IAEA Coordinated Research Activities in 2012

I. General Information

I.1. Statutory provisions

The International Atomic Energy Agency (IAEA) is authorized under its Statute to encourage and assist research on atomic energy for peaceful uses throughout the world and its development and practical applications. The IAEA's programme and budget for 2012 accordingly provides for the placing of research, technical and doctoral contracts and research agreements with universities, colleges, research centres, laboratories and other institutions in Member States on subjects directly related to the IAEA's work.

I.2. Financial support

The IAEA's financial support of a project is normally in the form of a lump-sum cost-sharing contract. The Contractor is usually expected to bear part of the cost of the project and, in any case, to continue to make normal contributions covering overheads and other expenses and the IAEA contributes an appropriate percentage of the total estimated costs. Owing to the limited resources available, the amounts awarded are rarely large — the present average being approximately €6000 per annum per contract. Larger awards may, however, be considered. In addition to the contract award, Contractors participating in IAEA coordinated research projects (CRPs) are invited to attend periodic research coordination meetings at the IAEA's expense.

Agreements may be awarded to institutions, normally in developed countries, for participation in an IAEA CRP. Under such agreements, no financial award is made to the agreement holder other than the provision to attend research coordination meetings at the IAEA's expense.

I.3. Selection of Institution

The IAEA selects the institutions to which research contracts and agreements will be awarded. When a specific proposal for research is made by an institution in a Member State, the decision to award a research contract or agreement is made after careful consideration of the technical merits of the proposal, the compatibility of the project with the IAEA's own functions and approved programmes, the availability of appropriate facilities and personnel in the institution and previous research work related to the project.

Additionally, where it is recognized that the award of a particular research or technical contract or research agreement would materially assist one of the IAEA's programmes, an invitation is sent to those institutions believed to have the necessary facilities and personnel, and the Government of the Member State concerned is kept informed.

In providing research support from the limited funds available to the programme, priority is normally given to proposals received from institutions in developing Member States and to qualified young and female researchers.

I.4. Formal submission of proposals

Based either on a proposal made by the IAEA, or a proposal developed at a research institution, a formal submission of a project proposal should be made by the institution concerned, and submitted directly to the IAEA's Research Contracts Administration Section.

If the proposed project is approved a contract or agreement will be sent to the head of the institution for approval and signature, and the Government of the Member State will be duly notified through the appropriate channels of the conclusion of the contract or agreement. For all research contract proposals, the Proposal for Research Contract form N-17/Rev.13 (Jul.09) must be used. Proposals for research agreements should be made on the Proposal for Research Agreement form N-20/Rev.13 (Jul.09). These forms are available on the Coordinated Research Activities (CRA) website: **http://cra.iaea.org** or may be obtained by writing to the IAEA at the following address:

For the attention of:

Ms Nathalie Colinet
Acting Head, Research Contracts Administration Section
International Atomic Energy Agency
Wagramer Strasse 5
PO Box 100
1400 Vienna
Austria

II. General Conditions of Contracts and Agreements

II.1. Period of contract or agreement

All research contracts are normally awarded for a period of one year and may be renewed each year for the duration of the project. Research agreements are awarded for the duration of the CRP.

II.2. Reports

Each Contractor must submit a final report at the end of the contract. If a contract is renewed, the requirement for a final report is waived until the end of the final year of contract. However, a progress report must accompany each renewal application. Agreement holders must submit a report at each meeting of the research coordination project.

II.3. Conditions of payment under contracts

The timetable of the IAEA's payments is established when the contract is negotiated. Cash payments are normally made to the Contractor for expenses covered under the contract, except in cases where the IAEA is requested to procure equipment or other project-related supplies on behalf of the Contractor. In such cases, the portion of the total amount designated for equipment and supplies is withheld.

Payment is normally made in two equal instalments, the first being made at the start of the contract and the second upon the successful completion of the work envisaged in the contract. If the contract is renewed, one half of the amount is normally paid at the start of the contract renewal and the second half upon the successful completion of the work envisaged under that contract. Under contracts providing for purchase of equipment by the IAEA on behalf of the Contractor, only one cash payment will be made at the start of the contract. The IAEA reserves the right to pay to institutions 60% of the

first cash payment due in the currency of the Member State. Second and final cash payments for each contract or renewal are made upon receipt of a satisfactory progress or final report evaluated positively by the IAEA. Funds awarded under research contracts will remain available for three years (the year in which the contract was awarded, plus two further years). All efforts should be made to submit the required reports in a timely manner.

II.4. Publication of results and patent rights

Publication, either by the institution or the IAEA, of the results of work performed under research contracts and agreements is recognized as being normally the most appropriate and effective way of bringing these results to the notice of other scientists. The Contractor must acknowledge the IAEA's support of the work in any publication. Appropriate provision for patent rights is also made in the contract/agreement.

II.5. Provision of equipment

The Contractor may wish to use a portion of the funds provided by the IAEA for the purchase of equipment required in connection with the contract. Only items relating to the project concerned can be purchased from the funds provided by the IAEA. These items can be purchased directly by the Contractor or, upon request, procurement of equipment items can be arranged by the IAEA in cases where this expedites their supply. Funds reserved for the purchase of project-related supplies and equipment by the IAEA on behalf of the Contractor are transferred to a Trust Fund in which they remain until all foreseen purchases are made. No orders for supplies or equipment will be made by the IAEA after the contract is terminated.

II.6. Other provisions

Each contract/agreement provides that the IAEA shall not be liable for any death, injury or damage arising out of the implementation of the research project; as a rule, a clause is included requiring the Contractor or Agreement holder to hold the IAEA harmless from any damage suits. Provision is also made for the settlement of disputes, usually by arbitration, and for the adoption by the Contractor of the applicable health, safety and other standards.

III. IAEA Coordinated Research Projects for which Research May Be Supported in 2012

Most of the research supported by the IAEA is related to its coordinated research projects (CRPs) developed in line with overall IAEA goals. Only in exceptional cases will research contract funds be used to finance individual contract proposals that, while not forming part of a CRP, deal with topics in the IAEA's programme. The following list includes CRPs under which the IAEA may consider support of research in 2012. Additionally, the Coordinated Research Activities website: **http://cra.iaea.org** will list new CRPs which have received approval and those for which proposals are solicited.

All proposals will be carefully considered. Enquiries concerning specific CRPs should be addressed to the IAEA's Research Contracts Administration Section, email: **research.contracts@iaea.org**.

Programme 1.1	**Nuclear Power**
Project 1.1.1.1	**Engineering support for operating nuclear power plants including safety aspects**

CRP Title: **Qualification, Condition Monitoring, and Management of Ageing of Low Voltage Cables in Nuclear Power Plants**

CRP Code: **I21021**

The objectives of the CRP are to provide the current and next generation of nuclear facilities with information and guidelines on how to qualify new cables, monitor the performance of existing cables, and establish a programme of cable ageing management for both the current fleet of reactors and the next generation of nuclear facilities. The CRP will identify all areas of concern such as cable qualification, environmental monitoring, in-situ testing, performance trending, condition monitoring, identification of failure mechanisms, ageing effects and the prediction of useful remaining life. In particular, the results of current research in Member States will be shared, documented, and benchmarked through this CRP and new methods will be identified for further development and implementation. The CRP will result in recommended practices for managing cable ageing in existing facilities and will identify steps in order to benefit from long-term cable service and improved cable reliability.

CRP Title: **Review and Benchmark of Calculation Methods of Piping Wall Thinning due to Erosion and Corrosion in Nuclear Power Plants**

CRP Code: **I21022**

Although efforts to reduce the number of piping and equipment failures caused by flow accelerated corrosion have been quite effective, piping and components will continue to degrade as plants age. Guidelines on where and how to inspect (software predictions), how to perform chemistry improvements to reduce damage rates, and proposals for material upgrades for replaced components have to take into account new economic studies, reduced time outages, and personnel ageing. The CRP will address the behaviour and degradation mechanisms of pipe wall thinning and rupture, as well as methods for inspection and monitoring by developing a guideline to be used as a reference and will benchmark the most widely used prediction tools available in the market for this purpose.

CRP Title: **Ability of Digital Instrumentation and Control Systems in Nuclear Power Plants to Withstand Malicious Acts**

CRP Code: **I22003**

Much attention is currently being paid to cybersecurity. Digital instrumentation and control (I&C) systems and equipment are playing an increasingly important role in nuclear power plants (NPPs), either at the time of the initial design or as a result of I&C modernizations and upgrades. Malicious attacks on these systems could have serious effects on plant safety, which in turn could lead to severe, unacceptable consequences for society. Also, particularly in countries where nuclear power represents a significant part of electricity production, the availability and performance of NPPs may be of vital economic interest. The overall objective of the CRP is to strengthen Member States' capabilities for optimizing nuclear power plant performance and service life by means of improved understanding of the related engineering and management areas of cybersecurity. This includes taking appropriate measures against malicious acts targeting the digital I&C systems of NPPs.

Project 1.1.5.2	**Technology advances in water cooled reactors for improvements in economics and safety**
CRP Title:	**Prediction of Axial and Radial Creep in Pressure Tubes**
CRP Code:	**I21023**

Pressure tube deformation is a critical ageing issue in pressure tube type reactors. Depending on their age, horizontal pressure tubes may have three kinds of deformation: diametral creep leading to the flow bypass and the penalty to critical heat flux for fuel rods; longitudinal creep leading to disruption of the feeder pipes and/or the fuelling machine; and sagging leading to interference with in-core components and potential contact between the pressure tube and calandria tube. The CRP scope includes the establishment of a database for pressure tube deformation, microstructure characterization of pressure tube materials collected from reactors currently operating in Member States and development of a prediction model for pressure tube deformation.

Project 1.1.5.3	**Support for fast reactor research, technology development and deployment**
CRP Title:	**Benchmark Analysis of an EBR-II Shutdown Heat Removal Test**
CRP Code:	**I31021**

The CRP will deepen the physical understanding of the inherent safety characteristics of sodium cooled fast reactors. This will be achieved through numerical simulation of the “highly instrumented tests” that were performed by the Argonne National Laboratory (ANL) teams at EBR-II before final shutdown of the reactor. These tests were meant to demonstrate fast reactor safety in the event of pump trips with and without a reactor scram. The objective of the CRP is verification, validation and qualification of data and numerical codes to be used for the design and the safety analysis of innovative liquid metal cooled fast reactors. Basic geometrical and material data, as well as operating conditions will be provided by the ANL.

Project 1.1.6.2	**Nuclear hydrogen production**
CRP Title:	**Examining the Economics of Nuclear Hydrogen Production and Benchmark Analysis of the IAEA Hydrogen Economic Evaluation Software (HEEP)**
CRP Code:	**I23003**

Assessing the technical and economic aspects of nuclear hydrogen production plays an important role in defining the future hydrogen economy. With the global increased demand for hydrogen, volatile oil prices, and concern over the environment, nuclear power is poised to become a strong candidate for hydrogen production. The current growth rate for nuclear power (which is now about 2% per year) could double or triple should the market for hydrogen production from nuclear energy materialize. This potential of hydrogen production using nuclear energy lead the IAEA to developthe Hydrogen Economic Evaluation Program (HEEP). HEEP is used for the evaluation of nuclear hydrogen production and economic assessment of comparative studies of various energy sources, potential processes for hydrogen production, and transport and storage of hydrogen production. This CRP aims to improve Member States’ analytical capabilities in the field of the economic evaluation of hydrogen production using nuclear energy and to perform benchmarking of the IAEA HEEP with a view to further improvement and updating of the software.

Project 1.3.2.1	**Techno-economic analysis**
CRP Title:	**Techno-economic Evaluation of Options for Adapting Nuclear and other Energy Infrastructures to Long-term Climate Change and Extreme Weather**
CRP Code:	**I11007**

The emerging impacts of climate change will increasingly modify the weather conditions under which energy installations and infrastructures will operate in the future. Meaningful strategies of sustainable energy development will need to take these impacts into account and find economically efficient solutions to adapt to them. This CRP will address key scientific and policy issues. Participants will explore the most important climate change impacts on their existing and possible future national energy systems, including nuclear installations, and examine the technological and other adaptation options, together with their costs and implications for national energy strategies, by developing, testing and improving a risk assessment framework. The topic is of special importance for developing countries where the fast expansion of energy systems will take place in regions that are likely to be exposed to increasing extreme weather events.

Project 1.3.2.2	**Topical issues related to sustainable energy development**
CRP Title:	**Financing Nuclear Investments**
CRP Code:	**To be assigned**

Compared to other power generation technologies, nuclear energy is competitive on the basis of its low levelized cost. However, large upfront capital costs and long construction times make its financing more challenging compared to fossil fuel investments. This CRP will structure and assess sources of risks pertinent to financing stemming from national energy strategies and policies, power sector structures and nuclear energy regulations. Participants will explore the viability of new financing structures in this broader context and develop possible strategies for managing and mitigating financial risks, which is imperative to secure successful well-structured nuclear financing. The CRP will also provide an opportunity to share experience regarding the financing challenges and opportunities faced by countries that are starting or expanding nuclear power programmes.

Project 1.4.1.3	**Nuclear data for medical applications and analytical techniques**
CRP Title:	**Nuclear Data for Charged-Particle Monitor Reactions and Medical Isotope Production**
CRP Code:	**To be assigned**

The goals of this CRP are to improve the ability of Member States to produce novel positron emitters and selected gamma and alpha emitters of high purity in an efficient manner through precise evaluation of production reaction cross sections and relevant decay data; and to update the charged-particle monitor reaction database. The radionuclides to be studied are aimed at both diagnostic and therapeutic applications.

Project 1.4.1.4	**Atomic, molecular and plasma-material data for fusion experiments**
CRP Title:	**Erosion and Tritium Retention in Beryllium Plasma-Facing Materials**
CRP Code:	**F43020**

This CRP is intended to enhance the knowledge base on fundamental particle–material interaction processes involving beryllium in the fusion plasma environment. The central issues are erosion under regular heat and particle loads from the plasma, tritium retention, and ways to extract trapped tritium. The key processes to be studied are interactions with hydrogen, helium and plasma impurities, the transport of hydrogen in beryllium and modifications of surface microstructures. The CRP will bring together experimentalists and computational theorists that are engaged in studies of plasma–material interactions with beryllium and related mixed materials and of hydrogen migration in solid beryllium.

Project 1.4.2.1	**Enhancement of utilization and applications of research reactors**
CRP Title:	**Development of an Integrated Approach to Routine Automation of Neutron Activation Analysis**
CRP Code:	**F12025**

Enhancement of low and medium power research reactor (RR) utilization is often pursued by increasing the neutron activation analysis (NAA) activities. Whereas the markets for NAA laboratories may have been identified and quality may have been established, an underestimated problem remains the absence of automation, which limits tremendously the analytical capacity. The CRP objective is to coordinate activities on the implementation of automation processes for NAA technique at RR centres. The CRP will have a modular structure in developing the hitherto missing tools for automated data processing and analysis reporting, as well as include design principles, interaction with and control of sample changers. Quality assurance/quality control procedures will be a cross-cutting component. It will strengthen the optimization and competitiveness of the NAA process by harmonizing automation hardware and software, and ultimately result in an increased NAA service capacity.

CRP Title:	**Effective Adaptation of Increased Neutron Flux for Enhanced Utilization of Research Reactors**
CRP Code:	**To be assigned**

Research reactors (RRs) with adapted design and specific modifications may have increased neutron fluxes as a result of increased reactor power, higher core power density, advanced moderator/reflector systems, change of the irradiation channel position, change of the neutron guide, modernized instrumentation etc. The main objective of this CRP is to coordinate activities to ensure the more efficient and enhanced utilization of RRs by increasing/optimizing the neutron fluxes. Such fluxes offer new capabilities for studying material irradiation and fuel testing, radioisotope production, beam line applications, nuclear transmutation doping and various analytical services. The final goal is to establish a network of RR facilities and strong links between experts from different countries enabling them to better develop their technology and methodologies to respond to requests for RR products and services requiring high neutron fluxes.

Project 1.4.2.4	**Research reactor operation and maintenance**
CRP Title:	**Improved I&C Maintenance Techniques using the Plant Computer**
CRP Code:	**To be assigned**

As interest in nuclear technologies continues to rise, facility availability and reliability, as well as limited financial resources, pose challenges for many research reactors worldwide. In addition, the global community of research reactors is expected to decrease in the coming decades as older facilities are shut down and fewer multipurpose facilities are constructed to replace them. Within this context, research reactors in the future will be expected to operate more reliably as fewer facilities work to serve an expanding user base. Research reactor maintenance can be optimized by using the plant computer and operational data. This can reduce maintenance costs and can be used as a tool for lengthening the maintenance intervals. Improvement of maintenance will directly lead to improved operational availability.

CRP Title:	**Assessment of Core Structural Materials and Surveillance Programme of Research Reactors**
CRP Code:	**To be assigned**

The proposed CRP will provide a forum for input and evaluation of relevant materials data and operating experience with research reactors (RRs) to establish a Research Reactor Components and Material Properties Database, to be used by operators and regulators to help predict ageing related degradation, in order to mitigate lengthy and costly shutdowns and to promote safe and reliable operations and lifetime extension. The database will be a compilation of data based on the input from RR scientific centres, comprehensive worldwide literature reviews and experimental data, The data will be provided to all potential end users in Member States to define a structure for future incorporation of new data that become available. In addition, the CRP will specify further activities needed to address the data gaps identified in the database for potential follow-on and the CRP will also define activities required by Member States.

Project 1.4.3.2	**Fostering interdisciplinary developments in accelerator applications**
CRP Title:	**Applications of Intense Neutron Beams for Material Investigations**
CRP Code:	**To be assigned**

Neutron scattering encompasses all scientific techniques whereby the deflection of neutron radiation is used as a scientific probe. Neutrons readily interact with atomic nuclei and magnetic fields from unpaired electrons, making a useful probe of both structure and magnetic order. For many good reasons, moderated neutrons provide an ideal tool for the study of almost all forms of condensed matter. Moderated neutron beams are produced by a slowing-down and thermalization process, which suffers from very low efficiency. Indeed, only few neutrons which enter the moderator will appear in the useful neutron beam direction. The aim is to improve the utilization and productivity of neutron sources at medium and high power facilities by enhancing neutron beam intensities.

Project 1.4.3.3	**Sustainable use of nuclear instrumentation for environmental and other applications**
CRP Title:	**Optimization of Nuclear Instrumentation for Modern Environmental and Industrial Applications**
CRP Code:	**To be assigned**

The unique properties of synchrotron radiation (SR) in combination with the various modalities of photon–matter interactions offer remarkable analytical capabilities including chemical/structural analysis, morphological characterization, and the investigation of the electronic/magnetic properties of materials. Many scientific fields and industrial sectors have been benefited from SR analytical applications: for example, research in the field of energy storage and conversion materials, protein crystallography, the life sciences, pharmaceuticals and biotechnology, semi-conductors, etc. However, nowadays, modern environmental and industrial applications demand even more advanced analytical requirements, as for example the need for elemental/chemical speciation analysis of nanoparticles/nanolayers with nanometer depth resolution. The CRP will explore new analytical and synergistic methodologies of SR based techniques to meet and fulfil the state-of-the art characterization needs required in modern environmental and industrial applications.

Project 1.4.3.4	**Nuclear spectrometry for analytical applications**
CRP Title:	**In situ Characterization of Contaminated Sites Using Nuclear Analytical Techniques**
CRP Code:	**To be assigned**

The objective of the CRP is to develop and assess portable instruments and analytical methods for in situ measurements; to consider quality assurance/quality control (QA/QC) aspects for in situ analysis The CRP will contribute to the enhancement of the analytical capabilities of laboratories in Member States and will extend analytical services in the area of environmental monitoring.

Programme 2.1	**Food and Agriculture**
Project 2.1.1.1	**Soil management and conservation for sustainable agriculture and environment**
CRP Title:	**Agro Ecosystem Carbon and Nutrient Budgeting for Comparative Assessment of Land Resource Sustainability for Food and Bioenergy Production in Different Soil Types and Agro-Ecological Regions**
CRP Code:	**To be assigned**

In view of the rapid increase in global energy demand and the environmental consequences of using fossil fuel, it is necessary to identify renewable and carbon-neutral sources of energy. Bioenergy crops have the potential to increase rural income and improve the environment, while providing renewable energy. Identifying suitable bioenergy crops is essential to any successful implementation of an energy strategy. The objective of the CRP is to identify those bioenergy production systems which can be produced on agriculturally marginal or surplus land, have high biomass production capacity, are environmentally compatible and generate a high proportion of net energy, without competing with food production systems. The CRP seeks to combine efficient water and nutrient management technologies that enhance biomass production of these crops in different agroclimatic zones.

CRP Title: **Soil Quality and Nutrient Management for Sustainable Food Production in Mulch-Based Cropping Systems**

CRP Code: **To be assigned**

Combating land degradation for sustainable intensification of crop production systems requires an integrated soil–water–plant–nutrient management approach to improve crop productivity and at the same time to restore and maintain soil fertility and soil resilience against degradation and climate change. The objective of this CRP is to optimize mulch-based farming systems where crop residues are used in an integrated manner taking into account other factors such as soil fertility, soil quality, nutrient and water resource use efficiency, soil and water ecosystem services and the economic feasibility of mulch farming systems. Mulch-based cropping systems can help to achieve a green revolution in Sub-Saharan Africa, since mulch farming practices may help to reduce fertilizer inputs, improve soil quality, mitigate land degradation and soil erosion and promote climate proof agriculture systems that can adapt to climate change and variability and hence ultimately promote food security and agricultural sustainability.

Project 2.1.1.2 **Technologies and practices for sustainable use and management of water in agriculture**

CRP Title: **Managing Saline Soils through Soil Management and Supplemental Irrigation to Improve Food and Fibre Production**

CRP Code: **To be assigned**

Soil salinity is one of the major causes of low crop productivity in many arid and semi-arid regions around the world. About 20% of irrigated land has been affected by soil salinization and crop yield has been reduced by 20-30%. The global climate change accelerates soil salinization by raising sea levels, and by increasing the frequency of tidal waves and water movement between soil surface and groundwater. The objective of the CRP is to develop innovative soil, water and crop management technologies and practices as well as decision support tools for farmers to enable them to manage and improve crop productivity in salt affected soils and to improve their livelihood and food security.

CRP Title: **Improving Irrigation and Soil Water–Nutrient Management Practices in Integrated Cropping–Livestock Production Systems for Enhanced Food Security and Climate Change Adaptation**

CRP Code: **To be assigned**

Mixed cropping–livestock systems in developing countries support millions of poor people and produce more than 50% of the developing world's livestock and crop commodities. They also provide diversification of income, year-round income and soil fertility improvements. The key challenges for the cropping–livestock systems are to increase the productivity and efficiency of food and feed crops per unit area with the same level of input, to scale up their adoption, and minimizing their impact on climate change through reduced greenhouse gas (GHG) emissions. Strategies based upon sound scientific information to improve water productivity, nutrient use efficiency and GHG emissions are important. The objective of the CRP is to enhance the efficient use of soil, nutrient and water resources for crop and livestock production to enhance food security, and to adapt to and mitigate the effects of climate change.

Project 2.1.1.3	**Crop Improvement for high yield and enhanced adaptability to climate change**
CRP Title:	**Better Adaptation of Crops to High Temperatures Caused by Climate Change and Variability**
CRP Code:	**To be assigned**

Climate change has become a real and pressing global problem. The main adverse impacts of climate change on agriculture will most probably include temperature variability, different rainfall patterns and increasing rates of evaporation. It has recently been estimated that developing countries will bear 70–80% of the costs of climate change damage, with agriculture being the most affected sector. The objective of the CRP is to develop high yielding rice and bean mutant germplasm adapted to the high temperatures expected as a result of climate change and variability over the next 20 to 40 years, resulting in improved resource use efficiency and contributing to sustainable food security.

Project 2.1.1.5	**Integrated soil–water–plant approaches to enhance food production and biomass productivity**
CRP Title:	**Utilization of barley mutant varieties and advanced lines for food and feed in integrated crop–livestock production systems**
CRP Code:	**To be assigned**

The objective of this CRP is to assess and enhance soil and plant resilience to climate change in order to ensure sustainable food and biomass production. At the intersection of food and feed, a large part of residual food crop biomass could be used as fodder and thus improve biomass productivity. Mutant cultivars for improved fodder, i.e. the use of appropriate mutants in breeding, would have beneficial effects on animal nutrition, but may have knock-on effects on soil fertility. Food–feed/dual purpose crops play a key role in smallholder crop–livestock systems, providing food for humans and fodder for livestock at the same time (no additional land and water). Food–feed/dual purpose crops therefore make very efficient use of resources. Crop residues provide the major feed resources for smallholders.

CRP Title:	**Improvement of Biomass Productivity Through Effective Mutation Induction**
CRP Code:	**To be assigned**

The CRP is aimed at developing methodologies to allow rapid screening of mutated crop lines to be selected for improved nutritive value of the crop by-products to improve livestock productivity. These crops should also play a determinant role in improving the water productivity of crop–livestock enterprises and reduce methane emissions by ruminants. Although this CRP will use a limited number of crops, concepts will be developed to provide tools for improving the nutritive value of crop by-products in mutation-assisted, plant breeding programmes, for understanding the impact of these changes in nutritional quality on both plant and livestock physiology, and for evaluating the impact of the genes involved in nutritive quality when introgressed into other food–feed crops.

CRP Title: **Sustainable Productivity and Quality Enhancement of Orphan Crops as Affected by Climate Change and Variability**

CRP Code: **To be assigned**

Orphan/neglected/underutilized crops are a diverse set of crops ranging from cereals such as tef, the millets, grain legumes, such as cowpeas and bambara, root and tubers, such as yam, and indigenous fruits and vegetables, such as quinoa. These crops tend to be of regional or even local importance, being critical for food security for a significant number of poor farmers in developing countries by providing needed calories and nutrients. The objective of the CRP is to generate induced mutants in a range of orphan crops using in vitro and in vivo techniques which would allow for selection and evaluation of new genotypes for breeding. The CRP also aims to incorporate useful mutants in breeding programmes, including breeding programmes in which the farmers participate in order to ensure acceptance and facilitate the release of new varieties.

CRP Title: **Broadening Adaptability to Adverse Effects of Climate Change and Variability Using Integrated Soil–Water–Mutant Crop Integrated Methodologies**

CRP Code: **To be assigned**

Most countries have weather patterns and soil characteristics that constrain crop production over large tracts of land. In addition, the adverse prospects of global environmental variations add to these constraints. Thus, a major challenge is to weatherproof existing crop production systems. In order to make better use of both productive and marginal lands, it is essential to select, evaluate and develop crop genotypes that can flourish under conditions of high temperature, low rainfall, and flooding, or where soils suffer from salinity or acidity or have become nutrient deficient. The objective of this CRP is to broaden the adaptability of food crops to dynamic agroecologies and to foster the application of mutant varieties in crop production in developing Member States.

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

CRP Title: **Early and Rapid Diagnosis and Control of DNA Viruses such as Capripox Virus and African Swine Fever (ASF) Virus**

CRP Code: **To be assigned**

Capripox diseases are economically important ruminant pox diseases which are widespread in Africa, the Middle East, and Asia. They are caused by 3 different viruses which are very close related and cannot be distinguished serologically. African swine fever (ASF) is a highly infectious viral disease of swine. With a mortality rate which can reach 100% of infected animals, it is certainly the most feared swine disease currently. The CRP will aim to validate tests for Capripox virus and promote their transfer to IAEA Member States and to foster the development of new nuclear-based diagnostic test for rapid identification of ASF virus.

CRP Title:	**Use of Stable Isotopes to Trace Bird Migrations and Molecular Nuclear Techniques to Investigate the Epidemiology and Ecology of the Highly Pathogenic Avian Influenza**
CRP Code:	**To be assigned**

Integrating information on wild waterfowl migration through stable isotope analysis (SIA) and detecting avian influenza (AI) viruses in faecal and environmental samples will contribute to understanding the epidemiology and ecology of the long range transmission of AI viruses, using non-invasive methods. The CRP will focus on four main targets: i) SIA in feather samples in order to determine the long range migration pathways of wild waterfowl; ii) detection of AI viruses in faecal samples; iii) DNA barcoding, using faecal samples, in order to determine the bird species; and iv) potential of environmental water samples to transmit AI viruses. Merging information from all four sources should enable non-invasive monitoring of migration pathways, long range AI transmission and simultaneous detection of the bird species, without even capturing the birds.

Project 2.1.3.2	**Traceability to improve food safety and quality and enhance international trade**
CRP Title:	**Isotopic Traceability Techniques for Rapid Responses to Emerging Food Safety Risks**
CRP Code:	**To be assigned**

When a food-borne health incident arises, it is crucial to rapidly determine the origin of the food to eliminate the risk to the population. Conventional traceability systems may be compromised especially where fraud is involved. Stable isotope techniques provide independent information about origins, but are currently too slow for use in a rapid-response context. The objective of the CRP is to develop isotopic traceability systems to facilitate rapid tracking of contaminated products and their removal from the food chain, and related stable and radioisotope techniques that can be applied to detect and characterize emerging food safety hazards and assess and control the risks associated with those hazards.

Project 2.1.4.3	**Management of transboundary livestock insect pests for sustainable agriculture and rural development**
CRP Title:	**Enhancing Vector Refractoriness to Trypanposome Infection**
CRP Code:	**To be assigned**

The sterile insect technique (SIT) relies on the release of sterilized male insects to mate with virgin female insects. In the case of disease vectors, the sterilizing dose that the insects receive does not reduce their vectorial capacity. In the case of tsetse flies, disease transmission has in the past been minimized by adding trypanocidal drugs to the blood meal when feeding them before release. The development of strains that would be refractory to the transmission of trypanosomes would however be a much simpler and hopefully more effective method of ensuring that released sterile flies do not transmit the disease. The objective is to develop any relevant method, including transgenesis, paratransgenesis, and chemical approaches, to significantly improve the SIT for tsetse and other trypanosome vectors.

Project 2.2.1.2	**Sustainable strategies to combat micronutrient deficiencies**
CRP Title:	**Doctoral CRP on Longitudinal Body Composition 0-2 years**
CRP Code:	**To be assigned**

The importance of growth during the "window of opportunity", i.e., from conception to 2 years of age on later health status has been highlighted as a priority area globally. Unfortunately information on changes in body composition during the first two years of life is lacking, and there is very little data on what constitutes normal growth, beyond simple anthropometric measurements of weight and height. These measures do not capture the "quality" of growth in terms of body composition, the relative amounts of fat and lean tissue, which is related to risk of non-communicable diseases in later life. The objective of the CRP is to monitor changes in body composition during the first 2 years of life in infants living in different settings.

Project 2.2.2.1	**Managing chronic diseases with integrated diagnostic imaging modalities emphasizing infectious and cardiovascular diseases, and cancer**
CRP Title:	**Early Breast Cancer Detection by Mammography**
CRP Code:	**To be assigned**

Breast cancer is one of the most widespread cancers in Member States. Usually in developing countries the cancer is detected at a late stage hence the various treatment modalities are able to contribute very little to reducing morbidity and mortality. Mammography is an effective tool for early detection and localization of breast cancer. The objective of the CRP is to build capacity for early detection of breast cancer by optimal use of mammography in Member States.

CRP Title:	**Integrated imaging (SPECT–CT, PET–CT, CT and MRI) in Infection/Inflammation and Spine Pathology**
CRP Code:	**To be assigned**

Infection, inflammation and spine pathologies constitute a significant disease burden in most Member States. As a result of technological advances, SPECT–CT, PET–CT, CT and MRI can be used for the diagnosis and management of these disorders. Each modality has its own merits and limitations in contributing towards overall management. The specific role of each modality needs to be defined for an optimal utilization of the potentials of these nuclear technologies. The objective of the CRP is to define optimal use of SPECT–CT, PET–CT, CT and MRI in the management of infection, inflammation and spine pathology in view of the technological capability and cost effectiveness for Member States.

CRP Title:	**Nuclear Cardiology in Congestive Heart Failure**
CRP Code:	**To be assigned**

Heart failure is generally defined as inability of the heart to supply sufficient blood flow to meet the body's needs. The predominant causes of heart failure are difficult to analyse owing to challenges in diagnosis, differences in populations, and changing prevalence of causes with age. Heart failure may be the result of coronary artery disease, and its prognosis depends in part on the ability of the coronary arteries to supply blood to the myocardium (heart muscle). As a result, coronary catheterization may be used to identify possibilities for revascularisation through percutaneous coronary intervention or

bypass surgery. The objective of this CRP will be to identify a suitable pathway in order to enable early diagnosis of heart failure.

CRP Title: **PET–CT for Radiation Treatment Planning in Cancer**

CRP Code: **To be assigned**

Tumour volume delimitation and viable tissue is being defined through the use of morphological modalities such as computed tomography (CT) that do not provide information regarding the functional aspect. Owing to a lack of appropriate diagnostic imaging tools to evaluate the extension of cancer involvement, the treatment is often not delivered in an appropriate manner. In order to deliver an appropriate treatment, irradiation should precisely target the entire tumour and aim to minimize the size of microscopic extensions of the cancer, as well as minimize radiation damage to normal tissues. A new imaging technique is therefore required to allow precise delineation of the cancer target to be irradiated. The objective of the CRP is to evaluate the impact of 18F-FDG-PET in the planning of radiation therapy treatments. The project will facilitate the generation of an agreement on the use clinical PET–CT combined with the utilization of 18F-FDG in the radiation treatment planning to deliver high dose irradiation to the tumour and reduce unwanted side effects.

Project 2.2.2.2 **Cost-effective use of radiopharmaceuticals in therapy, neurology and paediatric diseases**

CRP Title: **Radionuclide Therapy in the Treatment of Non-Hodgkin's Lymphoma**

CRP Code: **To be assigned**

Nuclear medicine therapy plays an effective complementary role in the overall management of non-Hodgkin's lymphoma. The effectiveness has been shown in many advanced centres of nuclear medicine, but emerging Member States need to benefit from this modality. There are issues associated with the appropriate selection of patients, radionuclide therapy administration, short and long term monitoring of the effects of therapy, and understanding of the complementary role of this therapy vis-à-vis other available treatments. The objective of the CRP is to develop the capacity for appropriate and cost effective use of radionuclide therapy in the treatment of non-Hodgkin's lymphoma in Member States.

CRP Title: **Imaging of Neurodegenerative Disorders with Focus on Parkinson's and Alzheimer's Disease**

CRP Code: **To be assigned**

The prevalence of neurodegenerative diseases (NDDs) increases at an exponential rate with advancing age. This is a worldwide problem as life expectancy is rising. Early and accurate detection and diagnosis of NDDs in ageing populations will facilitate the timely introduction of life style and preventive measures for treatable forms, primarily those involving blood vessels. The objective of the CRP is to introduce and validate the clinical effectiveness of established and new SPECT or PET radiopharmaceuticals for the detection of various NDDs with special emphasis on Parkinson's disease.

Project 2.2.3.2	**Applied radiation biology**
CRP Title:	**Strengthening Biological Dosimetry in Member States**
CRP Code:	**To be assigned**

The objective of the CRP is to strengthen future research in the area of biological dosimetry in order to improve the current techniques and intensify collaboration and networking among the different institutions involved in biological dosimetry. The availability of national and regional biodosimetry programmes/laboratories will be very useful not only in the event of a nuclear disaster, but also for radiation workers in environments with a certain radiation risk and for the general public.

Project 2.2.4.1	**Quality audits in dosimetry for radiation therapy**
CRP Title:	**Development of Quality Audits for Advanced Technology in Radiotherapy Dose Delivery**
CRP Code:	**To be assigned**

The application of advanced technologies in cancer radiotherapy requires precise dosimetry to monitor the dose delivery to patients undergoing treatment. Clinical dosimetry in radiotherapy centres needs to be verified by an independent auditing organization. The IAEA has already developed guidelines for establishing such auditing organizations at the national level and developed a methodology for a range of dosimetry audits, from basic to complex. A new CRP will build on the previous achievements and will develop a new methodology that will enable independent verification of the delivery to cancer patients of radiation therapy using advanced technologies so that the national external audit organizations can develop further. The new CRP will also strengthen quality assurance in radiotherapy and will contribute to increased accuracy in the delivery of radiation doses to cancer patients.

Project 2.2.4.3	**Quality assurance guidelines for medical physics in clinical radiation imaging**
CRP Title:	**Doctoral CRP in Advanced Imaging Modalities**
CRP Code:	**To be assigned**

There is a significant shortage of scientific leaders in the area of imaging in radiation medicine, particularly with the emergence of advanced technologies. Doctoral candidates will investigate various imaging modalities, including diagnostic radiology and nuclear medicine. Diagnostic Radiology studies will focus on high risk investigations such as computed tomography (CT), mammography and paediatric radiology. In nuclear medicine therapy, treatment is currently delivered based upon an administered activity prescription. The failure to account for patient variability can lead to poor clinical outcomes. Developments of techniques for patient-specific internal dosimetry will, therefore, be part of these investigations. The objective of this CRP is to develop high quality capacity in radiation imaging to facilitate the education of new professionals and the appropriate implementation of advanced imaging technologies in Member States.

Project 2.2.4.4	Developments and harmonization of quality assurance in radiation medicine
CRP Title:	**Treatment Related Uncertainties in Image Based Radiation Therapy**
CRP Code:	**To be assigned**

The radiation treatment process involves multiple steps. Modern radiation therapy (RT) has advanced to image based RT. With the use of computed tomography (CT) based treatment planning, physicians need to draw clinical target volumes (CTV) on CT images. A planning target volume (PTV) around the CTV is then introduced to account for uncertainties related to daily set-up, equipment performance and internal organ motion. Various reports have recommended that the margin used to define the PTV should be determined for each individual institution. The objective of the CRP is to quantify and evaluate treatment-related uncertainties in image based radiation therapy. The CRP will contribute to the development of guidelines and recommendations for assessing uncertainties in dose delivery during image based radiotherapy that constitute a part of the quality assurance programme in a radiotherapy department.

Project 2.3.1.1	IAEA isotope data networks for precipitation, rivers, and groundwater
CRP Title:	**Isotopic Indicators of Climate and Land Use Change**
CRP Code:	**To be assigned**

This CRP will result in improving the ability to understand and adapt to the impact of climate change on water resources. Paleoclimate information plays an important role in understanding how climate change affects water resources and ecosystems because modern records are too short to do this adequately. Paleoclimate information is also needed to improve and validate climate models. The isotope compositions of ice, groundwater, carbonate deposits in caves (speleothems), marine sediments, corals, and trees can be used to build long-term paleoclimate records. Existing records need to be integrated and synthesized and data gaps filled with new isotope based records. A related issue is the use of isotopes to benchmark or baseline current climate conditions. One important benchmarking aspect is how changes in climate will affect carbon cycling and fluxes in groundwater, rivers, and overland runoff. As of yet, there has not been a systematic study of riverine carbon fluxes. The use of carbon isotopes in such a study would be very effective because they can be used to identify sources and/or key processes affecting carbon cycling that ordinary concentration measurement cannot identify. In summary, this CRP will incorporate studies using isotopes to integrate and improve paleoclimate records and t carbon isotopes to benchmark fluxes of carbon from freshwater systems.

Project 2.3.3.1	**Characterization of fossil groundwater systems using long-lived radionuclides**
CRP Title:	**The Use of Environmental Isotopes to Assess the Sustainability of Intensively Exploited Aquifer Systems**
CRP Code:	**F33019**

There is a need to assess the sustainability of groundwater extraction in intensively exploited aquifer systems. The objective of the CRP is to assess declining water tables in heavily exploited aquifer systems in terms of groundwater recharge, changes in groundwater flow and age patterns and groundwater quality, through the use of hydrogeochemical and isotope methods, coupled with numerical modelling. Access to new dating tools and approaches for groundwater dating covering different timescales not only offers the possibility to evaluate changes in groundwater dynamics and flow patterns, but also provides key data to predict the evolution of aquifers and their sustainability as major sources of water. This CRP also aims to assess the performance of these new dating tools and approaches and the possible adoption of these methods by water management experts. The results can be used to understand the impact of large scale exploitation of aquifers and to develop future scenarios of water availability for agriculture and drinking water supplies.

Project 2.3.3.2	**Helium and other noble gas isotopes for estimating groundwater recharge and vulnerability to pollution**
CRP Title:	**Environmental Isotopes to Assess Water Quality Issues in Rivers**
CRP Code:	**To be assigned**

The objective of the CRP is to obtain an improved and quantitative understanding of how groundwater discharge directly influences the water quality of our global river and surface water systems. The CRP will test proven and novel stable and radiogenic isotopic approaches to assess and map groundwater and surface water connectivity, evaluate the impacts of groundwater discharge on river water flow and quality, and help improve current riverine management models. The CRP will encourage interdisciplinary application of established and new isotope techniques, with the aim of developing diagnostic stable and radiogenic isotopic tools that can be used in Member States to solve surface water quality issues involving rivers and streams where groundwater impacts are a major factor.

Project 2.4.4.1	**Methodologies for understanding environmental processes in terrestrial, aquatic and atmospheric ecosystems**
CRP Title:	**Environmental Behaviour and Impact of Radioactive Particles**
CRP Code:	**To be assigned**

The objective of the CRP is to enhance Member State capabilities in assessing the long term environmental behaviour and biological effects of radioactive particles released to the environment. The main focus is to provide a link between the radioactive particle releasing sources, the physical/chemical characteristics of the released radioactive particles, and the associated biological responses in the contaminated environment. Radioactive particles are not only representative point sources of potential external radiological significance, but may be incorporated and retained by humans and non-human biota for unexpectedly long periods of time.

Project 2.5.2.1	**Supporting national capacity building to adopt radiation based techniques for industrial process management and compositional analysis of materials/objects**
CRP Title:	**Application of Two and Three Dimensional Neutron Imaging with Focus on Cultural Heritage Research.**
CRP Code:	**F11018**

There is a continuous need from the cultural heritage community for non-invasive characterization of their research objects, which include irreplaceable unique findings recovered from archaeological, palaeontologic, and historical sites. The CRP aims to provide an advanced, comprehensive neutron based imaging approach which will be implemented for the imaging of elemental and phase composition of various objects. It includes the identification of ancient manufacturing technologies, detection of hidden objects, mensuration, authentication, provenance and the identification of the best ways of conservation. The development and harmonization of methodologies will help improve quality control methods in the participating Member States.

CRP Title:	**Radiometric Methods for Measuring and Modelling Multiphase Systems for Process Management**
CRP Code:	**F22060**

Multiphase flow systems are widely used in vast industrial and environmental processes. The fluid dynamic properties of such systems are not yet well understood and hence, it is essential to properly and accurately measure these properties. Since these multiphase flow systems are opaque, radiometric techniques offer the best means of performing such measurements. The main objective of the CRP is to develop and validate integrated nuclear methods for the investigation of multiphase flows and extend these methods to real systems for the evaluation and efficient management of industrial processes in the wastewater treatment, food, petrol, gas and chemical industries. It includes the development of nuclear techniques for measuring the spatial and temporal distribution of each phase in industrial multiphase systems and the development of an integrated methodology for measuring phase flow rates in industrial multiphase flow systems.

Project 2.5.2.2	**Radiation technology support for materials development and Nano science**
CRP Title:	**Application of Radiation Technology in the Development of Advanced Packaging Materials for Food Products**
CRP Code:	**To be assigned**

The prepared convenience food sector has become a significant part of the economy and/or is evolving in many developed and developing countries. Packaging technology underpins the development of this sector and ensures food quality and safety. Radiation processing could provide attractive options for the food packaging industry worldwide. The focus of the CRP is on the application of radiation processing of food packaging material to address food safety and quality challenges. The overall objective is to utilize radiation techniques to develop new packaging technologies, packaging materials and dye printing techniques which are both sustainable and environmentally friendly. This includes both sanitary and phytosanitary applications of food irradiation.

Programme 3.1.	**Nuclear Safety and Security**
Project 3.5.2.2	**Research and development to support the further development of the nuclear security framework**
CRP Title:	**Development of a Nuclear Security Assessment Methodology(NUSAM) for Nuclear Fuel Cycle Radioactive Sources and Associated Facilities and Activities**
CRP Code:	**To be assigned**

This CRP covers the assessment of the security of nuclear and other radioactive materials, as well as associated facilities and activities under regulatory control. The CRP will also explore new approaches to security assessment, consistent with the recommendations, requirements and guidance provided in current publications in the IAEA Nuclear Security Series. The objective of the CRP is to provide a methodological framework for the security assessment of the relevant facilities and activities in a systematic and transparent manner. The CRP will be structured so that the use and applicability of the methodological framework can be illustrated on a practical basis through the use of security test cases. It is expected that the CRP will continue for approximately three years. The CRP will result in the production of a well-documented methodological framework with practical examples of its application. At the end of the CPR one document will be produced that describes each element of the NUSAM framework and the output from each of the working groups; and a second document will be produced that illustrates the application of the NUSAM methodological framework to the security test cases.

CRP Title:	**Identification of High Confidence Nuclear Forensic Signatures for the Development of National Nuclear Forensics Libraries**
CRP Code:	**J02003**

A national nuclear forensics library consists of comprehensive descriptions, and potentially sample archives, of nuclear and other radioactive material produced in, used or stored in a State. This CRP aims to address the data requirements of a national nuclear forensics library for each stage of the nuclear fuel cycle and for the manufacture of radioactive sources. It will promote research into novel signatures that are indicative of processing, that are imparted naturally and that are significant for nuclear forensic interpretation. A fundamental question to be addressed is how nuclear forensics signatures are imparted and how they persist. The results will be used to provide guidance for the development of national nuclear forensics libraries, including the identification of high priority signatures to be included.