**Programme 1.1** **Nuclear Power**

**Subprogramme 1.1.1** **Integrated Support for Operating Nuclear Facilities**

**Project 1.1.4.2** **Coordination of international activities for innovative nuclear systems**

**CRP Title:** **Identification and Assessment of the Role of Heavy Water Moderated Reactors for Optimum Utilization of Global Fuel Resources Under Proliferation Requirements, and during the Transition Toward Full-Scale Utilization of Innovative Nuclear Systems (INS)**

**CRP Code:** **To be assigned**

In order to ensure the use of nuclear power technologies in supporting sustainable development of the world, including its resources, strategies and measures must be in place during the transition from the current stage of nuclear power technologies to the future full-scale utilization of innovative nuclear systems. It is believed that heavy water moderated reactors can play a unique and useful role in the optimization of the world's nuclear fuel resources, including during the transition period. The CRP will attempt to develop a common understanding of this role through reviews and assessments of relevant fuel-cycle-related information generated for various reactor technologies including water cooled reactors, fast reactors and small and medium sized reactors (SMRs).

**CRP Title:** **Heat Transfer Behaviour and Thermohydraulics Code Testing for Supercritical Water Cooled Reactors (SCWRs)**

**CRP Code:** **I3.10.16**

This CRP will focus on developing SCWR designs. Experimental data for convective heat transfer from fuel to coolant, covering a range of flow rate, pressure and temperature conditions, are required. It is necessary to collect, evaluate and assimilate existing data and to carry out new experiments to obtain the required data and to establish accurate techniques for predicting heat transfer in SCWR cores. Validated thermohydraulic codes are required for design and safety analyses of SCWR concepts. Existing codes for water cooled reactors need to be extended in their application and improved to model phenomena such as pressure drop, critical flow, instability behaviour and transition behaviour from supercritical to two-phase conditions, and the appropriate predictive models for computing the heat transfer to supercritical water need to be incorporated. This CRP is designed to promote international collaboration among IAEA Member States for the development of supercritical water cooled reactors in the areas of thermohydraulic behaviour and testing of computer methods.

**Project 1.1.5.4** **Common technologies and issues for small and medium sized reactors (SMRs)**

**CRP Title:** **Development of Advanced Methodologies for Substantiation of Passive System Performance in Innovative Reactors**

**CRP Code:** **To be assigned**

The objective of this project is to determine a common analysis-and-test based method for the assessment of passive safety system performance. Such a method could facilitate the application of risk-informed approaches in order to optimize the design of future advanced reactors, contributing to their enhanced safety levels and improved economics. The CRP is conducted in cooperation with the technical working groups on advanced reactor technologies of the Department of Nuclear Energy and of the Department of Nuclear Safety and Security. The CRP has been started with 8 participating research institutions from Argentina, France, India, Italy, the Russian Federation, and the USA.

**Project 1.1.6.1** **Support for demonstration of nuclear seawater desalination**

**CRP Title:** **Advances in Nuclear Desalination Technologies**

**CRP Code:** **I3.50.03**

Desalination is a very rapidly evolving field, and as more countries are opting for dual purpose integrated nuclear desalination systems, the need for advances in technologies leading to more efficient and economic systems is obvious. This CRP will focus on the introduction of innovative technologies which may help to make nuclear desalination safer and more economical. The new technologies are expected to enhance the harvesting of waste heat available in nuclear reactors for use in seawater desalination. New technologies may involve technologies related to desalination processes such as low temperature horizontal tube multi-effect distillation (LT-HT-MED), related to efficient systems to maximize heat recovery, such as heat pipes, or related to the optimization of the coupling configuration between nuclear reactors and desalination systems. Additional dimensions of the CRP are to analyse the economics of cogeneration systems (i.e. for electricity and water production), and improve the IAEA Desalination Economic Evaluation Program (DEEP) software.

**Project 1.2.3.2** **Providing technical guidance on good practices for long term management of spent fuel**

**CRP Title:** **SPAR III Spent Fuel Performance and Assessment Research**

**CRP Code:** **T1.30.13**

As the long term storage of spent fuel over long periods of time of 100 years and possibly more becomes a reality, assurances are sought that spent nuclear fuel and storage systems can retain their integrity and enable the retrievability of spent fuel for the next phases of spent fuel management irrespective of whether reprocessing or disposal is selected in future. The SPAR III CRP covers spent fuel performance and assessment research and is the continuation of the SPAR II CRP. Previous CRP (SPAR II) research has identified some potential deterioration mechanisms that have to continue to be investigated and extrapolated over long periods of time. In addition, the integrity of fuel under some potentially adverse conditions in correlation with identified ageing mechanisms needs to be investigated. Research and investigation of these topics will be coordinated with the participating countries to achieve maximum efficiency of investigation and efficient exchange of information.

**Project 1.2.4.1** **Supporting nuclear fuels and fuel cycle activities of fast reactors, high temperature gas cooled Reactors (HTGRs) and small and medium-sized reactors (SMRs) with long core life**

**CRP Title:** **Accelerator Simulation and Theoretical Modelling of Radiation Effects in Structural Materials of Nuclear Reactors**

**CRP Code:** **T1.40.02**

Growing operational loads and plans for the introduction of new innovative nuclear power technologies make it necessary to enhance the operational characteristics of existing fuels and to develop advanced radiation-resistant structural materials. This presupposes a new level of basic understanding of radiation-induced degradation of nuclear materials and a need for deeper consideration of the basic aspects of radiation damage, including accelerator simulation and atomistic modelling of radiation effects. This CRP will focus on the promotion of best experimental practice of accelerator simulation of radiation effects, the development of atomistic models and validation of numerical codes for the evolution of radiation defects and radiation-induced changes of material

structure and properties, enabling predictable comparisons to be made among different irradiation environments.

**Project 1.3.2.1** **Techno-economic analysis**

**CRP Title:** **Techno-Economic Comparison of Ultimate Disposal Facilities for Carbon Dioxide Storage and for Nuclear Wastes**

**CRP Code:** **To be assigned**

As part of the IAEA's ongoing work on sustainable energy development, this CRP will generate state-of-the-art information about a range of issues associated with the geological disposal of $CO_2$ and nuclear waste relevant for the participating countries in a comparative framework. Participants will draw on the results of earlier research in the relevant fields and on the background material prepared by the IAEA for this CRP. The investigations will focus on the feasibility, options and capacities for geological disposal of $CO_2$ and nuclear waste, potential environmental impacts and socio-economic circumstances (costs and benefits, legal issues, public acceptance, etc.) in the participating countries or selected regions. The outcomes of the CRP are expected to be in the areas of science and policymaking, particularly in energy and environmental policy.

**Project 1.4.1.4** **Atomic and molecular data for fusion experiments**

**CRP Title:** **Atomic and Molecular Data for Burning Plasmas**

**CRP Code:** **To be assigned**

This CRP will focus on data needed for diagnostics of isotope ratios in burning fusion plasmas. Efficient control of the fuelling system for burning plasmas requires accurate knowledge of the isotopic mix in order to precisely control the plasma burn. A number of possible diagnostic methods exist, including charge exchange recombination spectroscopy (CXRS), diagnostic neutral beams, beam neutralization alpha particle diagnostics and numerical simulations. Data requirements include information on physical processes affecting the CXRS reactions inside the beam volume, a full set of atomic data in the form of total cross sections for beam attenuation, data on the metastable fraction of neutral atoms, impurity ion impact ionization and charge exchange cross sections of He neutrals with ions. This CRP will address these data needs.

**Project 1.4.2.1** **Enhancement of utilization and applications of research reactors**

**CRP Title:** **Development, Characterization and Testing of Materials in Energy Sector Using Neutron Beams**

**CRP Code:** **To be assigned**

The objectives of this CRP are to address the use of neutron beams for non-destructive characterization and testing of materials and components produced for applications in industry with special reference to the nuclear energy sector (fission and fusion). This CRP aims to bring together the stakeholders, facility providers and end-users of research reactors in order to enhance the use of the available facilities and to develop new infrastructures for applied material research in the nuclear energy sector. Work planned under this CRP relates to the development and upgrading of research reactor based neutron techniques, including facility and instrument modifications, improved processes for data acquisition and analysis systems. Particular emphasis is placed on variable environments of materials to be characterized and tested as required by some applications. This includes high temperature and high pressure conditions, the presence of magnetic and electric fields, characterization

and testing of irradiated materials. Targeted neutron beam techniques are material residual stress and texture measurements, advanced neutron radiography/tomography, and small angle neutron scattering.

**Project 1.4.2.2** **Supporting research reactor modernization and innovation**

**CRP Title:** **Innovative Methods in Research Reactor Analysis: Benchmark against Experimental Data on Neutronics and Thermohydraulic Computational Methods and Tools for Operation and Safety Analysis of Research Reactors (jointly with NSNI)**

**CRP Code:** **J7.10.13**

With the progress in computer technology and numerical methods, the capabilities of computer codes have been substantially improved. The recent development of these methods and codes allows for better simulation of the complex processes taking place during the steady state operation and transient conditions of research reactors. The main objective of the CRP is to benchmark different codes against experimental data, to assess the quality of these computational methods. Benchmarking of advanced research reactor analysis codes will help in improving the design, operation and safety performance of research reactors and associated experiments.

**Project 1.4.3.1** **Accelerator techniques for modification and analysis of materials for nuclear technologies**

**CRP Title:** **Numerical Modelling and Simulation of Irradiation Effects**

**CRP Code:** **T1.40.02**

The properties of materials can be strongly affected by irradiation, therefore the behaviour of materials under irradiation has been studied for more than 50 years. However not all scientific and technological aspects have been fully understood and further research is still necessary, in particular there is lack of information on new and improved core materials irradiated at very high doses. This CRP reflects the needs of Member States in the area of the effects of high dose radiation on core structural materials in nuclear reactors and other nuclear systems (fusion reactors and accelerator-driven systems (ADS). The CRP aims to enhance the capability of interested Member States to build up advanced or innovative technologies by promoting information exchange, including the assessment of the constructive use of such innovative technologies to resolve some of the issues associated with existing nuclear fuel cycles for the sustainable growth of nuclear energy. The objectives of the CRP in the first phase are focused mostly on the improvement, development and testing of core structural materials for higher burn-up in advanced water cooled and fast reactors. The identified goals will be addressed by accelerator simulation of high dose irradiation and complementary application of theoretical modelling. The approach of coupling accelerator studies with modelling has tremendous potential for improved understanding of radiation damage in high dose materials, for validation of complex materials models and for increased use of novel characterization techniques for enhanced understanding of the basic problems and processes. The outputs of the CRP will contribute to the extension of knowledge about radiation effects and the development of core structural materials with improved radiation-resistant properties.

**CRP Title:** **Complementary Techniques for Advanced Engineering Research for Nuclear Applications**

**CRP Code:** **To be assigned**

There is a collection of techniques in materials science and chemistry based on radioactive hyperfine probes, such as Mössbauer spectroscopy, perturbed angular correlations, beta-detected nuclear magnetic resonance (βNMR), and muon spin rotation. Therefore, radioactive beam facilities and nuclear probes are widely and successfully used to study and characterize materials of technological relevance. These probes are complementary to macroscopic and scattering techniques. The objective of the CRP is to improve the provision, scope and utilization of advanced muon and radioactive ion-beam techniques together with complementary techniques for the characterization of scientifically and technologically important materials.

**CRP Title:** **Application of Nuclear Methods in Microstructural Characterization and Performance Testing of Materials for Hydrogen Fuel Cell and Storage Technologies**

**CRP Code:** **F1.20.22**

A hydrogen-based source of energy can greatly contribute to more sustainable, less carbon-dependent global energy production. The major components in the expected hydrogen economy involve production, storage, transportation and conversion of hydrogen. All parts in this chain are facing considerable technological challenges, particularly those related to the structural materials used. The research efforts to solve these challenges will require new materials and solutions, particularly for production and storage, and not simply, incremental improvements in current technologies. Nuclear methods will play an important role in the development of new/improved materials, but most importantly as a major tool to characterize the properties and performance of the materials. A typical example is the optimization of the membrane properties of fuel cells or enhancement of the hydrogen storage capacity of solid storage materials. In both cases, the nuclear techniques are applied in a very effective way due to the direct characterization of the hydrogen interaction with the structural materials used. The scope of the CRP is to enhance the abilities for testing of performance and microstructural characterization of materials for fuel cells and hydrogen storage through the application of selected nuclear probing techniques. The CRP outputs will provide significant added value and unique contribution to the R&D of new advanced solid state materials relevant to the hydrogen economy and to the selection of candidate materials, as well as the further qualification and quantification of the key parameters.

**Project 1.4.3.4** **Nuclear spectrometry for analytical applications**

**CRP Title:** **Special Configurations and New Applications of Microanalytical Techniques Based on Nuclear Spectrometry**

**CRP Code:** **To be assigned**

The CRP relates to emerging new techniques and applications of nuclear spectrometry for characterization of materials in areas such as industry, mining, environmental pollution monitoring, biomedicine, archaeology, study of cultural heritage objects, forensic science, food and agriculture etc. In particular, the development of new microanalytical techniques based on synchrotron radiation sources and low-energy particle accelerators, as well as portable instruments and associated methodologies for in-situ measurements will be addressed. A major objective of the CRP is the development or improvement of instruments and analytical methodologies based on nuclear spectrometry, as well as their application to elemental analysis, 2D and 3D microscopy imaging and chemical speciation.

**Project 1.4.4.1** **Supporting plasma physics and fusion research**

**CRP Title:** **Integrated Approach to Dense Plasma Applications in Nuclear Fusion Technology**

**CRP Code:** **To be assigned**

This CRP aims to support the fusion programme by coordinating research on new fusion grade materials, new physics studies and new technology developments. Thus, the work will focus on the development of a network of dense plasma devices; testing of materials for fusion in round robin experiments; the development of the technology of plasma focus; the development of prototypes for commercial applications; and the contribution of expertise exchange with large laboratories in developed Member States.

**CRP Title:** **Safety and Security Aspects of Fusion**

**CRP Code:** **To be assigned**

The decision to construct the International Thermonuclear Experimental Reactor (ITER) represents a landmark in the area of burning plasma research. There is now increased demand for assessing the balance between technological outputs and safety requirements to satisfy the licensing requests for ITER. Efforts in this direction started to be developed during the ITER design phases, and the host factor has now been included in it. However, this work represents just the beginning of a more challenging process: the establishing of the safety basis for the licensing of a demonstration fusion power plant. The objective of this CRP is to examine in an integrated way all safety aspects anticipated to be relevant to ITER, and to the first power plant prototype expected to become operational by the middle of the century, leading to the first generation of economically viable power plants with attractive safety and environmental features.

**Programme 2.1** **Food and Agriculture**

**Subprogramme 2.1.1** **Sustainable Intensification of Crop Production Systems**

**Project 2.1.1.1** **Soil management and conservation for sustainable agriculture and environment**

**CRP Title:** **Assessing the Interactions between Conservation Land and Water Management Practices and the Fate of Herbicides in Agro-ecosystems and the Implications for Sustainable Agriculture: The Role of Isotopic and Related Techniques**

**CRP Code:** **To be assigned**

Herbicide use plays a vital role in adopting conservation land and water management practices in various agro-ecosystems, such as conservation tillage and improved rice cropping systems. Sustainable use of herbicides in these systems not only achieves increased productivity, but also aims to mitigate the environmental impacts of herbicides. However, the interactions and feedback mechanisms between herbicide fate and soil carbon, soil nutrients, soil moisture and temperature dynamics in agro-ecosystems that adopt conservation land and water management practices are poorly characterized. This CRP will provide improved understanding and quantification of these interactions and mechanisms under a variety of environments for several important crop species using both nuclear and non-nuclear techniques, including the use of isotopically labelled herbicides, fertilizers and crop residues ($^{14}C$, $^{13}C$ and $^{15}N$).

**CRP Title:** **Integrated Isotopic Approaches for Area-wide Precision Conservation to Control the Impacts of Agricultural Practices on Land Degradation and Soil Erosion**

**CRP Code:** **D1.20.11**

Concerns about food security and widespread land degradation have highlighted the effect of agricultural land use and management on soil erosion losses and related impacts on the farmers' environments. New technologies will need to be developed and applied to better understand and manage natural and agricultural resources in agro-ecosystems to meet this dual goal of sustainable agricultural production and agro-environmental sustainability. Precision conservation is a rapidly developing key science integrating geospatial techniques, models and other tools, including compound specific stable isotopes and fallout radionuclides to identify hot spots on the farm and throughout the agricultural land on an area-wide basis. This approach provides better informed decisions relating to critically degraded areas and assists land resource managers/farmers to target soil conservation measures and appropriate land uses to these site-specific hot spots. The objective of this CRP is therefore to develop integrated approaches for establishing comprehensive soil redistribution studies and identifying hot spots diffuse pollution areas in agricultural catchments to support implementation of precision conservation.

**CRP Title:** **Strategic Placement and Area-Wide Evaluation of Water Conservation Zones in Agricultural Catchments for Biomass Production, Water Quality and Food Security**

**CRP Code:** **D1.20.10**

The competition for water from various sectors and the impacts of climate change and variability are making it crucial to devise sustainable and resilient policies and management strategies for strategic placement and area-wide evaluation of water conservation zones in agricultural catchments for biomass production, water quality and food security. The CRP will apply existing nuclear-based and related techniques for tracking pathways and quantifying water fluxes through water, plant and soil systems, as well as for determining the water storage capacity of wetlands, ponds and riparian zones. In addition, work will be carried out using both nuclear and non-nuclear techniques to assess nutrient/pollutant attenuation capacity within the wetlands, ponds and riparian zones and to understand the link between water and nutrient dynamics in wetlands, ponds and riparian zones and biomass production.

**Project 2.1.1.5:** **Integrated soil-plant approaches to increase crop productivity in harsh environments**

**CRP Title:** **Approaches to Improvement of Crop Genotypes with High Water and Nutrient Use Efficiency for Water-Scarce Environments**

**CRP Code:** **To be assigned**

Most countries in the tropics and subtropics have weather patterns and soil characteristics that constrain crop production over large tracts of land. Thus, a major challenge for making better use of these marginal lands is to select, evaluate and develop crop genotypes that can produce under conditions of high temperatures and low rainfall, or where soils suffer from salinity or acidity or have been 'mined' of nutrients. This CRP will address various facets of moisture stress by adapting, testing and applying existing nuclear-based techniques and related methodological options for evaluating crop genotypes with enhanced adaptation to water scarce environments. This CRP will focus on increasing

crop production in marginal lands by identifying and promoting the development of food crop genotypes with enhanced water productivity and high nutrient efficiency and by developing integrated soil, water and nutrient management practices in low fertility soils and water-scarce environments.

**CRP Title:** **Sustainable Productivity and Quality Enhancement of Mutant Crop Varieties as Affected by Soil Quality**

**CRP Code:** **To be assigned**

Owing to weather patterns and soil characteristics in the tropics and subtropics, crop production is constrained over large tracts of land. Thus, a major challenge for making better use of these marginal lands is to select, improve and develop crop genotypes that can produce under conditions of high temperatures and low rainfall, or where soils suffer from salinity or acidity or have been 'mined' of nutrients. The overall objective of the project is to enhance productivity and quality in mutant crops under low input cultivation in a range of agro-ecologies with inherent poor soil fertility.

**Project 2.1.2.2:** **Reducing risk from transboundary animal diseases (TADs) and those of zoonotic importance**

**CRP Title:** **Early and Rapid Diagnosis of Emerging Diseases**

**CRP Code:** **To be assigned**

Avian influenza (bird flu), the subject of this CRP, poses a pandemic risk to humans and animals and it is therefore important to diagnose and control this disease at the animal level, its point of entry. The overall objective is to develop, evaluate and validate early and rapid nuclear and nuclear-related diagnostic technologies to provide Member States. The CRP supports the strengthening of competence in the use of modern biotechnology, including molecular and serological methods, to provide systems and technologies to be used in the field as well as in laboratories.

**CRP Title:** **Diagnosis and Surveillance of Peste des Petits Ruminants**

**CRP Code:** **To be assigned**

Peste des Petits Ruminants (PPR) is a highly contagious transboundary animal disease of small ruminants caused by a morbillivirus similar to rinderpest. High morbidity and mortality rates of up to 90% make PPR a killer disease. The sustainable intensification of small ruminant production is a key factor in improving the livelihoods of rural communities as a trading commodity as well as being considered as a main food source. An outbreak of PPR affects therefore not only their access to food, but also increases their poverty level. The disease is endemic in parts of Africa, the Near and Middle East and South Asia and is gradually expanding to countries south of the equator and to Asia. The main objective of this CRP is to develop and apply nuclear and nuclear-related technologies to facilitate the early and confirmatory diagnosis of the disease.

**Project 2.1.3.1:** **Irradiation and agricultural countermeasures for food safety and trade**

**CRP Title:** **Development of Generic Irradiation Doses for Quarantine Treatments**

**CRP Code:** **D6.20.08**

The main purpose of the CRP is to validate generic treatment doses for groups of arthropods of quarantine significance in international trade. Secondary objectives include an examination of the effects of low oxygen commodity storage and dose rate on efficacy and commodity tolerances. Research may result in a reduction in the existing 400 Gy dose levels for Insecta (except for pupae and adults of Lepidoptera). The work will help to set doses for the phylum Arthropoda and a few subgroups within that phylum as well as specific minimum doses that provide quarantine security against pests in various commodities.

**CRP Title:** **Development of Safe Foods for Specific Target Groups including Immunocompromised Patients**

**CRP Code:** **To be assigned**

This CRP will aim to increase the variety of foods available for target groups, such as fresh vegetables, fruits and frozen foods and the development of simple as well as complex foods through the use of irradiation, alone or in combination with other food processing technologies (e.g. modified atmosphere packaging (MAP), natural coatings and additives) and flexible packaging materials. The overall objective is to develop a complete set of safe foods for consumption by selected target groups. The specific objective will be to evaluate (nutritionally, microbiologically and organoleptically) the use of irradiation technology alone or in combination with other food technologies to produce a variety of safe foods for the selected target groups.

**Project 2.1.3.2:** **Integrated control of food and environmental hazards**

**CRP Title:** **Development of Radiometric and Allied Analytical Methods to Strengthen National Residue Control Programmes for Antibiotic and Anthelmintic Veterinary Drug Residues**

**CRP Code:** **D5.20.36**

The main purpose of the CRP is to assist the National Reference Laboratories of FAO and IAEA Member States in meeting the need for effective and appropriate monitoring methods for residues of selected antibiotic and anthelmintic veterinary medicines through the development and application of screening methods that exploit the advantages (robustness, sensitivity, transferability) of radiotracer detection methods, in conjunction with confirmatory techniques using stable-isotope labelled molecules. The aim is to develop multi-analyte screening methods using various techniques, including microbiological growth inhibition methods and immunochemical assays with radioactive and alternative labels, and physico-chemical screening techniques, including high performance thin-layer chromatography (HPTLC) with optical scanning and/or autoradiography. Confirmatory isotope dilution assays meeting the performance requirements of regulatory authorities will also be investigated to complement the screening methods developed under the project.

**CRP Title:** **Development and Evaluation of Improved Strains of Insect Pests for Use with the Sterile Insect Technique (SIT)**

**CRP Code:** **D4.20.14**

As the sterile insect technique (SIT) continues to expand, new strains of insect pests need to be developed to substantially increase the efficiency and applicability of the technique and to facilitate its expansion to other insect pests. Such strains are developed using both classical and modern biotechnological methods as appropriate, and include genetic sexing strains, strains refractory to disease transmission, strains carrying a genetic marker to enable them to be distinguished from wild insects, and strains in which the males carry a marker in their sperm. Genetic sexing strains will be essential in order to expand the use of the SIT to some mosquitoes and other vectors of disease. The suitability of the new strains for use with the SIT will be assessed under a) standard laboratory conditions and b) semi-mass rearing conditions.

**Project 2.2.1.1:** **Combating the double burden of malnutrition**

**CRP Title:** **Exposure to Toxic Elements during Infancy**

**CRP Code:** **To be assigned**

Exposure to toxic elements such as arsenic and mercury via contaminated drinking water and food is affecting hundreds of millions of people in developing countries. The transfer of arsenic and mercury from mother to infant via human milk is poorly understood and only limited information is available on the quantities of total element and species of arsenic and mercury ingested by breastfed infants. As infants are especially vulnerable to the negative health effects of exposure to toxic elements owing to their rapid growth and development, more information is clearly needed with respect to this age group. This CRP will focus on estimating the exposure of arsenic and mercury in breastfed infants in areas where maternal exposure to arsenic and/or mercury is high. Exposure will be estimated by a combination of analyses of total element and species of arsenic and/or mercury in human milk samples and stable isotope techniques to measure the intake of human milk in breastfed infants.

**Project 2.2.1.3:** **Nuclear techniques in the prevention and control of HIV/AIDS and other infectious diseases**

**CRP Title:** **Nutrition and Malaria, Tuberculosis and Other Infectious Diseases in Infants and Children**

**CRP Code:** **To be assigned**

The global burden of infectious diseases is enormous. For example, about 40% of the world's population live in areas where malaria is transmitted. Malaria is a major cause of morbidity and mortality, in particular among young children and pregnant women. In sub-Saharan Africa, where the impact of malaria is greatest, approximately 3000 children under the age of five die of malaria every day, resulting in a total death toll of more than 1 million children per year. Infectious diseases and undernutrition often overlap in young children. The relationship between undernutrition and morbidity is complex, as illness often results in undernutrition and undernutrition increases susceptibility to disease. Children living in poor areas are thus often caught in a vicious cycle. This CRP will focus on the effect of improved nutritional status on incidence and severity of infectious diseases in young children.

**CRP Title:** **Short Course versus Standard Course Radiotherapy, in Elderly and/or Fragile Patients with Glioblastoma Multiforme (GBM)**

**CRP Code:** **E3.30.33**

Primary treatment of patients with a GBM consists of surgery followed by radiotherapy. Although the effectiveness of radiotherapy on survival has been demonstrated in several clinical trials, the prognosis for GBM patients remains poor. At present 60–66 Gy in 30 fractions is the most commonly used treatment schedule. However, for elderly and/or fragile patients it is difficult to complete conventional treatment and give total doses up to 60 Gy because of the poor performance status. Altering the fractionation schedule using a short course can be an option to complete the planned treatment schedule for the elderly and/or fragile patients as soon as possible in order to shorten the hospital/treatment time and, therefore improve the quality of life of these patients. Under this CRP, a randomized trial will be carried out in order to evaluate the question of optimized dose/fractionation and treatment time in elderly/frail patients with GBM. The objectives are: to compare two different durations of radiotherapy with regard to the quality of life of GBM patients receiving radiotherapy; to assess the overall survival rates as well as the toxicity of a short course regimen in the treatment of patients with GBM.

**Project 2.2.3.2** **Curative cancer management using radiotherapy**

**CRP Title:** **Altered Fractionation and Radio-Sensitization in Head and Neck Cancer Radiotherapy**

**CRP Code:** **E3.30.30**

Advanced head and neck cancer is common in many developing countries. The disease has a huge negative clinical, psychological and social impact. However, it has a small but finite curative potential with aggressive, adequately planned oncology treatment. To test the relative effectiveness of an accelerated radiotherapy regimen of 6 fractions/week compared with the same regimen plus the radiosensitizer nimorazole. The accelerated regimen was shown in CRP E3.30.18 to be superior to 5 fractions/week for local control in advanced head and neck cancer. The radiosensitizer has been shown in one clinical trial to improve local tumour control, and its use is now standard treatment for head and neck cancer patients in Denmark receiving radiotherapy. This CRP aims at maximizing the chances of curing this disease while sparing resources.

**CRP Title:** **Resource-Sparing Curative Treatment for Rectal Cancer**

**CRP Code:** **E3.30.34**

Preoperative radiotherapy has gained wide acceptance in the treatment of rectal carcinoma because it results in tumour shrinkage, increased radiosensitivity and decreased toxicity. However there is no uniform consensus for the selection of the optimal preoperative fractionation schedules. Under this CRP, a multicentre/multinational randomized clinical trial will be carried out to compare two preoperative regimens: 1) the control arm will be a combined chemo-radiotherapy regimen using a standard fractionation schedule (50 Gy in 2.0 Gy per fraction), compared with 2) an experimental arm using a hypo-fractionated schedule (25 Gy in 5.0 Gy per fraction) followed by two courses of chemotherapy. These two different fractionation regimens will be compared in terms of the respectability rate (primary endpoint) as well as local control, early toxicity and survival and cost-effectiveness rates (secondary endpoints).

**Project 2.2.3.3:** **Advanced techniques for cancer radiotherapy**

**CRP Title:** **Improving Outcomes in Radiotherapy Using New Strategies of Treatment Delivery with Focus on Oesophageal Cancer**

**CRP Code:** **E3.30.27**

A previous IAEA study of 232 patients has demonstrated the efficacy of fractionated high dose rate brachytherapy (HDR BT) in the palliative management of dysphagia. A pilot study has shown no additional morbidity in 30 patients treated with HDR BT plus external beam radiation therapy (EBRT), as opposed to that seen in 30 patients treated with HDR BT alone. A recent IAEA study demonstrated an advantage in palliation with the addition of EBRT in a randomized study of 219 patients. This CRP will test if treatment with EBRT for one week gives the equivalent palliation of symptoms as treatment with EBRT for two weeks. The CRP is open to radiotherapy institutions where HDR BT using microsource $^{192}$Ir and teletherapy (cobalt and/or linac) and simulation (or CT planning) are available. The centres will need to agree to provide to the study more than 20 patients per year with advanced Mo or M+ oesophageal squamous carcinoma. Only raw data will be required; all the analysis will be performed at a selected Technical Contract centre.

**Project 2.2.4.1:** **Quality audits in dosimetry for radiation medicine**

**CRP Title:** **Development of Quality Audits for Radiotherapy Dosimetry for Complex Treatment Techniques**

**CRP Code:** **To be assigned**

The external audit is a crucial element of any quality assurance (QA) programme for clinical dosimetry. So far the procedures for national TLD networks involved beam calibration checks and measurements in non-reference conditions for rectangular fields. As the next step, new procedures will be developed that will address complex irradiation techniques used for the treatment of cancer patients, such as conformal radiotherapy, which uses irregular radiation fields conforming to the tumour geometry either by shaping the field with customized shielding blocks or by using multileaf collimators (MLCs). Under this CRP, national audit networks will incorporate in their procedures for checking hospital dosimetry for these techniques. TLD-based dosimetry audit procedures for national external audit groups for dose measurements for irregular fields used in conformal radiotherapy will be developed.

**Project 2.2.4.3:** **Quality assurance and guidelines for medical physics in the optimization of clinical radiation imaging**

**CRP Title:** **Development of Quantitative Nuclear Medicine Imaging for Patient-Specific Dosimetry**

**CRP Code:** **E2.10.07**

Nuclear medicine instruments have the potential to provide quantitative information and the distribution of that information with time, i.e. biokinetics. This information provides the basis for internal dosimetry and is needed to properly optimize the use of any radiopharmaceutical. Patient-specific dosimetry is often a legal obligation when administering radiopharmaceuticals for therapy. There are, however, no harmonized protocols or guidelines for acquiring quantitative information from nuclear medicine instruments. Nor are there documents that address the possibilities and limitations of these instrumentations for quantitative information. This CRP aims at addressing this gap. The specific objective is to develop and test guidelines for accurate quantitation using nuclear medicine instruments such as gamma probes, gamma cameras and positron emission tomography (PET) scanners. The CRP

will also investigate to what extent combined scanners (PET/CT and SPECT/CT) can provide enhanced quantitative accuracy.

**Project 2.3.2.1:** **Isotope methods for the assessment of groundwater sustainability**

**CRP Title:** **Use of Environmental Isotope Tracer Techniques to Improve Basin-Scale Recharge Estimation**

**CRP Code:** **To be assigned**

Groundwater will become ever more important because of population increases and the impact of land use and climate changes. There is a need to improve estimates of groundwater recharge at the basin scale, which is the most relevant scale for water management. The difficulties associated with the quantification of basin-scale recharge impede the sustainable use of groundwater resources. Environmental isotopes are powerful tools for recharge estimation, but because they yield rates that typically represent recharge at a point or small area, their potential for basin-scale estimation has not been realized. This CRP aims to apply environmental isotope tracer methods to quantify the recharge distribution within basins and to link these results to a GIS tool that can be used by Member States to upscale their isotope results and make better basin-scale recharge estimations.

**Project 2.4.1.2:** **Diagnosing contaminant sources and fates using nuclear and isotopic techniques**

**CRP Title:** **Development of Validated Methods for the Speciation of Selected Forms of Hg, As and Sn in Marine Samples**

**CRP Code:** **To be assigned**

The exact toxic or beneficial effects of an element in the biosphere are dependent on the precise chemical form of that element within the compartment studied. Knowledge of speciation is therefore imperative for much decision making related to the environment and also in certain trade issues (such as the import of fish for human consumption). Reference materials provide a vital tool for method validation studies and for assuring the validity of analytical data. Currently, very few materials exist that are characterized for species content in marine samples. Under this CRP, validated speciation methodologies for As, Hg and Sn species, for a basket of analytical techniques will be developed.

**Project 2.4.1.4/2.4.4.1:** **Novel methods for measuring low level radionuclide concentrations in marine samples**

**Laboratory quality management activities and metrology**

**CRP Title:** **Benchmarking Calibration for Low-Level Gamma Spectrometric Measurements of Environmental Samples**

**CRP Code:** **To be assigned**

The calibration of hyperpure germanium (HPGe) gamma ray detectors for measuring low levels of radionuclides in the environment is a complex task relying on a combination of experimental and modelling approaches. Computational approaches such as Monte Carlo simulations offer a cost-effective and flexible alternative to multiplying the number of volume standards used for experimental calibrations, but suffer some disadvantages because they rely on data on detector characteristics that may be difficult to obtain and because the accuracy that can be attained is generally lower than with the experimental approach. Under this CRP the development of validated calibration methods relying on combined experimental and modelling approaches in IAEA Member States will be coordinated. The CRP also addresses metrological aspects, including a compilation of useful nuclear data and the

comprehensive quantification of measurement uncertainties associated with low level gamma spectrometric analyses of environmental samples, and the development of training materials.

**Project 2.4.5.2:** **Ecotoxicology**

**CRP Title:** **Environmental Impact of Radioactive Particles on Man and Non-Human Species**

**CRP Code:** **To be assigned**

Research carried out under a previous IAEA CRP recognized the importance of radioactive particles released into the environment from a wide range of different nuclear sources, with respect to environmental impact and risk assessments. Common problems related to analytical measurements and sample homogeneity, incomplete dissolution of samples, and potential differences in the transport, solubility and dosimetric properties of particle associated radionuclides compared with those existing as atoms, molecules, ions or complexes were highlighted. This new CRP will focus on the biological and health effects induced by radioactive particles and will seek to improve environmental impact and risk assessments for ecosystems contaminated with radioactive particles by increasing the scientific knowledge about radioactive particles released from artificial and natural radioactive sources to the environment, and their impact on man and biota.

**Project 2.5.1.1:** **Fostering the development of emerging radioisotopes and generators for medical and industrial applications**

**CRP Title:** **Production Methods for Emerging Positron Emitters for Medical Applications**

**CRP Code:** **To be assigned**

The development of new radiopharmaceuticals which can be routinely used for diagnosis or for the evaluation of radiotherapy would be valuable additions to the arsenal available to the nuclear medicine physician. There is great potential for the development of new radiopharmaceuticals using non-standard positron emission tomography (PET) radionuclides at facilities with medium energy cyclotrons. The CRP intends to develop better production routes, better separation and purification of emerging PET radionuclides such as $^{64}$Cu and $^{68}$Ge/$^{68}$Ga generator. The CRP will foster the development of new radiopharmaceuticals which incorporate these radionuclides for the diagnosis of specific diseases and to provide improved dosimetry of therapeutic radionuclides based upon improved quantification of tumour and normal tissue (organ) distribution using PET instrumentation.

**CRP Title:** **Radiometric Methods for Measuring and Modelling Multiphase Systems Towards Process Management**

**CRP Code:** **To be assigned**

Multiphase systems are indispensable in many modern industrial and environmental processes, and their optimization is important in ensuring enhanced performance, economic viability and environmental acceptability. The fluid dynamical properties and process parameters of such systems must be measured to facilitate process control and optimization. Radioisotope techniques offer, in many cases, the only means of performing such measurements. The use of radiotracers and sealed source techniques for the study of simple industrial systems is generally well known and the techniques have been adopted by many developing countries. However, the techniques for the investigation of multiphase flow systems are less understood, and need further development to ensure

their transfer to developing countries. Under this CRP, radiometric methods for optimization of processes in industrial and environmental multiphase systems will be identified and validated.

**Project 2.5.2.2:** **Radiation technology for advanced materials development**

**CRP Title:** **Potential Applications of Radiation Processed Nanomaterials in Health Care and Industry**

**CRP Code:** **To be assigned**

Nanotechnology has recently received enormous scientific attention due to the known benefits for advanced material development for potential applications in industry and healthcare. The use of radiation processing techniques to enhance the commercial value of materials is well practised in many Member States. In recent years there has been wide spread interest in the development of nanostructured materials using X-rays, electron beams and ion beams. This CRP has been designed to assess the potential role of radiation processing as a powerful tool for the synthesis and investigation of nanostructured materials and will strengthen the understanding of this emerging technology for potential applications in industry, healthcare and other fields of science. The CRP will concentrate on the study of mechanisms of the interaction of radiation on single particle or clusters in solutions or solid materials, the development of methods for radiation-enhanced synthesis of nanocomposites and evaluation of the physico-chemical properties of the resultant materials.

**CRP Title:** **Radiation-Induced Grafting of Polymers for Selective Separation Purposes and Adsorption of Materials**

**CRP Code:** **To be assigned**

Radiation-induced graft polymerization has now gained much more acceptance for the manufacturing of advanced polymeric materials by modifying the surfaces of commercially available commodity polymers. Polymer surface grafting offers a versatile means of providing existing polymers with new functionalities such as, hydrophilicity, adhesion, biocompatibility, conductivity, anti-fogging properties, anti-fouling properties, and lubrication. This CRP will focus on the development and evaluation of techniques for radiation-induced grafting of polymeric membranes, polymeric adsorbents and polymers for medicine and biotechnology for applications in areas such as recovery of metal ions from seawater and aqueous waste, chemically resistant self-cleaning filtration membranes and implants for bone replacement applications.

**Project 2.5.2.3:** **Remediation of pollutants using radiation technology**

**CRP Title:** **Radiation Processing for Remediation of Organic Pollutants in Solid and Aqueous Environments**

**CRP Code:** **To be assigned**

Municipal and industrial activities lead to environmental degradation and the destruction of non-biodegradable organic compounds. The removal of biological contamination of sludge and aqueous effluents are important for environmental preservation. Industrial effluents, which carry chemical compounds, heavy metals, organic pollutants, (most often petrochemicals, pesticides, dyes and some pollutants synthesized in situ, as for example, chloro organic compounds), cause contamination of surface and groundwater, resulting in the risk of infection and adverse health effects. The development and implementation of alternative technologies for the clean-up of industrial wastewater containing organic compounds is critical for the sustainable development of many countries. Radiation technology can play an important role in tackling these problems by degrading and destroying organic

and biological contaminants. Thus this CRP will focus on evaluating the effect of radiation on organic pollutants in solid and aqueous environments and address the related analytical and remediation techniques where applicable.

**Project 2.5.2.4:** **Strengthening capabilities for detection of explosives and illicit materials and for compositional analysis**

**CRP Title:** **Applications of Nuclear Analytical Techniques using Transportable Neutron Sources**

**CRP Code:** **To be assigned**

Analytical techniques in-situ are appropriate for investigations of the geochemistry of rocks, minerals and ores, the detection of components of metals and alloys, the detection and control of nuclear material content, the ecological monitoring of the environment, the control of agriculture production, and the detection of poison and other toxic substances without disassembling the containers. Applications of neutron activation analysis in geological sciences to determine trace impurities in gem stones (diamonds), trace element analysis of minerals to obtain element partitioning, or trace multi-element analysis of bulk rocks will be enhanced by the use of transportable sources and a combination of analytical techniques. Work under this CRP is aimed at improving in-situ non-destructive examination of specific materials by using cold neutrons as analytical probes for prompt gamma activation analysis and neutron depth profiling as well as neutrons in instrumental and radiochemical neutron activation analysis.

**Programme 3.1** **Incident and Emergency Preparedness and Response**

**Subprogramme 3.2.3** **Development and use of Advanced Safety Assessment: Methods and Applications**

**Project 3.2.3.3:** **Fostering technical developments and trends in safety analyses**

**CRP Title:** **Safety and Security Aspects of Fusion**

**CRP Code:** **To be assigned**

There is currently an increased demand for assessing the balance between technological outputs and safety requirements to satisfy the licensing requests for ITER. Efforts in this direction started to be developed during the ITER design phases, and the host factor has now been included in it. However, this work represents just the beginning of a more challenging process: the establishing of the safety basis for the licensing of a demonstration fusion power plant. Thus, the objective of this CRP is to examine in an integrated way all safety aspects anticipated to be relevant to ITER, and to the first power plant prototype expected to become operational by the middle of the century, leading to the first generation of economically viable power plants with attractive safety and environmental features.

**Project 3.2.6.1:** **Enhancing the safety of research reactors**

**CRP Title:** **Benchmark on Neutronics and Thermohydraulic Computational Methods and Tools for Safety**

**CRP Code:** **To be assigned**

With the progress in computer technology and numerical methods, the capabilities of computer codes have been substantially enlarged. The recent development of these methods and codes allows for better simulation of the complex processes taking place during the steady state operation and transient

conditions of research reactors. Application of these methods and codes helps to improve the design and operation of research reactors and the associated experiments, and to enhance their safety. In addition, the conclusions obtained from the completed CRP entitled "Safety Significance of Postulated Initiating Events for Different Research Reactor Types and Assessment of Analytical Tools" emphasized the need for benchmarks against experimental data to demonstrate the quality of these computational methods and codes, through a formal qualification process, before judgement on the validity of their application to the safety analysis of research reactors. These experimental data can also be used to improve the design, operation and the safety performance of research reactors and associated experiments.

**Project 3.4.2.3:** **Implementing sustainable waste management strategies and programmes**

**CRP Title:** **Upgrading of Near Surface Disposal Facilities to Enhance Repository Performance and Safety**

**CRP Code:** **T2.30.15**

Many of the existing disposal facilities for low and intermediate level radioactive waste were developed and began operations long before current regulatory requirements took effect or more recent site suitability guidance, technical and technological advances, safety assessment methodologies, and quality assurance systems became available. Changes in national laws, regulations and disposal methods and technologies have evolved and improved with time. Various Member States have ongoing programmes both to upgrade these facilities and/or to develop new near surface disposal facilities for radioactive waste. Recently, a binding international regime for radioactive waste management was established through Article 12 of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. The specific objective of this CRP is to exchange information and promote R&D among participating Member States in the area of upgrading near surface disposal facilities to enhance repository performance and safety.

**Project 3.4.4.3:** **Facilitating the transfer of sustainable technologies for decommissioning of facilities**

**CRP Title:** **Planning, Management and Organizational Aspects in Decommissioning of Nuclear Facilities**

**CRP Code:** **T2.40.08**

A major weakness in the planning and execution of decommissioning projects is often poor planning and management, rather than the lack of available technology. This is particularly true for projects undertaken by research or other smaller organizations without recent experience in project execution and without the requisite internal organization to clearly define roles and responsibilities. This CRP intends to stimulate early and effective planning for decommissioning projects by identifying the necessary skills, organization and approaches required for successful decommissioning project management. Successful examples of decommissioning project management will be described and analysed to permit the most important lessons learned to be extracted and conveyed. The output from this CRP will be in the form of a Technical Report giving clear, practical guidance to Member States with a need to plan and implement decommissioning projects.

**Project 3.5.2.1:** **Developing guidelines and recommendations for the prevention of malicious acts**

**CRP Title:** **Development of a Methodology for Risk Assessment and State Management of Nuclear Security Regimes**

**CRP Code:** **J0.20.20**

There is an obvious need for many States to have a methodology for risk assessment of adversary activities and for evaluation of the effectiveness of State nuclear security measures. Depending on the scale of nuclear activities in a State, these assessments and evaluations could require special expertise and experience, which might not be immediately available in the State. The objective of the CRP is to develop an internationally agreed and tested methodology to help the State identify the components and technologies in its nuclear related infrastructure that could be used by adversaries to acquire nuclear material and fabricate an improvised nuclear explosive device (IND); to sabotage a nuclear facility or transport; to disperse or cause exposure to radioactive material (radiological dispersal device (RDD) or radiological explosive device (RED)). It should also help to develop optimal nuclear security measures and manage the comprehensive State security regime, which would include, along with physical protection of the facilities, all other technical and administrative measures.