation Research Area) and **PREPARE** (Innovative integrated tools and platforms for radiological emergency preparedness and post-accident response in Europe). The conference involved a broad range of stakeholders (more than 120 participants, see Annex 2): experts in public communication, media representatives, researchers from social sciences, humanities and natural sciences, radiation protection officers, practitioners in nuclear medicine, nuclear power plant operators and other nuclear industry professionals, nuclear safety authorities, various project partners, NGOs and representatives from civil society (http://ricomet2015.sckcen.be).

The conference covered the following topics:

- The role of media in nuclear and radiological emergencies (PREPARE)
- Traditional media in the context of the Fukushima nuclear accident (PREPARE)
- Social media in the context of the Fukushima nuclear accident, challenges and opportunities in nuclear emergencies (PREPARE)
- Dialogues with journalists reporting about ionising radiation issues (EAGLE, PREPARE)
- Quality of information, the role and process of mass media in public information in the context of emergency and post-emergency as well as in daily life (EAGLE, PREPARE)
- Information and participation of local populations and expert-to-expert interactions in nuclear emergency and post-emergency situations in the perspective of the implementation of the Aarhus Convention on access to information, public participation in decision-making and access to justice in environmental matters (PREPARE)
- Public understanding of ionizing risk information, mental models, challenges and solutions (EAGLE)

- Future European research agenda for communication, risk perception and ethics in radiological protection (OPERRA, CONCERT)
- The meaning of ethics for radiological protection research and research policy (OPERRA, CONCERT)
- Results of on-going or recent research in sociology, psychology, humanities and political science related to:
  - Nuclear emergency and post-emergency (PREPARE)
  - Education, training and information (EAGLE)
  - Communication and stakeholder involvement about new nuclear energy build, nuclear waste management and decommissioning (EAGLE)
  - Perception of ionizing radiation risks (EAGLE)
  - Radiation protection in medicine (OPERRA)

The RICOMET conference clearly showed, among other, the need for social science research, in particular on risk perception and risk communication, and transdisciplinary approaches in the field of radiation protection *(Perko T. [edit.], Lazaro P. [edit.], Choffel de Witte I. [edit.], Koron B. [edit.].- Book of Abstracts. International conference: RICOMET 2015. Risk perception, communication and ethics of exposures to ionising radiation. - Mol, Belgium: SCK•CEN, 2015.- 100 p.- (Book of Abstracts; BA-69)).* A very large discrepancy between the recommendations on communication and public involvement in nuclear and the real practical implementation was recognised by the participants. The conference stressed many areas, among which the link and/or communication between hard and soft sciences, where improvements could be made and where additional research and/or coordination would be beneficial for the entire EU. The conference conclusions resulted in the RICOMET conference declaration: *Appeal to implement Responsible Research and Innovation in Euratom nuclear research, development and activities.* The appeal aims at deeper integration of social sciences and humanities which resonates with the spirit of the European Research Area (ERA). In line with the Responsible Research and Innovation (RRI) Agenda, the RICOMET conference affirmed that the Social Sciences and Humanities deserve a more prominent place in Horizon 2020 Euratom projects than is presently the case. This is because the Social Sciences and Humanities can facilitate RRI in a timely and supportive manner. (For the exact content of the conference declaration see annex 1)

Research topics related to risk perception and risk communication highlighted during the RICOMET conference
Case studies about mutual learning and transparency among all stakeholders in radiation protection. Public involvement methods, reaching towards involvement of citizens at a large scale, including local communities, teachers, students, mothers, volunteers, etc.
Understanding of ionizing radiation concepts by different stakeholders in medicine, industry and natural radiation (e.g. patients, local population…)
Citizen science initiatives and citizen engagement opportunities (e.g. public involvement in monitoring radioactivity in a contaminated environment). Citizen involvement in Emergency Planning
Inclusion of values in the research and practice of communicating about nuclear and radiological emergencies. Risk communication and stakeholder involvement in post-accident recovery Integration of communication and other societal aspects in analytical platforms for nuclear emergencies. Development of a tool for public information and engagement during and after nuclear emergencies.
Observation of doctor-patient communication about ionizing radiation risks and related mental models.
Development of coordinated communication and education material including state of the art knowledge from mental models and other socio-psychological research
Communication and stakeholder involvement about nuclear energy new build, nuclear waste management and decommissioning.
Communication and risk perception of radiation protection in medicine.
Ethical issues related to the developments in information technology: e.g. privacy and "relationship ethics" addressed between different countries. Public access to information
Information needs concerning various applications of ionising radiation and cross-country comparisons Societal concerns and risk communication related to decommissioning, NORM pollution and remediation.
Use of monitoring for confidence building in geological disposal and involvement of local communities in oversight activities.
Relationship between dose limits and risk perception and the role of confidence and trust. Discourse based communication about underlying values, objectives, actors and procedures when defining limits, and potential alternatives and complements to established limits.
Ionizing radiation in daily life presented and communicated in mass media. The meaning and use of mass media communication before, during and after a nuclear emergency. Framing/counterframing of nuclear technologies and applications of ionising radiation (e.g. in the medical field) Quantitative and qualitative differences in media reporting about radiation protection and longitudinal studies Interaction between mass media, public opinion and elites on radiation protection and nuclear energy policy

Table 4: Research topics and ideas related to risk perception and risk communication aroused during the discussion at the RICOMET conference

The way forward

Beside of specific suggestions for a future research collected in this document and still to be discussed within SSH network of stakeholders, in general, the 2.6 Task members recommend:

a) that proposals for the first CONCERT calls should give due attention to social and ethical issues, including but not limited to the context and the implications of the proposed research outcomes, stakeholder engagement, risk communication, safety culture and humanities. Proposals should make explicit how this will be addressed in the project. It is recommended that consortia foresee transdisciplinary collaboration with Social Sciences and Humanities. The 2.6 Task members are able to provide a list of possible topics to be included;
b) to develop a separate social science and humanities strategic research agenda (SSH SRA);
c) to open a discussion and collaboration of social and ethical issues at stakeholder meetings (WP5) and education and training courses (WP7).

Further analysis of a research needs and opportunities will be carried out in the next phase of the CONCERT project Task 2.6 in order to fully develop a draft Strategic Research Agenda for integration of Social Sciences and Humanities into Radiation Protection Research. This will build on the results summarised in this document, extended network with FP7 and Horizon 2020 programmes as well as the network of researchers identified in annexes of this document. The intention of the 2.6 Task is to involve a broad range of stakeholders in a discussion about Strategic research agenda for Social Sciences and Humanities. The stakeholders should be involved in a decision-making process by using different engagement methods (e.g. round table discussions, reflection groups, consensus conferences, interviews…).

- The workshops on ethics of radiation protection carried out in the framework of the OPERRA project
- The extended analysis of the conclusions of the RICOMET conference
- The ALARA culture/EAN workshop
- The workshops in Shamisen project
- The ICRP workshops on the Ethics of Radiological Protection
- Forthcoming workshops and stakeholder engagement activities to be held for subtasks 2.6.1, 2.6.2 and 2.6.3.

Summary

This document summarises the research needs and priorities addressing radiation protection research relevant for communication and risk perception identified in some pre-CONCERT activities. It also reports on a first reflection exercise with the technical platforms conducted by the CONCERT Task 2.6 on the needs and opportunities to integrate Social Sciences and Humanities in the priorities of the technical platforms.

The document gives a starting point for an open discussion about needs and stakeholders' expectations related to risk perception and risk communication research in radiation protection field. It also provides first input for the development of a *Strategic research agenda for Social sciences and Humanities*.

Overall, there was a high interest among the radiation protection community in research related to risk perception and communication. More broadly, the need for integration of social sciences and humanities (a transdisciplinary approach) was identified in different activities. A general conclusion is that risk communication in modern society should be seen as an important form of stakeholder engagement, and one that stresses dialogue and two-way communication rather than a simple provision of information.

Future research about risk communication and risk perception in the field of radiation protection should integrate stakeholder engagement as an integral part of a decision-making and should be considered in all aspects of future research and innovation in the field of radiation protection.

The future development of the SSH Strategic Research Agenda should also address other fields of SSH, such as ethics and safety culture. Furthermore, after the first reflection exercises with the platforms, the outcomes should be compared by a joint forum of all platforms, in order to highlight the most relevant priority areas where SSH can contribute to RP research.

The work on Task 2.6 will intensively continue in direction of a proposal for joint SSH, which will be presented and broadly discussed within a research community at the RICOMET 2016 conference in co-organisation of the following EC projects related to the field and strategic research agenda: CONCERT, EAGLE, PLATENSO and OPERRA. The Conference will be held in Bucharest, Romania from 1st to 3rd of June 2016. The conference will be an opportunity for extensive discussions and exchange on trans disciplinary research and practice related to radiation protection, strategic research agenda for social sciences and humanities, socio-economic and ethical challenges, stakeholder engagement, governance, communication about ionizing radiation (in emergency management, low doses, communicating uncertainty, ethics, mass media communication, public understanding, research needs …) The conference will involve an international level of different stakeholders, from experts, media representatives, researchers, project partners, EU officials, NGOs to representatives of inform civil society.

After the RICOMET 2016 conference, the Task 2.6 members will work on a final proposal of the SSH, present it at the Radiation protection week in Oxford in September and discuss it with the European platforms: MELODI, NERIS, EURADOS and ALLIANCE.

Annex 1: Public declaration after the RICOMET Conference; Appeal to implement Responsible Research and Innovation in Euratom nuclear research, development and activities

Mol, Belgium; Karlsruhe, Germany; Fontenay-aux-Roses, France; October, 2015

Public declaration after the RICOMET Conference

Appeal to implement Responsible Research and Innovation in Euratom nuclear research, development and activities

Responsible Research and Innovation (RRI) is a cross-cutting issue in Horizon 2020 research programme. It implies giving due attention to social and ethical issues, as well as stakeholder and public participation in science, technology and innovation (European Commission, 2013).

In line with the RRI Agenda, the International Conference on "*Risk perception, communication and ethics of exposure to ionizing radiation"* (RICOMET, June 2015; http://ricomet2015.sckcen.be) affirmed that the Social Sciences and Humanities research deserve a more prominent place in Horizon 2020 Euratom projects than is presently the case. This is because the Social Sciences and Humanities can facilitate RRI in a timely and supportive manner.

The RICOMET Conference highlighted that areas like medical, industrial and nuclear energy applications of ionising radiation research, as well as emergency management and rehabilitation, would benefit from nuclear risk governance. This would include, among other things, enabling citizens to weigh on nuclear research policy by setting priorities and inputting values.

We believe that Horizon 2020 should pursue the Responsible Research and Innovation Agenda in future nuclear and radiological protection research in Europe. We call for the **incorporation of activities to broaden the social and ethical aspects taken into account during core scientific and nuclear research and development.** Shaping R&D pathways in socially desirable ways implies transdisciplinary methodological approaches and activities to build strong societal justification. More resources should be put into stakeholder dialogues and commitment to establishing socio-technological forums (conferences, pluralistic study groups, etc.).

The appeal to deeper integrate social sciences and humanities resonates with the spirit of the European Research Area (ERA). In the working document *Science, society and the citizen in Europe*, emphasizing "*growing scepticism*" and "*hostility*" of society towards the advances in knowledge and technology, the European Commission argues that the relationships between science, technology and society "*have to change because of the impact of science and research on competitiveness, growth and jobs and on the quality of life in Europe*". More recently, in the more specific context of the Framework Programmes, the Commission states that "*for Europe to become the most advanced knowledge society in the world, it is imperative that legitimate societal concerns and needs concerning science and technology development are taken on board"* (Work Programme 2007, Capacities, Part 5, Science in Society).

Addressing the social, ethical and participatory dimensions of nuclear R&D offers great opportunities for the development of transdisciplinary project proposals in the nuclear field, and collaboration with partners from multiple disciplines that embrace a range of issues, dimensions and expertise. R&D including what is commonly called 'governance' aspects allows researchers from related fields of nuclear technology, radiological protection, safety and emergency response *in fine* to better serve their responsibility towards European society, responding to the expectations of both authorities and publics.

In order to fulfil the full range of targets identified, it is important that the upcoming Euratom Horizon 2020 calls ensure the continuity of a forum for different stakeholders and include governance topics to the extent necessary. We feel that the ethical and societal dimensions of nuclear technologies and applications are of high importance and research and innovation need to be strengthened.

On behalf of the RICOMET participants,

Dr. Tanja Perko, SCK•CEN, Belgium
FP7 EAGLE project coordinator

Dr. Jean-Rene Jourdain, IRSN, France
FP7 OPERRA coordinator

Wolfgang Raskob, KIT, Germany
FP7 PREPARE coordinator

Annex 2: Potential stakeholders to be involved in the identification of a Strategic Research Agenda for the Social Sciences and Humanities

The intention of the 2.6 Task is to involve a broad range of stakeholders in a discussion about Strategic research agenda for Social Sciences and Humanities. The stakeholders should be involved in a decision-making process organised by the 2.6 Task by using different engagement methods (e.g. round table discussions, reflection groups, consensus conferences, interviews…). This part of the document lists the potential stakeholders (researchers and research institutes, Universities) involved in radiation protection research related to social sciences and humanities collected in some pre-CONCERT activities (mainly in OPERRA and EAGLE) that will be contacted in the future activities. The final list of the 2.6 stakeholders will be extended and defined during the work flow of the 2.6 Task.

Summary of institutions involved in risk communication, risk perception research and ethics of radiation protection

The OPERRA project dedicated a special attention to reaching out to universities & professional partners. An overview of the institutions, universities and research groups involved in risk communication, risk perception, and ethics of radiation protection was collected by using different data-bases *(Perko T., Zolzer F., Meskens G.- Summary of Institutions involved in risk communication, risk perception, and ethics of radiation protection.- Brussels, Belgium: European Commission, 2014.- 33 p.- (European Commission; FP7 OPERRA)).*

The conclusions were:

- In most cases, communication and risk perception research in the nuclear field approached in parallel and with little mutual interaction; either by social scientists or by nuclear or radiation protection experts.
- Lack of a transdisciplinary approach. (This results in a rather weak and inconsistent recognition in the field.)
- Risk communication and risk perception is studied in general, with the ionizing radiation field being taken only once or twice as a case-study.

Although the OPERRA managed to identify many institutions in almost every EU country, the collected list of institutions shows that there are only few research groups in the EU continuously in the field and professionally conducting research in the field for risk communication, risk perception and ethics of radiation protection.

The following lists of the researchers and institutions involved in the research about risk communication and risk perception in the radiation protection ware collected by using five different data-basses.

1. Using Web of Knowledge;

2. Tracing the institution by using Google, Google Scholar, Bing and Yahoo internet browsers;

3. Applying dedicated questions related to institution identification in the OPERRA e-survey

4. Registering attendants of the Symposium on ethics of environmental health;

5. Including stakeholders from research institutions and universities, participating in a Platform for communication about ionizing radiation - FP7 EAGLE project.

Identification of institutions by web of knowledge						
Institution	**Country**	**Author(s)**	**Contact**	**Link**	**Title of the research article**	**Type of risk investigated**
Belgian Nuclear Research Centre SCK·CEN	Belgium	Perko T., Železnik N., Turcanu C., Thijssen P.	Nuclear Science and Technology Studies, Institute for Environment, Health and Safety, Belgian Nuclear Research Centre SCK·CEN Boeretang 200, B-2400 Mol, Belgium Tel.: +32 14 33 28 51 E-mail:: tperko@sckcen.be /	Web:http://www.sckcen.be	Is knowledge important? Empirical research on nuclear risk communication in two countries.	Nuclear waste, radiological risks after a nuclear accident
EDF Rech & Dev, Dept Management Risques Ind, Grp Facteurs Humains	France	Mbaye S	1, avenue du Général de Gaulle 92141 Clamart Cedex, Tél. : 00 (+33) 1 47 65 43 21	http://www.edf.com/le-groupe-edf-3.html	Effects of the feeling of invulnerability and the feeling of control on motivation to participate in experience-based analysis, by type of risk	radiation risk
Institute of Risk Research, University of Vienna	Austria	Druzhinina, I	Türkenschanzstrasse 17/8, A-1180 Vienna, Austria. druzhini@mail.zserv.tuwien.ac.at	http://www.univie.ac.at/en/	Radioactive contamination of wild mushrooms: a cross-cultural risk perception study	radioactive contamination of wild mushrums
Université Pierre Mendès France de Grenoble	France	Kouabenan DR	1030 Avenue Centrale, 38400 Saint-Martin-d'Hères, France, +33 4 76 82 60 00	http://www.sciencespo-grenoble.fr/	Effects of the feeling of invulnerability and the feeling of control on motivation to participate in experience-based analysis, by type of risk	radiation risk
Université de Nantes	France	Chauvin, B; Hermand, D	2 Chemin de la Houssinière, 44300 Nantes, France, Phone: +33 2 40 74 29 01	http://www.univ-nantes.fr/english	New age beliefs and societal risk perception	nuclear waste storage

Ecole Pratique des Hautes Etudes Toulouse	France	Mullet, E	15 rue des Lois, 31000 Toulouse, France, Tel. +33 (0) 561 148 010 - Fax +33(0) 561 148 020	http://en.univ-toulouse.fr/our-strengths	New age beliefs and societal risk perception	nuclear waste storage
Université de Technologie de Belfort-Montbéliard	France	Hussler, C	19 Avenue Maréchal Juin, 90000 Belfort, France, Phone: +33 3 84 58 77 00	http://www.utbm.fr/	Is diversity in Delphi panelist groups useful? Evidence from a French forecasting exercise on the future of nuclear energy	nuclear energy
Université de Strasbourg	France	Hussler, C; Muller, P	4 Rue Blaise Pascal, 67400 Strasbourg, France, Phone: +33 3 68 85 00 00	http://www.unistra.fr/index.php?id=accueil	Is diversity in Delphi panelist groups useful? Evidence from a French forecasting exercise on the future of nuclear energy	nuclear energy
Université de Haute Alsace	France	Rondé, P	18 Rue des Frères Lumière, 68093 Mulhouse Cedex, France, Phone: +33 3 89 33 65 00	http://www.uha.fr/	Is diversity in Delphi panelist groups useful? Evidence from a French forecasting exercise on the future of nuclear energy	nuclear energy
Medical University of Lübeck, Institute of Anaesthesiology	Germany	Huppe, M; Weber, J	Ratzeburger Allee 160, 23562 Lubeck, Germany, Phone:+49 451 5000	http://www.uni-luebeck.de/	Effects of distance, age and sex upon attitudes toward nuclear power plants: An empirical study	nuclear power plants
Kinderumwelt gGmbH of the German Academy of Pediatrics and Adolescent Medicine	Germany	Otto, M; Von Mühlendahl, KE	Westerbreite 7, 49084 Osnabrück, Germany	http://www.dakj.de/	Risk communication in environmental medicine	noxious anthropogenic environmental conditions

Kaunas University of Technology	Lithuania	Balzekiene, A; Butkeviciene, E; Rinkevicius, L; Gaidys, V	Kaunas University of Technology, K. Donelaičio St. 73, LT-44029 Kaunas, Lithuania, Tel.: + 370 37 300000 / 324140 Fax + 370 37 324144 E-mail ktu@ktu.lt	http://en.ktu.lt/	Public perception of environmental and technological risks: sociological exploration of the attitudes of Lithuanian society	nuclear power
Lithuanian Culture Research Institute	Lithuania	Balzekiene, A; Butkeviciene, E; Rinkevicius, L; Gaidys, V	LIETUVOS KULTŪROS TYRIMŲ INSTITUTAS, Įmonės kodas 111961791, Saltoniškių g. 58, LT-08105, Tel./faks. (8~5) 275 1898, el. paštas: LKTI@LKTI.LT	http://www.lkti.lt/en/aboutus	Public perception of environmental and technological risks: sociological exploration of the attitudes of Lithuanian society	nuclear power
European Commission, DG JRC	Netherlands	Kirchsteiger, C	European Commission, Drectorate-General Joint Research Centre, Institute for Energy and Transport, P.O. Box 2, NL-1755 ZG Petten, The Netherlands	http://iet.jrc.ec.europa.eu/	Current practices for risk zoning around nuclear power plants in comparison to other industry sectors	nuclear power plants
University of Groningen	Netherlands	De Groot, JIM; Steg, L	Broerstraat 5, 9712 CP Groningen, Netherlands, +31 50 363 9111	http://www.rug.nl/?lang=en	Values, Perceived Risks and Benefits, and Acceptability of Nuclear Energy	nuclear energy
Maastricht University	Netherlands	Visschers, VHM; Meertens, RM; Passchier, WF; deVries, NK	UM postal address: P.O. Box 616, 6200 MD Maastricht, The Netherlands, UM visiting address Minderbroedersberg 4-6, 6211 LK Maastricht, The Netherlands, +31 43 388 2222	http://www.maastrichtuniversity.nl/	How does the general public evaluate risk information? The impact of associations with other risks	6 different risks (not mentioned)
University Lisbon, Faculty Psychology	Portugal	Palma-Oliveira JM.	Alameda Universidade, 1649-004 Lisbon, Portugal, Phone: +351 21 792 2600	http://www.ul.pt/	Radioactive contamination of wild mushrooms: a cross-cultural risk perception study	radioactive contamination of wild mushrums

Centro de Investigação e Intervenção Social, Ed. ISCTE	Portugal	Lima, ML	Av. das Forcas Armadas, Lisboa 1600 049, Portugal	http://www.foodrisc.org/centro-de-investigao-e-interveno-social_35.html	On the influence of risk perception on mental health: living near an incinerator	incinerator
Ciemat	Spain	Prades, A. Farre, RS; Martinez-Arias, R; Lopes, AP	MADRID: Centro de la Moncloa, Complutense, 40, 28040 (Madrid), Tlfno: 91-346.60.00 (centralita), Fax: 91-346.60.05 (central), Email: contacto@ciemat.es	http://www.ciemat.es/	Through a glass darkly: Experts' and the public's mutual risk perception .;Public risk perception - A variable to be considered in the risk evaluation process	nuclear waste
University of Gothenburg	Sweden	Biel, A; Dahlstrand, U	Address: PO Box 100, SE-405 30 Gothenburg, SWEDEN, Visiting address: Vasaparken, Phone: 46 (0)31 786 10 00	http://www.gu.se/	Risk perception and the location of a repository for spent nuclear fuel.	repository for spent nuclear-fuel
Swedish War College	Sweden	Mårdberg, B	Phone: +46 (0)8 788 75 00, Email: exp-hkv@mil.se	http://www.forsvarsmakten.se/en/	Forming homogeneous clusters for differential risk information	radiation
ETH Zürich	Switzerland	Keller, C; Visschers, V; Siegrist, M; Moser, C; Stauffacher, M; Krutli, P; Scholz, RW; Dohle, S; Hagmann, J	Institute for Environmental Decisions (IED), Consumer Behavior, Universitätstrasse 22, CHN J75.2, CH-8092 Zurich, Switzerland; tel: +41 44 632 4983; fax: +41 44 632 1029; ckeller@ethz.ch.	http://www.ethz.ch/index_EN	Affective Imagery and Acceptance of Replacing Nuclear Power Plants; The influence of linear and cyclical temporal representations on risk perception of nuclear waste: an experimental study; Fukushima: probing the analytical and epistemological limits of risk analysis	nuclear power plants-related risk
Gene Rowe Evaluations	United Kingdom	Gene Rowe	12 Wellington Road, Norwich NR2 3HT, UK	/	Public perceptions of everyday food hazards: A psychometric study	food-related risk

Kings College London, Department War Studies	United Kingdom	Rogers, MB	London WC2R 2LS, England, +44 20 7836 5454 Telephone: +44 (0)20 7848 1395, E-mail: brooke.rogers@kcl.ac.uk	http://www.kcl.ac.uk/index.aspx	The Impact of Communication Materials on Public Responses to a Radiological Dispersal Device (RDD) Attack	chemical, biological, radiological, or nuclear (CBRN) attack
Kings College London, Department Psychological Medicine	United Kingdom	Amlot, R; Rubin, JR; Chowdhury, AK	London WC2R 2LS, England, +44 20 7836 5454, (Rubin:) Room 3.26, 3rd Floor, Weston Education, Denmark Hill, SE5 9RJ, United Kingdom, E-mail: gideon.rubin@kcl.ac.uk	http://www.kcl.ac.uk/index.aspx	The Impact of Communication Materials on Public Responses to a Radiological Dispersal Device (RDD) Attack; How to Communicate with the Public About Chemical, Biological, Radiological, or Nuclear Terrorism: A Systematic Review of the Literature	chemical, biological, radiological, or nuclear (CBRN) attack
University College London	United Kingdom	Skarlatidou, A; Cheng, T; Haklay, M	Gower St, London, Greater London WC1E 6BT, United Kingdom, Phone: +44 20 7679 2000	http://www.ucl.ac.uk/	What Do Lay People Want to Know About the Disposal of Nuclear Waste? A Mental Model Approach to the Design and Development of an Online Risk Communication	nuclear waste
Institute of Food Research	United Kingdom	Frewer, L	Institute of Food Research, Norwich Research Park, Colney, Norwich NR4 7UA, UK, Tel: +44(0)1603 255000, Fax: +44(0)1603 507723, Email: ifr.communications@ifr.ac.uk	http://www.ifr.ac.uk/	Through a glass darkly: Experts' and the public's mutual risk perception	nuclear waste

Middlesex University London	United Kingdom	Stainer, A	Contact us: +44 (0) 20 8411 5555 (Option 1), Monday - Friday 9am - 5pm GMT, London Hendon, Middlesex University, The Burroughs, London, NW4 4BT, United Kingdom	http://www.mdx.ac.uk/	Young people's risk perception of nuclear power - A European viewpoint	nuclear power
University of Hertfordshire Business School	United Kingdom	Stainer, L	University of Hertfordshire, Hatfield, Hertfordshire, AL10 9AB, UK, tel +44 (0)1707 284000 fax +44 (0)1707 284115	http://www.herts.ac.uk/	Young people's risk perception of nuclear power - A European viewpoint	nuclear power
Bournemouth University	United Kingdom	De Groot, JIM; Steg, L	Bournemouth University, Fern Barrow, Poole, Dorset, BH12 5BB, United Kingdom, workTel: 01202 524111, Fax: 01202 962736, Email: askBU@bournemouth.ac.uk	http://home.bournemouth.ac.uk/	Values, Perceived Risks and Benefits, and Acceptability of Nuclear Energy	nuclear energy
Brunel University	United Kingdom	Goodwin, R; Gaines, SO Jr	Brunel University, Kingston Lane, Uxbridge, Middlesex UB8 3PH, Tel: +44 (0)1895 274000, Fax: +44 (0)1895 232806	http://www.brunel.ac.uk/	Modelling Psychological Responses to the Great East Japan Earthquake and Nuclear Incident	nuclear incident
London School of Economics	United Kingdom	Costa-Font, J; Rudisill, C; Mossialos, E	Houghton St, London WC2A 2AE, United Kingdom, Phone: +44 20 7405 7686	http://www.lse.ac.uk/home.aspx	Attitudes as an expression of knowledge and "political anchoring": The case of nuclear power in the United Kingdom	nuclear power
University of Surrey	United Kingdom	Hampson, SE; Fife-Shaw C.	University of Surrey, Guildford, Surrey GU2 7XH, United Kingdom, T: +44 (0)1483 300800, F: +44 (0)1483 300803	http://www.surrey.ac.uk/	Lay understanding of synergistic risk: The case of radon and cigarette smoking; 22 potential food hazards on a total of 19 risk characteristics	synergistic risk

Austria				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Österreichische Gesellschaft für Nuklearmedizin und Molekulare Bildgebung	Dr. Josef Preitfellner	Tel: + 43 - 699 198 26 556, E-Mail: office@remove-this.strahlenschutzgutachten.org	http://www.strahlenschutzgutachten.org/start/, http://www.ogn.at/home/	Google: risk perception radiation
Austrian Association for Radiation Protection	/	Österreichischer Verband für Strahlenschutz, Alexander Brandl, Asst. Prof. MSc Dr. CHP, sekretaer(at)strahlenschutzverband.at	http://www.strahlenschutzverband.at/	Google: risk perception radiation

Table 5: Institutions identified by using internet browsers in Austria

Belgium				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Scientific Institute of Public Health	Charlotte Stiévenart	J. Wytsmanstraat 14 1050 Brussel T +32 2 642 51 11 F +32 2 642 50 01	https://www.wiv-isp.be/Pages/EN-Home.aspx?pflg=1033	Google: risk perception radiation
Belgian Nuclear Research Centre, SCK - CEN	Tanja Perko Gaston Meskens Catrinel Turcanu	Nuclear Science and Technology Studies, Institute for Environment, Health and Safety Boeretang 200, B-2400 Mol	http://www.sckcen.be/	Google: risk perception, communication, ethics
KU Leuven	Baldwin van Gorp	Institute for Media Studies, KU Leuven, Parkstraat 45 - box 3603 3000 Leuven		Google scholar: risk communication
University Antwerp	Peter Thijssen	University of Antwerp, Faculty for social and political sciences, m2p	http://www.m2p.be/	Google scholar: risk communication, perception

Table 6: Institutions identified by using internet browsers in Belgium

Bulgaria				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
National Center of Radiobiology and Radiation Protection (Bulgaria Ministry of Health)	J. Vassileva	j.vassileva@ncrrp.org	http://www.ncrrp.org/new/en/	Bing: radiation risk communication

Table 7: Institutions identified by using internet browsers in Bulgaria

Croatia				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Croatian Radiation Protection Society	/	IRB - Institut "Ruđer Bošković" ZKM - Laboratorij za sintezu novih materijala Bijenička c. 54, 10000 Zagreb Tel.: (+385 1) 4561 184; Fax: 4680 227 E-mail: tantonic@irb.hr	http://www.hdzz.hr/index_hrv.html	Google: risk perception radiation

Table 8: Institutions identified by using internet browsers in Croatia

Cyprus				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Cyprus Association of Medical Physics and Bio-Medical Engineering - CAMPBE	/	Representative: Prodromos Kaplanis +4 P.O. Box 24039, Nicosia, 1700 Cyprus p.a.kaplanis@cytanet.com.cy	http://campbe.org/	Google: risk perception radiation

Table 9: Institutions identified by using internet browsers in Cyprus

Czech Republic				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
South Bohemian University	Friedo Zölzer	Branišovská 1160/31, 370 05 České Budějovice, +420 389 031 111	http://www.prf.jcu.cz/en/	Bing: Ethics radiation
National Radiation Protection Institute	/	Bartoskova 28 | 140 00 Praha 4 | +420 241 410 214 | suro@suro.cz	http://www.suro.cz/en	Google: risk perception radiation

Table 10: Institutions identified by using internet browsers in Czech Republic

Estonia				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
University of Tartu	Kelle Kepler; Mare Lintrop	Ülikooli 18, 50090 Tartu, ESTONIA, Fax: +(372) 737 5440, E-mail: info@ut.ee, studyinfo@ut.ee, WWW: http://www.ut.ee, Account kalle.kepler@ut.ee	http://www.ut.ee/en	Bing: radiation risk communication

Table 11: Institutions identified by using internet browsers in Estonia

Finland				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Radiation and Nuclear Safety Authority	A. Servomaa	Laippatie 4, 00880 Helsinki, P.O. BOX 14, 00881 Helsinki, Telephone +358 9 759 881, Telefax +358 9 759 88 500	http://www.stuk.fi/en_GB/	Bing: conference radiation risk communication
University of Tampere	Anssi Auvinen	Kalevantie 4, 33100 Tampere, Finland, Telefoon: +358 3 355111	http://www.uta.fi/english/	Google: risk communication radiation

Jyväskylän Yliopisto - University of Jyväskylä (Humanities Faculty)	Jurgita Kairytė; Litmanen, T	PO Box 35, FI-40014 University of Jyväskylä, Registry Office and Archive, (Seminaarinkatu 15, Library Building, B115), Tel +358 (0)14 260 1211 | Fax +358 (0)14 260 1021	https://www.jyu.fi/en	Google Scholar: Risk communication perception

Table 12: Institutions identified by using internet browsers in Finland

France				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
OECD Nuclear Energy Agency	/	Le Seine Saint-Germain, 12, boulevard des Îles, 92130 Issy-les-Moulineaux, France, 2 rue André-Pascal 75775, Paris Cedex 16, France, Fax: (33) 01 45 24 16 75, E-mail: ehscont@oecd.org	http://www.oecd-nea.org/	Google Scholar: Ethics Radiation
International Agency for Research on Cancer	Martine Vrijheid; Elisabeth Cardis	IARC, 150 Cours Albert Thomas, 69372 Lyon CEDEX 08, France - Tel: +33 (0)4 72 73 84 85 - Fax: +33 (0)4 72 73 85 75	http://www.iarc.fr/	Google: risk communication radiation
French Society for Radiation Protection	JF Lecomte; Jacques Lombart	Directeur : Valérie CHAMBRETTE, Coordonnées du Secrétariat, SFRP, B.P. 72, 92263 Fontenay-aux-Roses CEDEX, Tél. 01 58 35 72 85, Fax 01 58 35 83 59, Mél : valerie.chambrette@sfrp.asso.fr	http://www.sfrp.asso.fr/	Google: risk perception radiation
Institut de Radioprotection et de Sûreté Nucléaire	/	BP 17 - 92262 Fontenay-aux-Roses Cedex, 31, avenue de la Division Leclerc, 92260 Fontenay-aux-Roses, Tel. : +33 (0)1 58 35 88 88	http://www.irsn.fr/EN/Pages/home.aspx	http://www.who.int/ionizing_radiation/events/en/

International Union of Radioecology	/	IUR OFFICE SECRETARIAT, IRSN/DG-Dir, Centre d'Etudes de Cadarache – Bât 229, BP 3, 13115 Saint-Paul-lez-Durance France, Phone : +33 (0)4 42 19 97 35, Fax : +33 (0)1 46 29 02 80	http://iur-uir.org/en/	http://www.who.int/ionizing_radiation/events/en/
Centre d'Etudes et de Recherche sur le Médicament de Normandie, UFR des Sciences Pharmaceutiques	Patrick Dallemagne	Mél : patrick.dallemagne@unicaen.fr, Université de Caen Basse-Normandie, Boulevard Becquerel, 14032 Caen cedex, Tél : 02 31 56 68 13; Fax : 02 31 56 68 03	http://www.cermn.unicaen.fr/	Programm IRPA 13

Table 13: Institutions identified by using internet browsers in France

Germany				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Federal Ministry for the environment, nature conservation and nuclear safety	/	Bonn Office of the German Ministry of Environment (BMU) Robert-Schuman-Platz 3, 53175, Bonn, Germany, email: perezm@who.int, Berlin Office Stresemannstraße 128 - 130 10117 Berlin Germany Phone: +49 (0) 30 18 305-0 Fax: +49 (0) 30 18 305-4375	http://www.bmu.de/en/uebrige-seiten/the-federal-environment-ministry/	Bing: Risk communication radiation
Department of Nuclear Medicine, ZRN Grevenbroich	Lutz Stefan Freudenberg	Zentrum für Radiologie und Nuklearmedizin im Kreiskrankenhaus Grevenbroich von-Werth-Straße 41515 Grevenbroich Telefon: 02181 - 2140-0	http://www.zrn-grevenbroich.de/	Bing: Risk perception radiation
Department of Nuclear Medicine, University	Lutz Stefan Freudenberg; Thomas Beyer	Universitätsstraße 2, 45141 Essen, Duitsland, +49 201 183 ext. 0	http://www.uni-due.de/	Bing: Risk perception radiation

Hospital Duisburg - Essen				
Center of Technology Assessment in Baden-Württemberg	Michael M. Zwick; Ortwin Renn	Center of Technology Assessment in Baden-Württemberg, Industriestr. 5, 70565 Stuttgart, ++49-711-9063-0, Fax: ++49-711-9063-299, E-Mail: info@ta-akademie.de, Contact: Dr. Michael M. Zwick, +49-711-121-3972, E-Mail: zwick@soz.uni-stuttgart.de		Google Scholar: Risk communication perception
University of Technology Aachen	A. Hessler	Templergraben 55, 52056 Aachen, Tel: +49 241 80-1, E-Mail: info@rwth-aachen.de, Fax: +49 241 80-92312	http://www.rwth-aachen.de/cms/~a/root/lidx/1/	Google: risk perception radiation
University of Stuttgart, Sociology of Technologies and Environment	Ortwin Renn	Universität Stuttgart, Institut für Sozialwissenschaften, Abteilung für Technik- und Umweltsoziologie, Seidenstra. 36, 70174 Stuttgart	http://www.uni-stuttgart.de/home/	Google Scholar: Risk communication perception Program IRPA 13

Table 14: Institutions identified by using internet browsers in Germany

Greece				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
University of Crete	Ioannis Iliopoulos	Rethymno 741 00, Greece, Tel: +30 28310 77900, e-mail: secretary@rector.uoc.gr	http://www.en.uoc.gr/	Programm IRPA 13

Table 15: Institutions identified by using internet browsers in Greece

Hungary				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Hungarian Radiation Protection Association	Arpad Vincze; Tamas Pazmandi; Tibor Bujtas	7031 Paks, Pf.:71, Tel.: (75) 508-360 Fax: (75) 508-400, bujtast@npp.hu	http://www.kfki.hu/elftsv/	Google: risk perception radiation

Table 16: Institutions identified by using internet browsers in Hungary

Ireland				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Trinity College Dublin	Jim Malone	Trinity College Dublin, College Green, Dublin 2, Ireland, +353 1 896 1000	http://www.tcd.ie/	Bing: Ethics radiation
University College Dublin	James Mc Laughlin	University College Dublin, Belfield, Dublin 4, Co. Dublin, +353 1 716 7777	http://www.ucd.ie/	Google: risk communication radiation
Radiological Protection Institute of Ireland	Dr Mary T O'Mahony	3 Clonskeagh Square, Dublin 14, Ireland, Tel: +353-1-2697766 (Main Switch), Fax: +353-1-2697437 (Main Switch)	http://www.rpii.ie/	Google: risk perception radiation

Table 17: Institutions identified by using internet browsers in Ireland

Italy				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Institute of Clinical Physiology	Eugenio Picano	Email: picano@ifc.cnr.it, Institute of Clinical Physiology; Via Giuseppe Moruzzi, 1 - 56124 Pisa PI Toscana,National Research Council; Piazzale Aldo Moro, 7 - 00185, Roma, Italia, Tel : +39 06 49931 - Fax : +39 06 4461954	http://www.cnr.it/istituti/DatiGenerali_eng.html?cds=035	Google Scholar: Research Risk Communication radiation
Italian Radiation Protection Association	Elena Fantuzzi; Mario Marengo Daniela De Bartolo, Anna Giovanetti , Cantone Marie Claire, Giancarlo Sturloni	mario.marengo@aosp.bo.it	http://www.airp-asso.it/	Google: risk perception radiation

Table 18: Institutions identified by using internet browsers in Italy

Lithuania				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Vatesi	Michailas Demčenko; ...	A.Goštauto str. 12, LT-01108 Vilnius, INSTITUTION code: 188639874, Tel. +370 5 262 4141, Fax +370 5 261 4487, E-mail: atom(at)vatesi.lt	http://www.vatesi.lt/	Google Scholar: Risk communication perception
Radiation Protection Centre	/	Kalvarijų 153, LT-08221, Vilnius, ph. +370 5 236 19 36, fax +370 5 276 36 33, rsc@rsc.lt	http://www.rsc.lt/index.php/pageid/510	Google: risk perception radiation

Table 19: Institutions identified by using internet browsers in Lithuania

Nederland				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Dutch Society for Radiation Protection	Hielke Freerk Boersma	A-Solution, Postbus 342, 4000 AH Tiel, telefoon: 0344 - 78 69 01, fax: 0344 - 78 69 06, e-mail: administratie@nvs-straling.nl	http://www.nvs-straling.nl/cms/showpage.aspx	Google: risk perception radiation
University Medical Center Utrecht	Leijers, C	Heidelberglaan 100, 3584 CX Utrecht, Netherlands, Phone: +31 88 755 5555	http://www.umcutrecht.nl/zorg/	Programm IRPA 13

Table 20: Institutions identified by using internet browsers in Nederland

Norway				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Directorate of Reindeer Husbandry	Eikelmann, I	International Centre for Reindeer Husbandry, Bredbuktnesveien 50B, N-9520 Guovdageaidnu/Kautokeino., Norway, Mailing address: International Centre for Reindeer Husbandry, P.O. Box 109, N-9520 Guovdageaidnu/Kautokeino. Phone: +47 7860 7670, Fax: +47 7860 7671, office@reindeercentre.org	http://reindeerherding.org/	Programm IRPA 13
Norwegian University of Life Sciences	Deborah Helen OUGHTON	Department of Plant and Environmental Science P.O. Box 5003 Norwegian University of Life Sciences N-1432 Ås Norway Telephone: (+47) 64 96 55 44 Telefax: (+47) 64 94 83 59 email: deborah.oughton@umb.no		Bing: Ethics radiation

Table 21: Institutions identified by using internet browsers in Norway

Poland				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Radiation Protection Section, Polish Soc. of Medical Physics	Natalia Golnik; Michael Waligorski	Centrum Onkologii - Instytut im.Marii Skłodowskiej - Curie, Zakład Fizyki Medycznej, ul. Roentgena 5, 02-781 Warszawa, Telefon: 022 54 62 775	http://ptfm.pl/	Google: risk perception radiation

Table 22: Institutions identified by using internet browsers in Poland

Portugal				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Portuguese Health Physics Society	Joao Quintela De Brito; Joao Oliveira Martins; Antonio Miguel Lino Santos Morgado	Sociedade Portuguesa de Proteção Contra Radiações, Instituição de Utilidade Pública, Afiliada da International Radiation Protection Association, Rua 5 de Outubro Nº 26-1ºE 2695-697 S. João da Talha – PORTUGAL, Telefone: +351219552062	http://www.sppcr.online.pt/	Google: risk perception radiation

Table 23: Institutions identified by using internet browsers in Portugal

Romania				
Name of the institution	Key expert	Contact	Link	Browser/ Search criteria
Romanian Society for Radiation Protection	Mihai, LT; Milu, C; Voicu, B; Enachescu, D	Bucharest. ltmiha11@cmb.ro; Romanian Soc Radiat Protect, RO-050463 Bucharest, Romania; Res Inst Qual Life, Bucharest, Romania; Carol Davila Univ Med & Pharm, Dept Social Med, RO-050463 Bucharest, Romania	/	Google: risk perception radiation
Research Institute for the Quality of Life	B. Voicu	Casa Academiei Romane, Calea 13 Septembrie 13, sector 5, Bucharest 050711, Romania, ' (4021) 3182461, 7 (4021) 3182462, +iccv@iccv.ro, ü http://www.iccv.ro/	http://www.iccv.ro/oldiccv/english/newsite/index.htm	Google: risk perception radiation
Social Medicine Department, “Carol Davila” University of Medicine and Pharmaceutics	D. Enăchescu	40213180762, 40213180862, http://www.umf.ro/images/stories/Anunturi/locatii.jpg	http://www.umf.ro/	Google: risk perception radiation

Table 24: Institutions identified by using internet browsers in Romania

Slovakia				
Name of the institution	Key expert	Contact	Link	Browser/ Search criteria
Slovak Society of Nuclear Medicine and Radiation Hygiene	Denisa Nikdemova	MUDr. Pavol Povinec PhD. e-mail: povinec@biont.sk, tel.č.: +421220670178	http://www.ssnm.sk/	Google: risk perception radiation

Table 25: Institutions identified by using internet browsers in Slovakia

Slovenia				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
ARAO, REC	Nadja Železnik	ARAO-Agencija za radioaktivne odpadke Celovška cesta 182, 1000 Ljubljana, Tajništvo, Tel: + 386 1 236 32 00, Fax: + 386 1 236 32 30, e-pošta: public.arao@gov.si Regional environmental centre nadja.zeleznik@rec-lj.si	http://www.arao.si/	Google: risk perception radiation
Radiation Protection Association of Slovenia	Jasmina Kozar-Logar; IMichel Cindro; Nina Jug	President: Dr. Gregor OMAHEN, Institute of Occupational Safety, Chengdujska cesta 25, SI-1000 Ljubljana, Slovenia, Tel: +386 1 585 51 00, Fax: +386 1 585 51 01, E-mail: gregor.omahen@zvd.si	/	Google: risk perception radiation

Table 26: Institutions identified by using internet browsers in Slovenia

Spain				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Centre for Research in Environmental Epidemiology	Martine Vrijheid	Doctor Aiguader, 88 · E-08003 Barcelona · Tel +34 93 214 73 00 · Fax +34 93 214 73 02 · e-mail: info@creal.cat, mvrijheid@creal.cat	http://www.creal.cat/en_index.html	Google: risk communication radiation
Spanish Radiation Protection Society	Manuel Rodriguez, Oscar Gonzalez, Eduardo Gallego, Pedro Carboneras, María Teresa Macías, Ángeles Sanchez	Sociedad Española de Protección Radiológica, C/ Isla de Saipán, 47 - 28035 Madrid • Tel.: + 34 91 373 47 50 • Fax: +34 91 316 91 77, E-mail: secretaria@sepr.es	http://www.sepr.es/	Google: risk perception radiation

Table 27: Institutions identified by using internet browsers in Spain

Sweden				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Institute for Risk management and Safety analysis	Lars Harms-Ringdahl	IRS, Bergsprängargränd 2A S-116 35 Stockholm, Sweden, Tel. +46 8 643 20 80	http://www.irisk.se/english/irshome.htm	Bing: Ethics radiation
KTH Royal Institute of Technology	Sven Ove Hansson; Per Wikman-Svahn	KTH Royal Institute of TechnologyKTH Royal Institute of TechnologySE-100 44StockholmSweden+46 8 790 60 00	http://www.kth.se/en	Bing: Ethics radiation
Stockholm University	Thomas Jonter; Drottz-sjoberg, BM	Adres: Universitetsvägen 10, 114 18 Stockholm, Sweden, Telefoon: +46 8 16 20 00	http://www.su.se/english/	Bing: Ethics radiation
International Commission on Radiological Protection	Bo Lindell	Swedish Radiation Protection Institute (SSI), SE-171 16 Stockholm, Sweden	http://www.icrp.org/	Bing: Ethics radiation
School Center for Risk Research	Lennart Sjoberg, J. Truedsson	http://lennartsjoberg.blogspot.com/, Email: lennartsjoberg@gmail.com, Center for Risk Research, Stockholm School of Economics, Box 6501, 113 83 Stockholm, Sweden	http://www.kellogg.northwestern.edu/research/risk/	Google Scholar: Radiation sjoberg risk perception
Swedish Radiation Protection Institute	L. Persson	SE-171 16 Stockholm - Sweden, +46 (0) 8 729 71 00, +46 (0) 8 729 71 08	http://www.ssi.se	Google: risk communication radiation
Midsweden Research and Development Center	Malker, H; Olofsson, A; Rashid, S	Tel: +46 771975000, info@miun.se, Härnösand 871 88 Härnösand Besöksadr: Universitetsbacken 1	http://www.miun.se/sv/	Google: risk communication radiation

Table 28: Institutions identified by using internet browsers in Sweden

United Kingdom				
Name of the institution	**Key expert**	**Contact**	**Link**	**Browser/ Search criteria**
Imperial College London	Thomas Gerry	Charing Cross Hospital, Fulham Palace Road, London W6 8RF, tel: 0203 311 7342, fax: 0203 311 7175, mob: 07711 701382	http://www.melodi-online.eu/; http://www3.imperial.ac.uk/	Google: Risk communication perception
Health Protection Agency	Patt Troop; Anton Dittner	Email: tmhs@phe.gov.uk, Porton Down, England	http://www.hpa.org.uk/	Google Scholar: Research Risk Communication radiation
School of Psychology, Cardiff University	Dr. Karen Parkhill; Prof. Karen Henwood; Prof. Nick Pidgeon; Poortinga, W; Venables, D	Research Group:Social Psychology, Location: Tower Building, Park Place, Email:ParkhillK@cardiff.ac.uk, Telephone:+44(0)29 208 76520, Park Place Cardiff CF10 3AT, Verenigd Koninkrijk +44 29 2087 4000	http://www.cardiff.ac.uk/	Google Scholar: Risk communication perception
University of East-Anglia	Peter Simmons	Norwich Research Park Norwich, Norfolk NR4 7TJ, Verenigd Koninkrijk, +44 1603 456161	http://www.uea.ac.uk/	Google Scholar: Risk communication perception
Imperial College	Gale, RP;	South Kensington Campus, Exhibition Rd, London SW7 2AZ, +44 20 7589 5111	http://www3.imperial.ac.uk/	Google: risk communication radiation
Society for Radiological Protection	Andy Bradley; John Broughton; John Croft; Navneet Dulai; Christine Edwards; Rick Hallard; John Hunt; Shahed Khan; Neil Lewis; Sheila Liddle; Alan Marsh; George	The Society for Radiological Protection DS009, Dartington Hall, Devon, TQ9 6EN Tel: 01803 866743 Fax: 08442 724892 Email: admin@srp-uk.org	http://www.srp-uk.org/	Google: risk perception radiation

	Sallit; Andy Rogers; Richard Wilkins; Paul Leonard; Ian Robinson; Peter Thompson			
University of Cumbria	Englefield, C	Fusehill St, Carlisle, Cumbria CA1 2HH, United Kingdom, Phone: +44 1228 616234	http://www.cumbria.ac.uk/Home.aspx	Programm IRPA 13

Table 29: Institutions identified by using internet browsers in United Kingdom

The following institutions were identified by using the OPERRA e-survey:

- IRSN, France
- SCK-CEN Mol, Belgium
- University of Oslo
- University of Landcaster
- Leibnitz University of Hannover - Centre for radiation and radioecology
- KSU at Studsvik
- FOI, Sweden
- University of Ljubljana, Slovenia
- Institute SYMLOG, France (Poumadere. M.)
- State Institution National Research Center for Radiation Medicine of the National Academy of Medical Sciences of Ukraine. (V. A. Prilipko. Iu. Iu. Ozerova. M. M. Morozova. K. K. Shevchenko)

Figure 3: Institutions involved in SSH research identified by the OPERRA e-survey

Participants at the Symposium on Ethics of Environmental Health

Country	Institution, University	Participant/Researcher	Contact	Topic
Belgium	Science and Technology Studies Unit, Belgian Nuclear Research Centre, Mol	Gaston Meskens	gaston.meskens@sckcen.be	Risk governance, Justice, Democratic decision making about risks
Czech Republic	Department of Radiology, Toxicology and Civil Protection, University of South Bohemia	Friedo Zölzer	zoelzer@zsf.jcu.cz	Cross-cultural ethics, Biomedical ethics
France	Science and Society Department, University of Lyon	Marie-Hélène Hengé-Napoli	marie-helene_henge@orange.fr	Societal issues of radiation protection, Ethics of communication
France	ISRN	Francois Rollinger	francois.rollinger@irsn.fr	Risk perception, Science and Values
France	CEPN	Thierry Schneider	thierry.schneider@cepn.asso.fr	Ethics of emergency preparedness, Ethics and economics
France	CEPN	Jacques Lochard	lochard@cepn.asso.fr	Ethics of radiation protection
Germany	BfS	Christiane Pölzl-Viol	cpoelzl@bfs.de	Ethics of radiation protection
Germany	Department of Social Sciences, Goethe University Frankfurt	Susanne Bauer	bauer@soz.uni-frankfurt.de	Social aspects of risk, Sociology of science
Ireland	School of Medicine, Trinity College, Dublin	Jim Malone	jifmal@gmail.com	Radiation protection in medicine, Biomedical ethics
Italy	Department of Physics, University of Milan	Marie Claire Cantone	marie.cantone@unimi.t	Environmental ethics, Anthropocentrism/biocentrism, Environmental policies

Netherlands	Chairgroup Applied Philosophy, Wageningen University	Michiel Korthals	michiel.korthals@wur.nl	Ethics of food, health and environment
Netherlands	Faculty of Technology, Policy and Management, Delft University of Technology	Behnam Taebi	b.taebi@tudelft.nl	Ethics of risk acceptance, Democratic decision making about risks
Netherlands	Ethics and Philosophy of Technology, Delft University of Technology	Sabine Roeser	s.roeser@tudelft.nl	Emotion and value, Moral acceptability of risk
Norway	Centre for Environmental Radioactivity, Norwegian University of Life Science, Ås	Deborah Oughton	deborah.oughton@umb.no	Ethical concepts, Environmental ethics, Research ethics
Norway	Department of Psychology, Norwegian University of Science and Technology, Trondheim	Britt-Marie Drottz Sjöberg	Britt.marie.drottz.sjoberg@svt.ntnu.no	Risk perception, Ethics of risk communication
Sweden	Division of Philosophy, Royal Institute of Technology, Stockholm	Sven Ove Hansson	soh@kth.se	Ethical theories, System of radiation protection
Sweden	Division of Defence Analysis, Swedish Defence Research Agency	Per Wikman-Svahn	per.wikman.svahn@foi.se	System of radiation protection, Intergenerational equity
United Kingdom	School of English, Communication and Philosophy, University of Cardiff	Robin Attfield	attfiled@cardiff.ac.uk	Environmental ethics, Bioethics, Precautionary principle, Intergenerational equity
United Kingdom	Centre for Computing and Social Responsibility, De Montfort University, Leicester	Mark Coeckelbergh	Mark.coeckelbergh@dmu.ac.uk	Risk perception, Ethical aspects of risk policies
United Kingdom	Lothian Health Board, Glasgow	Christopher J. Kalman	chris.kalman@nhslothian.scot.nhs.uk	Radiation protection practice, Occupational radiation protection

Table 30: Participants at the Symposium on Ethics of Environmental Health

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