IAEA Coordinated Research Activities in 2016

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 as well as on its development and practical applications. The IAEA's programme and budget for 2016 accordingly provide for the placing of research, technical and doctoral contracts and research agreements with universities, colleges, research centres, and 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 €7000 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 (RCMs) at the IAEA's expense.

Agreements may be awarded to institutes, 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 RCMs 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 for the coordinated research activities 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 institute, a formal submission of a project proposal should be made by the institute 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-18/Rev.17 (Jan.16) must be used. Proposals for research agreements should be made using the "Proposal for Research Agreement" form N-21/Rev.15 (Dec.14). These forms are available on the Coordinated Research Activities website: **http://cra.iaea.org/cra/forms.html**.

II. General Conditions of Contracts and Agreements

II.1. Period of Contract or Agreement

As of 2016, research contracts are generally awarded for the entire duration of the CRP (They were previously awarded for a period of one year and 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 **yearly progress report**, which should also contain the proposed programme of work for the following year, and a **final report** at the end of the contract. The positive evaluation of the progress reports by the appropriate Project Officer constitutes the basis for the continuation of the project and payment of the next instalment of the project award. Agreement holders must submit a report at each meeting of the CRP.

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.

Generally funds are obligated when the contract is awarded and subsequently every year upon certification by the Project Officer for the CRP that progress reports have been received in due time and accepted by the IAEA. The final year tranche obligation is split into two instalment payments, one at the beginning of the final year and one at the end of the final year, upon certification by the Project Officer for the CRP that the final report has been received in due time and accepted by the IAEA. 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.

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 2016

Most of the research supported by the IAEA is related to its 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 2016. Additionally, the Coordinated Research Activities website: **http://cra.iaea.org** will list all CRPs open for proposals.

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**.

List of IAEA Coordinated Research Projects That Are Open for Submission of Proposals in 2016

(by Major Programme, Programme and Project)

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[1] AIPS: Agency-wide Information System for Programme Support
[2] AP: IAEA Action Plan on Nuclear Safety

List of IAEA Coordinated Research Projects That Are Open for Submission of Proposals in 2016
(by Major Programme, Programme, and Project)

Major Programme 1: Nuclear Power, Fuel Cycle and Nuclear Science

1.1 Nuclear Power	
Project 1000166	**1.1.5.001 Technology Development for Water Cooled Reactors**
CRP Title:	**Probabilistic Safety Analysis (PSA) for Multi-Unit, Multi-Reactor Sites**
CRP Code:	**2147**
One main conclusion from the International Workshop on Enhancing the Safety of Pressurized Heavy Water Reactors Post-Fukushima: Results of Experimental and Analytical Studies, Ottawa, Canada, 23–25 June 2014, which focused on post-Fukushima research and development status and needs, was the need for improving probabilistic safety analysis (PSA) methodologies applied to multi-unit, multi-reactor-type nuclear sites. Several methods have been proposed and are being developed around the world to extend or 'translate' per-unit PSA results to multi-unit site PSA results, such as core damage frequency and large release frequencies. This CRP would bring together experts from Member States with light water reactors and pressurized heavy water reactors to consolidate their current (and planned) practices, assumptions and results and, if required, develop a new framework for establishing risk factors, such as core damage frequency and large releases from multi-unit, multi-reactor sites, from existing or new PSA studies. Finally, technology solutions to reduce these risks will be explored.	
Project 1000153	**1.1.5.002 Small and Medium-Sized Reactor Technology Development**
CRP Title:	**Design and Performance Assessment of Non-Electric Engineered Safety Features in Advanced Small Modular Reactors**
CRP Code:	**I32010**
The purpose of this CRP is to support global development of advanced nuclear reactor designs, including small modular reactors that incorporate non-electric engineered safety features, such as passive residual heat removal and containment cooling systems and gravity driven core injection. The CRP will take into account lessons learned from major accidents to enhance the designs and the performance of such features to cope with extended station blackout and severe accidents. It will bring together global research and development activities aiming at reactor designs with the highest possible safety levels by substantially reducing both the probability and consequences of severe accidents compared to existing reactors. The CRP will focus on four key topics: (1) separation and independence of reactor trip and safety system actuation logics; (2) diversity and redundancy for depressurizing the reactor coolant pressure boundary to facilitate safety injection during a high pressure transient; (3) diversity and redundancy of core cooling; and (4) options and approaches for assuring containment structural integrity.	

Project 1000154	1.1.5.003 Advanced Technology for Fast and Gas Cooled Reactors
CRP Title:	**Radioactive Release from the Prototype Fast Breeder Reactor under Severe Accident Conditions**
CRP Code:	**I32009**

In a sodium fast reactor (SFR), a hypothetical core disruptive accident (CDA) is the beyond design basis event resulting from the mismatch between power produced and power removed from the reactor, with the simultaneous shutdown system not responding on demand, typically under conditions of either unprotected loss of flow or unprotected transient overpower events. The assessment of the consequences of a CDA in terms of radioactivity release outside the containment system which may affect the environment and the public is of paramount importance from public acceptance point of view, especially after the Fukushima Daiichi accident. The objective of this CRP is to make realistic estimates, through numerical simulation, of the fission product transport mechanisms in typical pool type SFRs and to determine the fission products retained within the reactor primary vessel and ejected into the reactor containment building. The exercise would be carried out for a reference pool type SFR with a capacity of 500 MW(e) fuelled with mixed oxide (MOX) fuel.

1.2 Nuclear Fuel Cycle and Materials Technologies

Project 1000157	1.2.2.003 AP Support Related to Nuclear Power Reactor Fuel
CRP Title:	**Analysis of Options and Experimental Examination of Fuels for Water Cooled Reactors with Increased Accident Tolerance**
CRP Code:	**T12030**

Globally, there is a great deal of experience with the performance of reactor fuel in off-normal conditions. Theoretical studies and experiments have been performed and there have been excursions from normal operating conditions in a few power reactors. During such an excursion, the difference between an incident of limited or no consequence and a severe accident, such the one at Fukushima Daiichi, depends on the conditions in the reactor and the performance of the fuel under those conditions. This CRP will explore the potential to design and operate advanced fuel types that are intended to be more tolerant of severe accident conditions whilst retaining the capability of current fuel designs for safe operation under normal operation and anticipated transient conditions.

Project 100036	1.2.3.001 Spent Fuel Storage
CRP Title:	**Ageing Management Programmes for Dry Storage Systems**
CRP Code:	**T21028**

The continued operation and the ability to eventually retrieve and transport spent fuel in dry storage systems is dependent upon being able to demonstrate that ongoing safety and operability related structures, systems and components (SSCs) are still fit for purpose/compliant with the original safety justification (and assessed against any revision in safety standards).With storage duration continuing to increase as a result of the lack of availability of reprocessing and disposal routes, it is expected that the original licences will need to be renewed and/or the original design life of these systems will be exceeded. As SSCs are subjected to degradation mechanisms and ageing processes, a sound knowledge of how they evolve with time is required. The CRP is aimed at collecting and sharing: up-to-date research and development on SSCs; information on monitoring, inspection and surveillance programmes in support of spent fuel dry storage, and how this information is used in licence or safety justification renewal; and experiences related to the development of ageing management programmes for spent fuel dry storage systems.

CRP Title:	**Spent Fuel Performance Assessment and Research — Phase IV**
CRP Code:	**T13016**
Continued spent fuel storage and future transitions from one phase of the backend of the nuclear fuel cycle to the next require that operational experience and research results be reported and disseminated to the Member States for input to continued operations safety assessments and the licensing of new facilities. In this respect, the CRP "Spent Fuel Performance Assessment and Research" (SPAR) has supported this requirement through the reporting of ongoing performance and research on the behaviour of power reactor spent fuel and materials in wet and dry storage. In looking forward, a number of participants of the SPAR project indicated that they would be continuing their research activities to bridge knowledge gaps in relation to existing fuel behaviour, as well as carrying out further research and development to underpin new facilities and dry storage systems and in support of fuel types being transitioned from a recycling strategy to direct disposal. A continuation of the project to report on these activities and to continue to collect and report fuel and system performance experiences, especially from the deployment of new technology, is proposed.	
Project 1000137	**1.2.3.003 AP Support Related to Spent Fuel**
CRP Title:	**Management of Severely Damaged Spent Fuel and Corium**
CRP Code:	**T13015**
The Fukushima Daiichi accident (March 2011) resulted in severe damage and reported fuel core meltdown in three of the reactors on the nuclear power plant site. A fourth reactor, although it could be shut down, suffered severe damage to its structure from a hydrogen explosion, which resulted in plant and roofing materials being deposited in the fuel storage pool. The fuel in this pool may also have been damaged due to loss of cooling water and the introduction of seawater as a replacement. In terms of multiple failures, an accident of this scale has not been experienced previously, and this gave rise to a substantial remediation challenge. The objective of this CRP is to expand the existing knowledge base and identify optimal approaches for managing severely damaged spent fuel. Severely damaged spent fuel covers: material from post-irradiation examination; fuel debris; fuel damaged during fuel handling operations; fuel damaged as a result of loss of cooling; corium; and molten core–concrete interaction products.	
Project 1000002	**1.2.4.001 Predisposal Management of Radioactive Waste**
CRP Title:	**Processing of Alpha Bearing Waste**
CRP Code:	**2104**
The objective of this CRP is to provide a network of parties interested in sharing their experience and developments relating to treatment and conditioning processes for alpha bearing, long lived and problematic waste streams. The project is directly aimed at promoting waste minimization, effective storage (including long term storage), and the development of new technologies for processing of radioactive waste streams (including disused sealed radioactive sources) of different activity levels and physical states.	
1.3 Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development	
Project 1000047	**1.3.2.002 Topical Issues Related to Sustainable Energy Development**
CRP Title:	**Assessments of the Potential Role of Nuclear Energy in National Climate Change Mitigation Strategies**
CRP Code:	**I12006**
This CRP will coordinate research efforts by Member States, supported by in-house activities, on the assessment of the potential role of nuclear energy in mitigating climate	

change. It will draw on background material prepared by the IAEA Secretariat, on scientific and technical support from the IAEA, and on the experience of the Member States in decarbonizing their electric power supply. The investigations will focus on the assessment and effectiveness of support mechanisms (i.e. domestic policies, carbon pricing) recognized in the Paris Agreement under the United Nations Framework Convention on Climate Change (December 2015) in order to identify key barriers and develop approaches to address investments in low carbon technologies, including nuclear. A set of analytical IAEA tools or Member States' own models or tools will be combined, tested and applied to assess the potential role of low carbon electricity generation projects, including nuclear, within long term national greenhouse gas mitigation strategies. The variety of starting points and national circumstances will provide an invaluable opportunity for both developed and developing Member States to share information when identifying least-cost decarbonization strategies.

1.4 Nuclear Science	
Project 1000161	**1.4.1.002 Nuclear Data Developments**
CRP Title:	**Recommended Input Parameter Library (RIPL) for Fission Cross Section Calculations**
CRP Code:	**F41033**
The aim of this new CRP is to obtain a comprehensive set of input parameters (and corresponding uncertainties) for the modelling of fission cross sections for actinides, based on microscopic and phenomenological approaches. Significant improvement in fission modelling will result in improved estimates of cross section values and associated uncertainties for nuclear energy applications.	
CRP Title:	**Nuclear Data Processing for Applications**
CRP Code:	**2142**
This CRP will address the preparation of nuclear data libraries for particle transport, activation, radionuclide production, uncertainty propagation and other applications starting from basic evaluated nuclear data files. The objective of the project is to provide users with data processing capabilities and/or up-to-date data libraries in formats suitable for use in specific applications.	
CRP Title:	**Updating the Photonuclear Data Library and Generating a Reference Database for Photon Strength Functions**
CRP Code:	**F41032**
Photonuclear data and photon strength functions are important for a wide range of energy and non-energy applications, including reactor technologies, radiation safety, management of nuclear waste, medical physics, and materials science. The aim of this CRP is to update the existing IAEA Photonuclear Data Library and generate a new database of photon strength functions. The tasks include a revision of evaluated photonuclear data using new published data and improved evaluated methods, compilation and assessment of experimental data used to derive photon strength functions, and evaluation of photon strength functions with the aid of theoretical models. All the experimental, evaluated and theoretical data will be made available to the user community through online databases.	

Project 1000121	1.4.1.003 Atomic and Molecular Data Developments
CRP Title:	**Data for Charge Transfer Processes Related to Neutral Beams in Fusion Plasma**
CRP Code:	**F43023**
Neutral beam injection is used to heat the plasma in fusion devices. Neutral beams also have diagnostic purposes, both via photoemission from the neutral beam following interaction with the plasma and via photoemission from plasma impurities after interaction with the beam. Modelling of beam penetration into the plasma and of spectroscopic signals relies on detailed data for atomic processes that involve the neutral beam particles. In spite of the importance of the data, there are significant gaps, especially related to processes starting from an excited state of the neutral atom. For processes starting from the ground state of the neutral atom there are often several families of data, obtained using different approximations or experimental methods. The CRP is intended to provide evaluated and recommended data for the principal atomic processes relevant to heating and diagnostic neutral beams in fusion plasmas.	
CRP Title:	**Plasma–Wall Interaction with Reduced Activation Steel Surfaces in Fusion Devices**
CRP Code:	**F43022**
Various kinds of reduced activation steel are being considered as wall material for a fusion reactor, but not enough is known about plasma–wall interaction, erosion and tritium retention in such steels. Erosion brings impurities into the plasma and limits the lifetime of the wall. Hydrogen penetration and retention in the surface remove tritium from the plasma, making it unavailable for fusion. This CRP will enhance the knowledge base and develop new databases on the interaction of fusion plasmas with reduced activation steel alloys that are being considered for fusion devices. The CRP will seek to quantify the erosion due to exposure to plasma and to quantify the retention and transport properties of tritium in the surface.	

Project 1000069	1.4.2.003 Addressing Research Reactor Fuel Cycle Issues
CRP Title:	**Accelerator-Driven System (ADS) Applications and Use of Low Enriched Uranium in ADSs**
CRP Code:	**T33002**
The proposed work to be undertaken within the framework of the present CRP will focus on the development of innovative applications for accelerator-driven system (ADS) facilities as well as on further development and validation of ADS technologies. Among the applications to be explored will be the use of ADS facilities to transmute nuclear waste (specifically, long lived fission products and minor actinide materials generated during the operation of nuclear power reactors), and the development of robust techniques for on-line monitoring of ADS facilities. Attention will also be given to investigating the potential for use of ADS facilities as neutron sources for basic and applied research, and for the production of radioisotopes needed for medical and industrial applications. A strong emphasis will be placed on the use of low enriched uranium fuel in the ADS facilities to be considered.	

Project 1000162	1.4.3.001 Fostering Accelerator Applications in Multiple Disciplines
CRP Title:	**Accelerator Simulation and Theoretical Modelling of Radiation Effects — SMoRE-II**
CRP Code:	**T14003**
In order to develop structural materials for advanced reactor concepts and life extension of existing reactors, a new paradigm for irradiation testing of candidate materials is required. This new paradigm is accelerator-based ion irradiation. The determination of its efficacy will	

be accomplished through the use of standardized testing, to establish confidence in ion irradiation results between various laboratories, and to verify agreement between neutron and ion irradiated property-controlling microstructures. In doing so, several important questions regarding the behaviour of materials under irradiation will be addressed, including: understanding the dose rate effect of accelerator irradiations; understanding the primary damage state of different irradiation conditions; and investigation of microstructure changes during the incubation period (e.g. of void swelling). In comparing ion and neutron irradiated property-controlling microstructures, the following will be addressed: determination of analysis procedure and criteria for comparing ion irradiation to neutron irradiation; conducting ion irradiation of previously neutron-irradiated materials; conducting very high dose/high-temperature ion irradiations for future reactor applications; and comparing ion and neutron irradiation within a steady state microstructure. A round robin experiment to fabricate and distribute selected materials for ion irradiation and post-irradiation examination will be a focus of this CRP. In addition to the scientific knowledge gained regarding the behaviour of the specific candidate materials under irradiation, it is through this mechanism that (i) the degree of interlaboratory variation will be quantified; and (ii) a direct comparison of the effects of ion beam and reactor irradiations on materials will be made. Simulation and modelling of the effects of irradiation are expected to support the interpretations of the experiments. The results from this CRP should lead to recommendations for best practices in the use of ion beam research for the emulation of in-reactor damage to materials.	
Project 1000165	**1.4.4.001 Nuclear Fusion Research and Technology**
CRP Title:	**Towards the Standardization of Small Specimen Test Techniques for Fusion Applications**
CRP Code:	**2121**
Small specimen test techniques (SSTTs) are required to generate material irradiation test data for the design, licensing, construction and safe operation of the next step fusion devices. The use of small specimens has become mandatory for the production of reliable and coherent databases due to the limited volume available for irradiation of specimens in materials testing reactors as well as the planned dedicated fusion neutron sources The objective of this CRP is to establish procedures for standardization of the SSTT to be used for determining relevant mechanical properties needed in the design of next step fusion machines.	
CRP Title:	**Utilization of the Network of Small Magnetic Confinement Fusion Devices for Mainstream Fusion Research (Phase 2)**
CRP Code:	**2161**
Small magnetic confinement fusion devices such as tokamaks, stellarators and others have played and continue to play an important role in fusion research. Thanks to their compactness, flexibility, low operation costs and the high skill of their personnel they contribute to a better understanding of phenomena in a wide range of fields. This CRP seeks to take advantage of an existing network of small magnetic confinement fusion devices to perform joint and comparative experiments to support technology development, modelling analysis and the development of simulation and communication tools. The CRP aims to contribute to enhancing international collaborations and increasing the impact of the small magnetic confinement community. This will open the door for more Member States to join the research efforts and contribute to the success of magnetic confinement fusion.	

Major Programme 2: Nuclear Techniques for Development and Environmental Protection	
2.1 Food and Agriculture	
Project 2000011	**2.1.2.001 Improving Animal Production and Breeding**
CRP Title:	**Application of Nuclear and Genomic Tools to Enable for the Selection of Animals with Enhanced Productivity Traits**
CRP Code:	**D31028**
The world will be facing the challenge of a manifold increase in the production of food from animal origin to address the high demand that is expected to arise from population growth, income increases and urbanization. Breeding for robust animals with production systems optimized for exponential increase in productivity while retaining their adaptability to harsh environments and tolerance to tropical diseases could remain the only option for the intensification of livestock production with the least possible environmental impact. This project is aimed at enhancing animal breeding with the application of nuclear and nuclear-derived molecular techniques to address two major issues prevailing in developing countries. Firstly, to enable breeders to deliver an effective artificial insemination service where sires will be selected based on data on performance and parentage and genetic admixture of pedigree animals. Secondly, cobalt-60 will be applied to develop a radiation hybrid panel for whole genome sequencing and identification of breeding markers in camels. The project is expected to: develop an animal identification system along the artificial insemination service in place and 1000 performance recorded animals per breed/population from each country as a foundation for sire selection; develop a gene bank of performance recorded animals in participating countries for making good breeding decisions; validate genetic tools for testing parentage, relationship and admixture level; develop whole genome radiation hybrid panels for camels; develop a set of performance data for animal breeds/population in different production systems and deliver standard operating procedures, protocols and guidelines for use of genetic tools in animal breeding and assisted reproductive technologies. The project will be running five years and will involve ten research contract holders from developing countries together with technical contract and research agreement holders from laboratories engaged in high level animal genetics, breeding and the delivery of artificial insemination services.	
Project 2000012	**2.1.2.002 Decreasing Transboundary Animal and Zoonotic Disease Threats**
CRP Title:	**Early Detection of Transboundary Animal Diseases (TADs) to Facilitate Prevention and Control through a Veterinary Diagnostic Laboratory Network (VETLAB Network)**
CRP Code:	**D32032**
Early and sensitive detection of animal diseases is based on the use of established nuclear and nuclear derived techniques for the identification and characterization of the disease causative pathogens (or parts of the pathogens). International harmonization is key when diagnostic techniques are to be disseminated in Member State laboratories. To support the harmonization of the established diagnostic techniques, the CRP aims to produce immunological and molecular references and standards for diagnostic purposes, which will be later distributed to Member State laboratories (through the IAEA's technical cooperation (TC) programme) for harmonization purposes. Techniques which allow for the differentiation of syndromic diseases (such as respiratory or gastro-intestinal diseases) are of the utmost importance for clarification of disease outbreaks, because they can be used not only to confirm/exclude the presence of a particular disease but also to clarify the cause of a particular outbreak. The CRP will contribute towards the development, verification and,	

potentially, wider application of such detection platforms in Member States.
Technologies for advanced understanding of the pathogens circulating in specific geographical regions, such as genetic sequencing, are essential for in-depth understanding of the disease epidemiology. Moreover, sharing of the generated data on open global platforms, such as the PubMed database hosted by the US National Center for Biotechnology Information (NCBI), may significantly enrich the knowledge of the global scientific/research community and thus contribute to the efforts for global control of priority animal and zoonotic diseases, such as avian influenza, peste des petits ruminants, foot-and-mouth disease and others. In order to give Member State laboratories access to sequencing services, as well as to compile the generated data on a single information platform, the IAEA, through its Animal Production and Health Section (APHS), has established a draft protocol for the preparation, submission, analysis, interpretation and sharing of data generated using genetic sequencing of priority pathogens. The protocol is included in the CRP as a draft standard operating procedure (SOP) for scientific review, gap analysis and definition of improvement targets, in order to enable its wide dissemination to Member State laboratories through the IAEA's TC programme. Finally, in order to ensure the consistency of the data obtained with the techniques used in the CRP, as well as with other relevant SOPs used for the detection of priority diseases, a review and selection of the priority SOPs will be performed, for uploading on the APHS's online information platform. The platform will be available to all counterparts from Member States for capacity building and technology transfer purposes through the IAEA's TC programme.
The CRP will utilize nuclear and nuclear derived techniques, such as the serological based enzyme linked immunosorbent assay and the polymerase chain reaction, as the basis for early detection of the priority diseases. Additionally, gamma rays (cobalt sources) will be used for inactivation of the biological materials.

CRP Title:	**Quantification of Intake and Diet Selection of Ruminants Grazing Heterogeneous Pasture Using Compound Specific Stable Isotopes**
CRP Code:	**D31029**

Optimization of the utilization of grassland that also include rangeland by livestock growers would benefit many millions of farmers in the world since 40.5% of the terrestrial area, excluding Greenland and Antarctica, is covered by grasslands, which are important as a feed source for livestock. The project aims to develop a practical method to predict pasture intake of ruminants grazing heterogeneous pastures and grassland using stable isotopes, in order to provide tools for better grassland management that enhances animal productivity and reduces the impact on the environment due to overgrazing, and to allow the design of effective feed supplementation strategies at the farm level to optimize animal production. Three major laboratory activities are planned: (a) the analysis of concentrations and stable carbon isotope composition of n-alkanes in plant and faecal samples to predict dry matter (DM) intake and its plant proportions; (b) the use of conventional chemical analysis of plants to determine their nutritional value; and (c) the development of near infrared reflectance spectroscopy (NIRS)-derived predictive equations of DM intake and the plant profile of that intake. The equation once developed using data from stable isotope analyses, NIRS and conventional feed analyses will have the potential to predict the intake of DM and plant population only on the basis of NIRS values of the plants and faeces. This will facilitate the design of diets and supplements required to cover the nutritional needs of animals so as to achieve the expected production levels. The combination of the three techniques applied to plant and faecal samples obtained in a common research protocol used by all participating countries will allow the scientific objectives of the CRP to be attained. The project will run for five years and will involve seven research contract holders from developing countries together with technical contract and research agreement holders from laboratories engaged in the use of stable isotopes and advanced techniques for measuring the nutritional feed value of plants.

Project 2000016	2.1.3.001 Food Irradiation Applications Using Novel Radiation Technologies
CRP Title:	**Use of Irradiation to Prevent Foodborne Parasitic Infections Associated with Fresh Fruits and Vegetables**
CRP Code:	**2156**
Parasites are a significant endemic problem affecting public health and increasingly associated with raw produce. Few processing technologies are capable of inactivating parasites without affecting the fresh character of fruits and vegetables. Irradiation, as a cold treatment, can play an important role in controlling parasitic foodborne illnesses, but the effectiveness of this technique against parasites found in fresh produce is not well known. The objective of this CRP is to develop irradiation and combination treatments that along with smart packaging will be effective against key parasites associated with fresh fruits and vegetables without adversely affecting quality. A team of four consultants has recommended that the Food and Environmental Protection Section of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture implement this CRP within the next five years to investigate the capability of such treatment methods to reduce the parasitic disease burden among the Member States.	

Project 2000031	2.1.5.001 Mutation Induction for Better Adaptation to Climate Change
CRP Title:	**Mutation Breeding for Resistance to *Striga* Parasitic Weeds in Cereals for Food Security**
CRP Code:	**D25005**
The parasitic weeds *Striga asiatica* and *S. hermonthica* are major biological constraints to cereal production in most of sub-Saharan Africa and in the semi-arid tropical regions of Asia. Yield losses are mainly in maize, millet, rice and sorghum and are most severe on marginal lands of subsistence farmers. The unique biology of *Striga*, tightly adapted to its crop hosts, limits control options. Because subsistence farmers either cannot afford or do not have access to inputs, host plant resistance is a vital part of *Striga* control. Resistance traits, however, are lacking in most cereal varieties sown in *Striga* prone areas. This CRP proposes the use of physical mutagenesis and associated screening technologies to broaden the genetic base of resistance. The project seeks to link cereal improvement programmes in the Member States with biologists working on *Striga* and with IAEA staff. This would combine expertise for screening in the field, greenhouse and laboratory to enhance mutation breeding so as to develop or adapt screening packages that can be used to generate novel sources of *Striga* resistance. The initial focus will be on sorghum and rice because of their importance to food security and their amenability to mutation breeding techniques. Up to ten research contracts are expected to be awarded and five no-cost agreement holders from advanced laboratories and research institutes with recognized expertise in the targeted technologies will be invited to share their experience with the contract holders and contribute to the development and validation of the planned technical packages. In addition, it is foreseen that two technical contracts will be awarded for services in advanced areas such as marker development and advanced efficiency enhancing technologies and mutant characterization. Coordination and technical management will be handled by the Scientific Secretary in the IAEA's Plant Breeding and Genetics Laboratory/Section.	

2.2 Human Health	
Project 2000010	**2.2.1.001 Health Effects of Nutrition and the Environment**
CRP Title:	**Growth of Malnourished Children**
CRP Code:	**2124**
In recent years, nutrition has risen to the top of the policy agenda in most developing countries. Undernutrition impedes cognitive development, education performance and productivity, undermining the development of nations. During infancy and early childhood, inappropriate feeding practices, nutrient deficiencies and frequent infections result in underweight and stunting, which affect about 171 million children under five years of age in low and middle income countries. A new CRP is proposed that will use stable isotope techniques to provide useful information on the impact of nutrition programmes aimed at improving the nutritional status and health of malnourished children. There is strong evidence linking early life undernutrition with increased risk of adult non-communicable diseases (NCDs), including cardiovascular disease, diabetes and cancer. The deuterium dilution technique can be used to assess changes in body composition as an indicator of nutritional status, as well as of healthy growth. The objectives of the CRP will be to evaluate programmes designed to prevent and treat malnutrition in children by assessing changes in body composition following recovery. This objective will be met by monitoring growth, risk factors for NCDs, such as waist circumference and blood pressure, and body composition (the relative amounts of fat and fat free mass) in children recovering from malnutrition, compared to those who have never been malnourished.	
CRP Title:	**Application of Stable Isotope Techniques in Environmental Enteric Dysfunction Assessment and Understanding Its Impact on Child Growth**
CRP Code:	**2136**
Micronutrient absorption (bioavailability) from foods has important implications on child growth and development. Retarded linear growth, widely referred to as stunting, is rampant in low and middle income countries, affecting a total of 161 million children under the age of five years; it develops in the first 1000 days of life, and becomes irreversible if no appropriate interventions are in place. The consequences of stunting include increased infant and child mortality and morbidity; increased risk of overweight, obesity and non-communicable diseases later in life; and low psychomotor development and lost economic potential. Inadequate nutrition and recurrent infection are the primary drivers of stunting. However, evidence now shows that all known nutritional interventions combined may only partially prevent stunting. Poor hygiene and absence of adequate sanitation may play a role, but evidence to support a causal relationship is largely lacking. Living in poor sanitary conditions may induce gut dysfunction, referred to as environmental enteric dysfunction (EED). Despite the significance of EED to infant and child nutrition and health, biomarkers and simple diagnostic techniques for the definition and classification of EED are lacking. The gold standard for diagnosing EED, intestinal biopsy, is too invasive. Using stable isotopes has significant potential in improving our understanding of EED and potentially could provide a non-invasive diagnostic test. Gastro-intestinal damage may result in reduced digestive/absorptive intestinal capacity, raised small and large intestinal permeability with the result that nutrient bioavailability is critically reduced. This CRP aims to explore the role of stable isotope techniques in the generation of an evidence base for a better understanding of EED and its impact on child health and nutrition.	

Project 2000015	12.2.2.001 Nuclear Medicine in the Diagnosis and Therapy of Non-communicable Diseases
CRP Title:	**PET–CT in the Evaluation of Locally Advanced Breast Cancer**
CRP Code:	**E13044**

Locally advanced breast cancer (LABC) is a leading cause of cancer related morbidity and mortality in many Member States. In many low and middle income countries approximately 45% of patients present with LABC, and most of them undergo neoadjuvant chemotherapy (NAC), which is defined as any pharmacological treatment given before primary therapy (surgery), and administered for 4 to 6 months, with an intent to downstage (reduce) the tumour so that patients can become candidates for surgery. Mammography and ultrasound are the diagnostic imaging modalities most commonly used for the initial evaluation of LABC, whilst magnetic resonance imaging (MRI) is used to establish the extent of the disease and for the assessment of NAC response. Fluorine-18 fluorodeoxyglucose (^{18}F-FDG) positron emission tomography–computed tomography (PET–CT) is a functional imaging modality which has shown similar efficacy to MRI in NAC assessment in multiple single-centre, small studies. In the last few years, a new dedicated PET scanning technique for the breast known as positron emission mammography (PEM) has emerged as a promising imaging modality. This modality offers higher special resolution than regular PET and the equipment is less expensive. It can be used for assessment of the response to NAC. No multicentric, multinational prospective comparative studies to establish the efficacy of MRI versus whole body PET–CT and versus dedicated breast PET have been published yet. Efficacy is defined as the capacity for beneficial change of a given intervention. This CRP aims to prospectively investigate the diagnostic accuracy of MRI versus whole body PET–CT and dedicated breast PET (PEM) for assessment of response to NAC in locally advanced breast cancer patients with pathologic response as the reference standard. Accurate pathological diagnosis of tumour mass before treatment and careful examination of specimens after treatment are two main objectives in the diagnostic process of neoadjuvant-treated breast cancer. To achieve the first objective, multiple core biopsies can be taken to assess intra-tumour heterogeneity. This three-year CRP will be organized by the Nuclear Medicine and Diagnostic Imaging Section within the IAEA’s Division of Human Health. In order to be able to select the research centres that have the required infrastructure to participate in the project, a survey that must be completed by centres interested in participating has been developed and should be completed by applicants.

CRP Title:	**Use of PET–CT with Gallium-68 Labelled Prostrate Specific Membrane Antigen in the Diagnosis and Follow-up of Patients with Prostate Cancer**
CRP Code:	**2150**

This CRP will focus on the appropriate use of molecular imaging using prostate-specific membrane antigen (PSMA) labelled with gallium-68 (^{68}Ga) for the evaluation and follow-up of patients diagnosed with prostate cancer. Positron emission tomography–computed tomography (PET–CT) with ^{68}Ga-PSMA is a molecular imaging technique that has shown promising results for the initial evaluation and follow-up of patients diagnosed with prostate cancer. The purpose of this project is to evaluate the role and accuracy of ^{68}Ga-PSMA–PET–CT in comparison to magnetic resonance imaging (considered to be the standard of care at the moment) for the evaluation of patients with prostate cancer as well as its impact on the management of this group of patients.

CRP Title:	**Comparison of Planar Multiple Gated Acquisition (MUGA) Scanning, Single Photon Emission Computed Tomography–MUGA and Echocardiography in the Evaluation of Chemotherapy Related Cardiotoxicity**
CRP Code:	**2158**
This CRP will focus on the comparison of planar multiple gated acquisition (MUGA) scanning versus single photon emission computed tomography (SPECT)–MUGA versus echocardiography in the evaluation of patients undergoing chemotherapy with potentially cardiotoxic effects, such as anthracyclines and monoclonal antibodies (trastuzumab). Anthracyclines, such as doxorubicin and idarubicin, remain an important class of chemotherapeutic agents. Unfortunately, their efficacy in treating cancer is limited by a cumulative dose dependent cardiotoxicity, which can cause irreversible heart failure. We can see the same collateral effects with monoclonal antibody-based chemotherapy such as trastuzumab. Ventriculography is the method of choice to evaluate cardiac functional parameters. There are nuclear based techniques, such as planar MUGA and SPECT–MUGA, that have been used for many years to assess the left ventricular ejection fraction (LVEF) among other parameters that can indicate the cardiotoxicity associated with the therapy and lead to withdrawal of the ongoing treatment. In recent years, non-nuclear techniques, such as echocardiography, have been used increasingly instead of MUGA studies. However, a comparison of the two modalities in terms of their accuracy in evaluating the LVEF has not been undertaken. The focus of this study will be to compare head to head the accuracy, reproducibility and reliability of these techniques for the early detection of cardiotoxicity in patients with breast cancer.	
Project 2000024	**2.2.3.001 Clinical Radiation Oncology**
CRP Title:	**Modern Radiotherapy Techniques in Cervical Cancer**
CRP Code:	**2137**
Brachytherapy is mandatory for the radical treatment of cervical cancer. This CRP will produce an economic model for high dose rate (HDR) brachytherapy in cervical cancer, including resources needed and costs based on the activity costing model. It will also validate the model in centres migrating from two-dimensional (2-D) film based HDR brachytherapy to three-dimensional (3-D) HDR brachytherapy based on computed tomography or magnetic resonance imaging. The CRP will begin with a large-scale survey of brachytherapy practice at centres of all income levels, followed by a detailed study of resources, costs, and times needed to implement 2-D and 3-D brachytherapy in different settings. The economic model will be produced with this data and the third phase will consist of the validation of the model in a number of centres adopting 3-D brachytherapy following certain criteria proposed by the economic model. Once validated, the model will allow new users to precisely calculate resources needed, costs, and predicted productivity of 3-D brachytherapy.	

Project 2000042	2.2.3.002 Biological Effects of Radiation
CRP Title:	**Clinical Applications of Biodosimetry**
CRP Code:	**2109**

Biological dosimetry is a powerful tool that uses markers of biological damage induced by ionizing radiation to estimate the radiation dose absorbed by an individual. The main aim of the project is to establish a network of biodosimetry laboratories conducting research on the clinical applications of biological dosimetry techniques. Specifically, the objective is to strengthen the role of biodosimetry in clinical radiation oncology for patient selection and in post-treatment phases. Biological markers in clinical radiation oncology can help in many areas, such as predicting tumour and normal tissue radiotherapy response. Furthermore, collaborative networks and codes of practice in clinical biodosimetry will be developed within the framework of the project. Developing clinical applications of biodosimetric methods would allow Member States to benefit from a better, personalized medical service. The project will also help countries to maintain and strengthen their expertise in accidental biodosimetry. The proposed project duration is four years (2017–2020).

Project 2000029	2.2.4.003 Clinical Medical Radiation Physics
CRP Title:	**Dosimetry in Molecular Radiotherapy for Personalized Patient Treatments**
CRP Code:	**2117**

Molecular radiotherapy has demonstrated unique therapeutic advantages in the treatment of an increasing number of cancers. As with other treatment modalities, there is related toxicity to a number of organs at risk. The clinical benefit of performing dosimetry has now been demonstrated for a number of nuclear medicine therapies. However, propagation of dosimetric methods into nuclear medicine practice has been slow and considerable uncertainties in the dose estimation still remain. Harmonized dosimetric protocols and methodologies should guide a personalized patient treatment with the aim of improving efficacy and reducing toxicity. The main objective of the CRP is to contribute to the standardization of dosimetric methods in nuclear medicine. Specific objectives are to assist Member States in testing and adopting harmonized dosimetric protocols and to assess the typical accuracy with which dosimetry can be performed in nuclear medicine practice.

<table>
<tr><td colspan="2">2.3 Water Resources</td></tr>
<tr><td>Project 2000063</td><td>2.3.3.001 Characterization of Fossil Groundwater Using Long Lived Radionuclides</td></tr>
<tr><td>CRP Title:</td><td>Use of Long-lived Radionuclides for Dating Very Old Groundwaters</td></tr>
<tr><td>CRP Code:</td><td>F33023</td></tr>
<tr><td colspan="2">This CRP addresses the use of new tools for estimating the age of very old groundwaters (> 50000 years), which is one of the most elusive hydrological parameters to assess in the case of groundwater resources. With an increasing population and the potential impact of climate change, groundwater extracted from deeper horizons is becoming the most important freshwater resource in many areas. Despite the significance of age information for water resources, waste management, subsurface reactive transport, and palaeoclimate, this parameter is always very difficult to assess. Additionally, comprehensive dating tools are not often available to many Member States. The main focus of this new CRP will be the implementation of several isotope hydrology assessments of deep/large aquifer systems using long lived radionuclides, isotope age tracers and noble gases (carbon-14, krypton-81, chlorine-36, helium-4, etc.). These techniques are either hard to access or to implement in many Member States. Following the recent increase in the analytical capacity of the IAEA's noble gas facility, this CRP will provide the possibility to improve Member States' capabilities in the assessment of deep groundwater systems by offering the combined use of the palaeo-temperature estimates from isotopes of neon, argon, krypton and xenon and the age dating by helium-4 cross-calibrated with other isotope techniques. Other noble gas isotopes, such as krypton-81, will also be analysed in selected samples. The case studies to be conducted as part of this CRP will provide a unique dataset and excellent information for expanding the use of these age dating tracers to technical cooperation projects aimed at assessing deep aquifer systems in Member States.</td></tr>
<tr><td>Project 2000064</td><td>2.3.3.002 Noble Gas Isotopes for Groundwater Recharge and Pollution Studies</td></tr>
<tr><td>CRP Title:</td><td>Use of Isotope Hydrology to Characterize Groundwater Systems in the Vicinity of Nuclear Power Plants</td></tr>
<tr><td>CRP Code:</td><td>F33022</td></tr>
<tr><td colspan="2">Nuclear energy remains the largest source of low carbon electricity in the world. Although the site selection and operation of nuclear power plants (NPPs) follow strict safety guidelines, there is always the possibility of unforeseen accidents such as the Great East Japan Earthquake of 11 March 2011, which triggered an extremely severe nuclear accident at the Fukushima Daiichi NPP, resulting in the release of radioactive materials into the environment and the contamination of groundwater. The main focus of the CRP is to develop guidelines for comprehensive characterization of local and regional groundwater systems in the vicinity of NPPs by using isotope techniques. The CRP aims to use newly developed isotope tools, including those based on noble gases isotopes, to provide better information on the dynamics of very fast and/or very slow moving groundwater near NPPs that will assist in controlling contamination of water resources in case of unforeseen incidents.</td></tr>
</table>

2.4 Environment	
Project 2000131	**2.4.2.001 Isotopic Tools to Study Climate and Environmental Change**
CRP Title:	**Application of Nuclear Analytical Techniques to Marine Environmental Studies of Climate Trends and Variability**
CRP Code:	**K41015**

This CRP is a fundamental contribution to the IAEA's programme on the use of nuclear techniques to understand climate and environmental changes. Climate projections rely on knowledge of the basic processes responsible for climate variability and the calibration and/or validation of climate models. For this, climatologists study environmental climate records, such as those found in corals and sediments. The use of nuclear techniques allows precise dating of temporal records and the analysis of minute traces of isotopes and other parameters which provide information about the past climate (known as 'proxies'). With this CRP, the IAEA will provide Member States with an assessment of the most recent advances in climate variability reconstruction and a better knowledge of recent climate change, through the synthesis of existing knowledge and the study of new records in relevant regions. The study of climate variability through the analysis of temporal records of various proxies critically depends on the use of advanced analytical technologies and accurate dating. The CRP will revise and use a large variety of nuclear analytical techniques to establish the climate records, such as alpha and gamma spectrometry, liquid scintillation, several kinds of mass spectrometry (including accelerator mass spectrometry, multi-collector inductively coupled plasma mass spectrometry, laser ablation mass spectrometry, and isotope ratio mass spectrometry), X-ray imaging and high-resolution X-ray fluorescence analysis. These are fundamental for both accurate dating and sensitive determination of several proxies. Accurate radiochronology will be achieved by using various radionuclides such as lead-210, carbon-14, thorium-230 and other pertinent isotopes. This CRP is a development of the previous successful CRP entitled "Nuclear and Isotopic Studies of the El Niño Phenomenon in the Ocean". The new CRP has an expanded scope and larger expected membership as it seeks to cover climate variability worldwide. It will thus be able to draw on wider regional experience and technology. The CRP could support the creation of a regional or interregional technical cooperation project on climate change and variability.

CRP Title:	**Benchmarking Ocean Models for the Dispersion and Radiological Impact of Radionuclides Released from Nuclear Power Plants in Emergency Situations**
CRP Code:	**2068**

The 2011 accident at the Fukushima Daiichi nuclear power plant released large amounts of radioactive substances into the Pacific Ocean. These radionuclides are being dispersed and transferred through the ocean, and numerous studies of these processes have been carried out using three-dimensional hydrodynamic circulation models, dispersion models and compartmental models on different space- and time-scales to predict the behaviour of the radionuclides and, further on, to estimate doses to biota and human populations. Similar studies, focusing mainly on short-term and short- to medium-range predictions, can be applied to other coastal nuclear facilities and various emergency scenarios. The objective of this CRP is to compare available ocean models, adapt operational models to radionuclide modelling, work out connections to real-time data streams and assist Member States in the development of expert systems for emergency preparedness. The Fukushima discharges will be used as a benchmark study for the Pacific Ocean. The simulated data will be compared with actual measurement results from that region. Measurement data can be used from the Asia–Pacific Marine Radioactivity Database (ASPAMARD), which has been updated under the IAEA regional technical cooperation project RAS/7/021, "Marine Benchmark Study on the Possible Impact of the Fukushima Radioactive Releases in the

Asia–Pacific Region". The CRP will also compare predictions obtained from different models and further develop models for dispersion and transfer of radionuclides in the marine environment, which can be used for radiological and environmental impact assessments in support of decision-making in case of accidental releases of radionuclides to the marine environment. The CRP will develop the scientific basis of marine modelling during nuclear and radiological emergencies and will be coordinated with relevant activities under the IAEA's Modelling and Data for Radiological Impact Assessments (MODARIA) programme in order to improve capabilities in the field of environmental radiation dose assessment.	
Project 2000076	**2.4.3.001 Radioactive and Non-radioactive Pollution and Impact on Environment**
CRP Title:	**Study of Temporal Trends of Pollution in Selected Coastal Areas by the Application of Isotopic and Nuclear Tools**
CRP Code:	**K41016**
The increasing worldwide exploitation of coastal areas poses serious environmental problems and requires science-based policy for a sustainable management of marine ecosystems and resources. Knowledge of pollution levels and trends is essential to define environmental protection measures. However, data availability in coastal areas is still very uneven. In large areas of the world information is totally missing and, although monitoring programmes are being undertaken, very little is known about past contaminant levels and trends. The use of natural environmental archives (sediments, shells, corals, etc.), when properly dated by radioisotopic methods, may allow the temporal variability (including trends) in the levels of a variety of contaminants in the marine environment to be determined, complementing conventional monitoring programmes and/or reconstructing past environmental conditions for which monitoring data are missing. The aim of this CRP is to critically review the use of natural environmental archives to retrospectively investigate pollution trends in the marine environment and to show how the application of nuclear techniques can contribute to an improved approach by producing comprehensive data on contaminants in coastal marine systems.	
CRP Title:	**Levels, Trends and Radiological Effects of Radionuclides in the Marine Environment**
CRP Code:	**2135**
This CRP aims to provide a timely follow-up to previous assessments coordinated by the IAEA under two earlier CRPs: "Sources of Radioactivity in the Marine Environment and their Relative Contributions to Overall Dose Assessment from Marine Radioactivity" (MARDOS; reference year 1990, and "Worldwide Marine Radioactive Studies" (WOMARS; 2000). The new assessment will result in an up-to-date picture of worldwide marine radioactivity. It will provide a comprehensive assessment of the status and trends of radioactivity in the world's oceans and seas, together with an analysis of sources and their relative contributions, as well as a comparative assessment of radiological doses through seafood ingestion, from natural and anthropogenic radionuclides. There is a huge pool of new marine radioactivity data accumulated since the time of the last assessment coordinated by the IAEA in the year 2000, sufficient to support a reliable new assessment. A significant volume of new data is expected to be contributed through this CRP to the IAEA's online marine radioactivity database MARiS (Marine Information System). The CRP aims to process and synthesize the data into different types of products (space and time averages, trends, maps, interactive models, etc.) by reaching consensus in a broad experts' community on representative levels, trends and radiological impacts. An IAEA Technical Document, project reports and scientific publications are planned to be produced within the framework of the project. The CRP will address the current need for a reference publication on the state of marine radioactivity. The CRP results will make it possible to compare local, regional and global scale marine environmental effects of different sources and will provide pre- and post-Fukushima baselines and trends of anthropogenic radionuclides. Past assessments which looked at	

anthropogenic radionuclides against the background of natural radioactivity also in terms of radiological doses from seafood ingestion, indicated that doses from natural polonium-210 are several orders of magnitude higher than those corresponding to anthropogenic radionuclides and are associated with a high variability. The study will be expanded to include the additional data collected since the year 2000.

2.5 Radioisotope Production and Radiation Technology

Project 2000090	**2.5.1.001 Development and Production of Medical Radioisotopes**
CRP Title:	**Therapeutic Radiopharmaceuticals Labelled with New Emerging Radionuclides (^{67}Cu, ^{186}Re, ^{47}Sc)**
CRP Code:	**F22053**

This CRP will identify important technical issues related to the production and quality control of emerging new radionuclides for use in the development of therapeutic radiopharmaceuticals. Copper-67 (^{67}Cu), rhenium-186 (^{186}Re) and scandium-47 (^{47}Sc) radionuclides have been selected because of their theranostic potential, their dual production routes through reactors and cyclotrons, target availability, and high specific activity production. In view of the potential demand of Member States, collaborative research is needed for the establishment of standardized production, quality control and the resolution of other important issues, including the preparation of technical protocols and guidelines for ultimate radiopharmaceutical development. The CRP will focus on methods for the production of the radioisotopes ^{67}Cu, ^{186}Re and ^{47}Sc as theranostic radionuclides for possible radiopharmaceutical development as well as research purposes. The objectives for this CRP include formulating guidelines to enhance and strengthen the expertise and capability of Member States in deploying emerging radioisotopes with theranostic properties (^{67}Cu, ^{186}Re and ^{47}Sc) that can be produced from research reactors and accelerators for medical applications in order to meet Member States' needs as well as to assimilate new developments and research initiatives.

CRP Title:	**Sharing and Developing Protocols to Further Minimize Radioactive Gaseous Releases to the Environment in the Manufacture of Medical Radioisotopes, as a Good Manufacturing Practice**
CRP Code:	**F23031**

This CRP will identify and present solutions to important technical issues related to the radioactive gaseous emissions from current and possible future medical isotope production facilities. The project will build on international work already completed to study how these emissions affect the environment and the public health, as well as the monitoring for nuclear explosions, and to develop a plan to keep gaseous emissions at medical radioisotope production facilities below a desired target. The objectives of this CRP are to: (1) foster collaboration between current and potential future producers of medical radioisotopes, such as molybdenum-99 and iodine-131, from the fission of uranium; (2) determine internationally accepted targets for selected radioactive gaseous emissions; (3) produce a summary of the factors which most significantly affect such emissions; and (4) determine methods which can be utilized to reduce emissions to the determined level.

CRP Title:	**New Ways of Producing Technetium-99m (Tc-99m) and Tc-99m Generators**
CRP Code:	**2140**

Technetium-99m (Tc-99m) radiopharmaceuticals are the major diagnostic tools in the clinical practice of nuclear medicine worldwide, used in some 35 million procedures annually. Over 95% of the molybdenum-99 (Mo-99) required for Tc-99m generators is produced by the fission of uranium-235 targets in nuclear research reactors. In recent years, a Mo-99 supply crisis occurred as a result of various factors such as the extension of planned outage and

the prolonged or unplanned shutdown of many reactors around the world. In response to the crisis, operating producers increased production to the extent possible, and alternative routes were also suggested for the production of Mo-99 and/or Tc-99m radionuclides. As a major platform for coordination in research and development activities on the production of Mo-99 and Tc-99m, and for defining the new potential production capacities in the Member States, the IAEA has initiated a number of research programmes to mitigate the effects of future shortages in the supply of Mo-99. The objective of this CRP is to evaluate new ways of producing Tc-99m, such as the Mo-100(γ,n)Mo-99 reaction, and also new Mo-99/Tc-99m generators using low specific activity Mo-99.	
Project 2000091	**2.5.1.002 Development of Diagnostic and Therapeutic Radiopharmaceuticals**
CRP Title:	**Positron Emission Tomography Radiopharmaceuticals Using Fluorine-18 and Gallium-68 Radionuclides for Infection, Inflammation Imaging and Stem Cell Tracking**
CRP Code:	**2075**
The objective of this CRP is to coordinated the development of new positron emission tomography (PET) radiopharmaceuticals, particularly, PET-based tracers which could offer improved specificity and better resolution of the images than the currently utilized single photon emission radionuclides such as technetium-99m, indium-111 and gallium-67. Similarly, early diagnosis of infectious diseases such as tuberculosis is essential for community health and infection control, as well as for starting appropriate therapy for patients. This CRP will provide a coordinated approach to select a number of promising peptides, saccharides or blood cell elements which, once labelled with gallium-68 or fluorine-18, can pinpoint the sites and extent of infection or inflammation. Organized by the Nuclear Medicine and Diagnostic Imaging Section at the IAEA's Division of Human Health, the project's objectives will include developing radiolabelling and quality control methodologies for clinical use of PET radiopharmaceuticals in infection, inflammation and stem cell tracking imaging studies.	
CRP Title:	**Copper-64 Radiopharmaceuticals for Theranostic Applications**
CRP Code:	**F22067**
This CRP will identify important technical issues related to the production and quality control of new theranostic copper-64 radiopharmaceuticals. Copper-64 (Cu-64) is the only known radionuclide that undergoes transmutation through three different routes, namely positron decay, beta decay and electron capture. These three processes result, respectively, in the emission of positrons, which can be used in positron emission tomography, beta particles and Auger electrons, both of which also find use in therapy. Thus, its unique nature allows Cu-64 to be used for both diagnostic and therapeutic purposes in nuclear medicine and has earned it the reputation of a 'theranostic' radionuclide. Recent studies showed that Cu-64 in the most simple form ($[^{64}Cu]CuCl_2$) as well as linked to a variety of bioactive molecules can be used as a theranostic agent to treat human malignancies such as prostate, glioblastoma, melanoma and breast cancers, and also for the diagnosis of human copper-associated diseases such as atherosclerosis, Alzheimer's, etc. This CRP focuses on the application of the newly-discovered theranostic properties of the Cu-64 cation, as well as on developing and evaluating the most promising Cu-64 chelated targeting theranostic agents for the therapy and diagnosis of human diseases.	
CRP Title:	**Preclinical Assessments of New Radiopharmaceuticals**
CRP Code:	**2146**
The objective of this CRP is to formulate laboratory requirements and protocols for preclinical assessment of biodistribution, dosimetry, toxicity, etc. for new radiopharmaceuticals for regulatory submissions to the appropriate national authorities. The regulatory authorities require safety and efficacy data for new radiopharmaceuticals before	

they can be used in humans. The CRP will develop shared protocols as applicable to various specific radiopharmaceuticals. The types of animal models that are appropriate for a particular disease will be identified. The type and number of animals to be used for testing radiopharmaceuticals will be tested in the field under real preclinical conditions. Data collection and statistical data analysis methodologies will be demonstrated through practical case studies that will be developed as part of this CRP.	
CRP Title:	**Use of Radiopharmaceuticals in Drug Development Activities**
CRP Code:	**2160**
Information obtained from radiopharmaceutical biodistribution can be utilized to characterize the effect of a new drug, and clinical evidence required for the proposed drug's efficacy can thus be obtained for submission to the regulatory authorities. The objective of this CRP is to formalize and apply protocols for the development of new drugs for cancer and other diseases. For the development of new conventional drugs the labelling of these drugs transforming them into radiopharmaceuticals can provide unique information e.g. in cardiovascular applications. Radiopharmaceuticals offer the possibility of studying noninvasively cardiac perfusion, oxygen consumption, oxidative and substrate metabolism, myocardial efficiency of work, neural actions and receptors, vascular inflammation, and molecular processes, all of which are relevant to understanding the effects of drugs. Using these surrogate end points, hypotheses can be tested in vivo in preclinical and phase I and II clinical studies before starting large-scale clinical phase III or IV trials. In addition, these approaches may allow improved selection of drug therapy for a given patient. Modern techniques such as gene therapy technology provide numerous new potential mechanisms of action and targets for drug development. Device therapies and cell therapies are also under rapid development. Standardizing the use of radiopharmaceuticals has great potential in evaluating these new therapies, selecting the patient populations and monitoring the effect of therapy. The CRP will develop practical guidelines on the use of radiopharmaceuticals for drug development.	
Project 2000094	**2.5.2.001 Industrial Applications of Radioisotopes and Radiation Techniques**
CRP Title:	**Development of Particle Tracking Methods and Modelling for Measurement of Flow Pattern and Dispersion of Particles in the Process Industries**
CRP Code:	**2113**
The CRP's objectives will be the establishment of the state of the art in the development of nuclear techniques and associated methodologies using radiotracers and based on the radioactive particle tracking (RPT) method to derive data in a simple manner from a variety of complex and closed systems. Multiphase flows and processes (i.e. those involving at least two phases) are widely used for the production of energy fuels, chemicals and biotechnological products, as well as in the mining and metallurgical industries. For example, in the mining industry, the compositions of feedstock are changing rapidly due to the shortage of conventional resources. The development of new mines is typical for many upcoming and future applications. The intrinsic variability of these new feedstocks combined with stringent environmental constraints make the processes much more difficult to design and operate. The use of high temperatures and/or high pressure during the conversion and handling of high viscosity materials results in extreme processing conditions for which the multiphase process hydrodynamics are completely unknown. Reliable measurement of the flow dynamics in various systems is essential. To do so, sophisticated measuring techniques have been developed and improved by advances in computer control and nuclear technology, including nuclear techniques such as RPT and positron emission particle tracking (PEPT). PEPT uses two positron-sensitive detectors mounted on the opposite sides of a system to detect pairs of exactly back-to-back gamma rays resulting from the annihilation of a positron. This technique is able to detect a tracer when the tracer is within	

the volume covered by the detectors. RPT employs an array of several compact detectors made of sodium iodide activated with thallium, which can be flexibly arranged around the system. Since RPT and PEPT use different detectors and rely on different algorithms to reconstruct tracer trajectories, they have their own advantages and drawbacks. For instance, RPT setups are compact, flexible and cheap compared to those used in PEPT.

CRP Title:	**Development of Radiometric Methods and Modelling for Measurement of Sediment Transport and Dispersion of Particles and Pollutants from Outfalls**
CRP Code:	**F22066**

It is well known, albeit not always well accepted, that there is a real lack of knowledge on the mechanisms of sediment transport. The equations which are the core of computational fluid dynamics models were developed in the first half of the twentieth century and are still used in most models with some adaptation using 'black box' coefficients. In order to acquire better knowledge of sediment transport mechanisms, there is a need for reliable and efficient measurement tools that can be used in the field, at real scale, and allowing the measurement of data without disturbing the hydrodynamical and physical conditions in the environment. Nuclear techniques are the most useful and efficient tools for this purpose. The CRP will focus on the development and improvement of relevant nuclear techniques (radiotracers and nucleonic measurement systems) and the associated methodologies in order to enhance their application and the quality of data obtained from their use and, ultimately, to provide the scientific community with the best possible tools to fill knowledge gaps in this area. Guidelines for the use of such techniques, with a special emphasis on safety and regulatory aspects, will also be developed. The CRP will contribute to a wider utilization of nuclear techniques in Member States by enhancing their availability and the range of their application.

CRP Title:	**Tomographic Techniques Associating X and Gamma Rays with Neutrons from Generators for Flow Visualization**
CRP Code:	**2157**

This CRP is aimed at the development of nuclear techniques and associated methodologies for the integration of different types of radiation in the same tool to visualize flow patterns in opaque systems, as well as at the development or improvement of neutron generators, X-ray generators and software used for this purpose. Imaging technologies recently became popular in many laboratories. The gamma-ray computed tomography (GCT) technique is the most suitable for the visualization of processes inside an opaque multiphase system Gamma transmission tomography (GTT) is based on the assumption that there is heterogeneity of a parameter in the system under investigation. In general, this parameter is the density of the medium, e.g. the density of a packed bed or the concentration of a phase in a dual phase flow. There are many geometrical arrangements of source and detector(s). The simplest of these is the parallel, or pencil beam, configuration in which a source, emitting a single pencil beam of radiation is coupled to a radiation detector. To obtain a single view, the source and detector (placed on opposite sides of the test specimen) are moved parallel to one another to measure the attenuation across the specimen at a number of positions. For the next view, the detector–source arrangement rotates about the test section and the translation is repeated. In process engineering, GTT applications consist mainly of the inspection of packed columns, bubble columns, fluidized beds and porous media. More complex systems are also available, consisting of e.g. one source coupled with several detectors; one source with an imaging device such as a flat panel; an X-ray generator instead of a radioactive source; multiple sources and multiple detectors without movement, etc. The configuration depends on the desired objectives in terms of space and time resolution. Neutron tomography also exists based on nuclear research reactor facilities. It is generally impossible to move part of a process unit to a research reactor. Thus, it would be highly interesting to evaluate the possibility of using neutron generators to enable on-site neutron imaging and tomography. To investigate flow dynamics in multiphase flows, with or without density variations, it is generally better to use a radioactive tracer, labelling one phase and observing the behaviour of this phase in the flow. Measuring radiotracer gamma radiation in a tomographic configuration, the visualization of the flow patterns inside vessels becomes possible. On the whole, the integration of different types of radiation and methods in the same tool would be extremely useful.

Major Programme 3: Nuclear Safety and Security

3.2 Safety of Nuclear Installations	
Project 3000167	**3.2.4.004 Supporting Long Term Operation Safety**
CRP Title:	**Evaluation of Structures' and Components' Material Properties Utilizing Actual Aged Materials Removed from Decommissioned Boiling Water Reactors**
CRP Code:	**2078**
To ensure safe long term operation of nuclear power plants, international collaborative research aimed at collecting, measuring, recording and analysing the properties of sample materials removed from systems, structures and components of decommissioned nuclear power plants, as well as of replaced components that are subject to physical ageing, is very important. Such research should address synergetic effects from a combination of different degradation mechanisms in real operational conditions, provide a basis for comparison with the results of laboratory tests and calculations, and make it possible to remove unnecessary conservatism in predicting the status of components important to safety. The specific objective of this CRP is to analyse material behaviours from the neutron irradiation embrittlement of reactor pressure vessel (RPV) steel and irradiation-assisted stress corrosion cracking of RPV internals through a Phase 1 (2016–2019) from decommissioned boiling water reactors, and then a Phase 2 (to be initiated in 2019 or later) covering various types of degradation such as low-cycle fatigue, including environmentally-assisted fatigue of primary circuit components; thermal ageing of two-phase stainless steels.	
3.5 Nuclear Security	
Project 3000151	**3.5.1.003 Information and Computer Security, and Information Technology Services**
CRP Title:	**Enhancing Computer Security Incident Analysis at Nuclear Facilities**
CRP Code:	**J02008**
This CRP will explore key areas such as good practices, technology, analytical methods, and recommended procedures for the response (including forensic activities) to computer security incidents at nuclear facilities. The results of this project will be disseminated as a non-serial IAEA publication on nuclear security and will additionally serve to inform the development of nuclear security guidance and training. This CRP provides the opportunity to participate in four activities to enhance computer security incident analysis and response: (1) operator support for computer security incident recognition and response; (2) analysis and technology support for computer security incident response; (3) computer security information exchange; and (4) cybercrime investigation. The objective of this CRP is to conduct activities which improve computer security capabilities at nuclear facilities to support the prevention and detection of, and response to, computer security incidents that have the potential to either directly or indirectly adversely affect nuclear safety and nuclear security.	
Project 3000152	**3.5.2.001 Integrated Nuclear Security Approaches for the Nuclear Fuel Cycle**
CRP Title:	**Nuclear Security for Research Reactors and Associated Facilities**
CRP Code:	**J02006**
The objective of this CRP is to simplify the process for developing, and enhancing the effectiveness of, nuclear security programmes to reduce the risk of theft of nuclear and/or other radioactive materials and sabotage at research reactors and associated facilities (RRAFs). This project includes the following research activities: 1- Review the assessment methodologies for regulated facilities developed by the CRP on	

nuclear security assessment methodologies (CRP code: J02004) in relation to RRAFs and develop case studies for RRAFs.
2- Identify factors for developing a comprehensive normalized ranking scheme for security risks posed by nuclear and radioactive materials while considering the unique characteristics of RRAFs.
3- Identify and assess open source data to develop a general threat basis statement for RRAFs.
4- Identify and assess available computer-based analytical tools (including their technical suitability) that can be used by non-security experts to evaluate the dispersal consequences of the introduction of external energy sources into RRAFs.
5- Identify and assess available databases for evaluating the performance effectiveness of nuclear security of RRAFs.

Project 3000153	**3.5.2.002 Enhancing Nuclear Materials Security Using Accounting and Control**
CRP Title:	**Preventive and Protective Measures against Insider Threats at Nuclear Facilities**
CRP Code:	**J02010**

The objective of this CRP is to enhance existing preventive and protective measures against insider adversaries to reduce the risk of theft of nuclear material and sabotage at nuclear facilities. The aim is to develop: (1) a predictive model for trustworthiness programmes; (2) a predictive model for identifying colluding insider adversaries; (3) tools and methods to be used in the application of process monitoring for nuclear security to improve detection capability, including analysis of technological barriers in process designs that may prevent or limit achievement of detection goals; (4) technical measures to enhance the control of nuclear material and personnel; and (5) a database for selecting nuclear material accounting and control measures for specific facility types.

Project 3000154	**3.5.2.003 Upgrading Security of Radioactive Material and Associated Facilities**
CRP Title:	**Improving the Security of Radioactive Material throughout its Lifecycle, Associated Facilities, and Associated Activities**
CRP Code:	**J02011**

This CRP will focus on several activities, including: an examination of radioactive material and current safety thresholds to validate if they are an appropriate basis for security; an assessment of security measures for radioactive material in fixed and portable applications to identify gaps and develop solutions to address those gaps; and an analysis of how security measures are responding to identified threats. The results of the proposed CRP are intended to form the basis of guidance for States to establish and/or enhance their national nuclear security regimes for radioactive material and associated facilities.

Project 3000155	**3.5.2.004 Nuclear Security in Transportation of Nuclear and Radioactive Material**
CRP Title:	**Enhancing Security in Transport of Nuclear and other Radioactive Material**
CRP Code:	**J02009**

This CRP is intended to identify and evaluate technologies that can be applied to strengthen the security of nuclear and other radioactive material during transport. This will include identifying gaps between existing transport security systems and more technologically advanced systems that can provide more efficient comprehensive security coverage appropriate for the potential consequences of the material being transported (i.e. in a graded approach). The CRP is open to institutes from IAEA Member States that will undertake

experimental/research/technical activities aimed at enhancing nuclear security during transport. It will create an encouraging environment for the development of innovative and new approaches to providing integrated technologies that support security elements such as detection, assessment of alarms, identifying the location of a security event and communications (both overt and covert). The project will serve as a collaboration platform for sharing knowledge and experience and for the exchange of information and expertise.	
Project 3000157	**3.5.3.002 Nuclear Security Detection and Response Architecture**
CRP Title:	**Improved Assessment of Initial Alarms from Radiation Detection Instruments**
CRP Code:	**J02005**
With literally millions of vehicles and people crossing borders every day, radiation portal monitors (RPMs) have become a critical tool for detecting the unauthorized transboundary movement of nuclear and other radioactive materials. The proper assessment of radiation alarms from RPMs is an essential part of the effort to combat the global problems associated with these unauthorized movements. Coordinated research and development work is needed, and will be conducted in this CRP, to provide peer reviewed and validated methodologies and guidelines for assessing radiation alarms and providing confidence that nuclear and other radioactive material out of regulatory control is detected and credible response actions initiated. The CRP's scope includes the establishment of a database of materials that cause radiation alarms and the development of a software tool that provides analysis of alarms to improve the decision process for determining whether an alarm is innocent or suspicious, i.e. whether or not the alarm is the result of the presence of nuclear or other radioactive material out of regulatory control.	