EUROPEAN RADIOECOLOGY ALLIANCE

ALLIANCE Statement – June 2017

Short- to medium-term research priorities in radioecology to improve the scientific basis and reduce uncertainties in human and environmental risk assessments, increasing radiation protection of humans and wildlife

1. The ALLIANCE, the Strategic Research Agenda for Radioecology and the topical roadmaps

The European Radioecology ALLIANCE[1] (ALLIANCE) was founded in 2009 as a European structure capable of ensuring long-term governance of research in radioecology on the basis of the recommendation from FUTURAE[2], a 2006-2008 coordination action granted by the EC to produce an analysis of the state of radioecology in Europe. Since being officially registered in 2012 the ALLIANCE has progressively grown, going from the 8 founding members to 27 members, from 14 countries, in April 2017. The objectives of the ALLIANCE are to coordinate and promote research in radioecology. The ALLIANCE members recognise that their shared radioecological research can be strengthened by efficiently pooling resources among partner organisations and by prioritising group efforts along common themes. A major step in the prioritisation process was to develop a Strategic Research Agenda (SRA) for radioecology.

The Strategic Research Agenda[3] was initiated by the STAR[4] Network of Excellence and integrated in the research strategy implemented by the COMET[5] consortium, defines a long-term vision (20 years) of the needs for, and implementation of, research in radioecology. The SRA constitutes a reference document, initiated by researchers and consolidated through interactions with stakeholders. The SRA outlines three scientific challenges and fifteen associated research lines, as a strategic vision of what radioecology can achieve in the future *via* a prioritisation of efforts at the global scale. These challenges are: (1) to predict human and wildlife exposure in a robust way by quantifying key processes that influence radionuclide transfers and exposure; (2) to determine ecological consequences under realistic exposure situations; and (3) to improve human and environmental protection by integrating radioecology. The SRA is being complemented by topical roadmaps[6] that have been initiated by the COMET EC-funded project, with the help and endorsement of the ALLIANCE. The strategy underlying roadmap development is driven by the need for improvement of mechanistic understanding across radioecology, one consequence of this being that we can provide fit-for-purpose human and environmental impact/risk assessments in support of the protection of man and the environment for the three exposure situations defined by the ICRP (*i.e.*, planned, existing and emergency). Topical roadmaps are building blocks that will be used to establish the ALLIANCE roadmap for radioecology at the end of 2017. Some of the research areas for radioecology are also relevant for post-emergency management and low-dose effect research and provide a powerful catalyst to further develop collaboration between the platforms of radiation protection (ALLIANCE, NERIS, MELODI, EURADOS and EURAMED[7]).

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[1] www.er-alliance.eu/

[2] FUTURAE - A Future for Radioecology in Europe, 2002-2006, FP6 Euratom Fission, GA180506

[3] Strategic Research Agenda for Radioecology – An updated version with stakeholder input. Issued on 24/02/2014, 92 p. D-N°2.5. Contract Number: Fission-2010-3.5.1-269672. https://wiki.ceh.ac.uk/x/YoFsD.

[4] www.star-radioecology.org ; STAR - Strategic Network for Integrating Radioecology, 2011-2015, FP7 GA269672

[5] www.comet-radioecology.org ; COMET– Coordination and implementation of a pan-European instrument for radioecology, 2013-2017, FP7 Euratom Fission, GA604974

[6] The topical roadmaps consider the following areas: 1) atmospheric transfer processes, 2) marine radioecology, 3) human food-chain modelling, 4) environmental issues associated to Naturally-Occurring Radioactive Materials (NORM), 5) inter- and intra-species radiation sensitivity and transgenerational effects.

[7] MELODI: Multidisciplinary European Low Dose Initiative, http://www.melodi-online.eu; EURADOS: European Dosimetry Group, http://www.eurados.org; NERIS: European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery, http://www.eu-neris.net ; EURAMED – for medical applications – in progress - http://www.eibir.org/scientific-activities/joint-initiatives/european-

2. The progress of the radioecology science during the last 10 years; remaining gaps

The progress accomplished during the past decade mainly dealt with improvement of basic knowledge and tools to assess transfers of radioactive substances in the environment and subsequent human and environmental exposure. These improvements serve among others radiological risk estimation of humans and wildlife. Recent EC-funded projects (STAR, COMET) have developed improved and innovative models, moving from empirical models based on transfer factors and concentration ratios to more process-based, dynamic models for quantifying radionuclide transfers to humans and wildlife (*e.g.*, biokinetic, taxonomy-based models, models with regional parameterisation). They also delivered guidance for development and validation of fit-for-purpose models (*e.g.*, marine dynamic transfer models, human food chain models, soil-vegetation-atmosphere transfer models, forest models). The complex issue of the influence of multiple stressors in radiological risk assessment was also significantly advanced, especially in the context of NORM contaminated sites. Another step forward has been to advance the integration of human and environmental protection frameworks with the development of a combined screening model for both human and nonhuman biota (CROMERICA tool). However, progress is still needed to gain fundamental knowledge and the validated tools and methods one of the outcome being to perform realistic, integrated and graded impact and risk assessments for humans and wildlife, across all ecosystems and exposure scenarios.

Although significant advances have been made since the Chernobyl and Fukushima accidents in predictive modelling to improve exposure estimates, large uncertainties remain, highlighting the need to take into account more realistically key physical, chemical and biological processes in transfer and exposure models. The priority is to develop and validate process-based, dynamic models that combine physical dispersion, biological and physico-chemical processes in an integrated approach. Improving the predictive capability of these integrated models by validation through comparison of predictions with observed data, alongside filling knowledge gaps on biogeochemical processes, is key to answer research questions on the global biogeochemical cycling of radionuclides in the environment and to reduce uncertainty in human and wildlife exposure estimates. How the fact that environmental transfers and subsequent exposure of humans and wildlife vary spatially and temporally (*e.g.*, with climate, soil type, human practices) is a key issue whatever the source term. Regarding post-accidental issues and communication with stakeholders, these ALLIANCE priorities are clearly shared with NERIS. These research needs largely relate to the radioecology SRA Challenge one (through model development and provision of data for parameterising and validating these models) and to SRA Challenge three (through the application of models in the integration of protection frameworks for humans and the environment for radionuclides and non-radioactive pollutants).

Biological effects of chronic exposure to ionising radiation are still a major concern for both human and environmental radiation protection. Recently, mechanistic models based on the stress-induced disturbance of metabolism in organisms exposed to ionising radiation have proved to provide insight on the causes of the effects observed and also represent tools towards more robust ecological protection benchmarks. COMET proved the relevance of using epigenetic markers in non-human species and started to delineate genetic *vs.* epigenetic causes of transgenerational effects of chronic exposure to ionising radiation. The exploration of omics responses of organisms exposed to ionising radiation have also been highlighted as a useful approach to unravel the basic mechanisms of the biological response to ionising radiation. This approach could be useful to help us understand how co-contaminants/stressors might

alliance-for-medical-radiation-protection-research-euramed/ ; Social Sciences and Humanities in Ionising Radiation Research – platform under development

influence the radiosensitivity of organisms. At present, the system of radiation protection needs more knowledge to be able to confidently address the wide biodiversity and also biological responses to ionising radiation especially in environmentally-relevant multiple stressors contexts. Exploration of intra- and inter-species causes of variation in radiosensitivity and of the mechanisms of multi- or trans-generational effects remains a priority topic to improve the basic knowledge and also to contribute to the validation of biomarkers as early warning tools. These needs, answering Challenge two of the radioecology SRA, are synergistic to those of MELODI research. The needs are challenging, as to meet them we need to establish processes that link radiation-induced effects from the molecular level to population, community or ecosystem levels, for a wide diversity of taxa and in the presence of co-stressors.

Finally, integrated and graded management approaches, and appropriate tools for their implementation over the spectrum of possible exposure scenarios, including scenarios of rehabilitation of impacted areas, are also drivers for radioecological research in the coming decades. This need is partially addressed by the two 3-year projects selected during the first call of CONCERT: (i) CONFIDENCE[8] largely shared with NERIS and EURADOS, which addresses some of the existing gaps in several areas of emergency management and long-term rehabilitation (*e.g.*, human food chain modelling; social, ethical and communication aspects related to uncertainties; combination of simulation and environmental monitoring). It concentrates on the early and transition phases of an emergency, but considers also longer-term decisions made during these phases; (ii) TERRITORIES[9] largely shared with NERIS and MELODI, that will produce novel guidance documents for medium to long-term dose assessment, risk management, and remediation for NORM sites on one hand and for radioactively contaminated sites as the consequence of a nuclear accident on the other hand, with harmonisation as far as possible of the consideration of uncertainties and stakeholder involvement in the decision making process

Even though very significant progress has been made during the last decade, with more expected through the ongoing projects from CONCERT first call (results from CONCERT second call unknown at the moment), research in radioecology needs additional resources and efforts since its drivers, such as policy changes, scientific advances and knowledge gaps, radiological risk perception by the public, and a growing awareness of interconnections between human and ecosystem health, require complex and multidisciplinary scientific questions to be answered.

[8] CONFIDENCE COping with uNcertainties For Improved modelling and DEcision making in Nuclear emergenCiEs - CONCERT Project from 1st call- 2017-2020

[9] TERRITORIES To Enhance unceRtainties Reduction and stakeholders Involvement TOwards integrated and graded Risk management of humans and wildlife In long-lasting radiological Exposure Situations - CONCERT Project from 1st call- 2017-2020

3. Research priorities

On the basis of (i) our previous SRA statements (2015, 2016), (ii) discussions within the ALLIANCE SRA WG and with the topical roadmap leaders and their associated WGs, (iii) the advances from EC-funded projects as described in section 2, our priorities are kept unchanged as follows.

Two priorities with impact expected mainly in terms of reduced uncertainty in exposure and dose assessment and increased human and wildlife radiation protection:

- Environmental availability and impact of radionuclides in terrestrial, freshwater, estuarine, brackish and marine ecosystems (including human and non-human foodwebs) and their interactions with atmosphere, incorporating physical, chemical and/or biological processes. Validated process-based model with robust parameterisation, characterisation of variability and uncertainty, and guidance to obtain fit-for-purpose models which can satisfy the goals of fundamental research;
- Development of models/tools, and datasets for their calibration and validation and guidance to select and evaluate the effectiveness of different remediation strategies in long-lasting exposure situations (*e.g.*, nuclear accidents, NORM/TeNORM) ;

Two priorities with impact expected mainly in terms of reduced uncertainty in effect assessment and increased wildlife radiation protection:

- Biomarkers of exposure and effects in living organisms as operational outcomes of a mechanistic understanding of intra- and inter-species variation of radiosensitivity under chronic low dose exposure situations, with a focus on the added value for both human and non-human radiological protection;
- Multiple stressors and modulation of radiation effects in living organisms;

The 4 priorities were not ranked since the outcomes from the recently started projects (selected under CONCERT first call (CONFIDENCE, TERRITORIES)) and from CONCERT second call (decision expected during summer 2017) are not known at the present time. The ALLIANCE SRA/roadmap working group has planned a meeting in autumn 2017 to identify and prioritise new drivers and associated topics for research in radioecology by interacting with an external advisory stakeholder board.

Annex 1. Detailed description of the ALLIANCE research priorities.

Priority title	**Environmental availability and impact of radionuclides in terrestrial, freshwater, estuarine, brackish and marine ecosystems (including human and non-human foodwebs) and their interactions with atmosphere, incorporating physical, chemical and/or biological processes. Validated process-based model with robust parameterisation, characterisation of variability and uncertainty, and guidance to obtain fit-for-purpose models which can satisfy the goals of fundamental research**
Priority description	A key goal of radioecology is to understand at the fundamental level and to predict the transfers of radionuclides and consequent exposure of humans and wildlife. More specifically, this is needed for improved knowledge in a wide range of sources and release scenarios, exposure situations and assessment contexts in continental environments, including interactions at the level of the total environment (atmosphere, hydrosphere, lithosphere, biosphere, and anthroposphere). Although considerable advances have been made since the Chernobyl accident in predictive modelling, the Fukushima accident in Japan has highlighted the need of improved transfer and exposure models. The new models should represent the behaviour of the radionuclides in a more realistic way, ideally considering the different levels of organisation present in the environment. The key physical, chemical and biological processes that govern radionuclide transfers, and how transfers and exposure of humans and wildlife vary spatially, temporally and with the source term, should also be taken into account. Research should contribute at the fundamental level to an improved process-based understanding of radionuclide transport and transfers in various radioactively contaminated areas and eventually into the human food chain. Major physical and biogeochemical processes should be identified, conceptualised and mathematically translated into models (from empirical to mechanistic, depending on the requirement) taking into account spatial heterogeneity and temporal variability of the environment under study. One of the expected outcomes is to provide guidance for selecting the level of refinement for models according to the targeted uncertainty. Another is to obtain calibrated and validated models which are fit for purpose.
European relevance	This topic is highly relevant for European radioecology in view of substantial advances in improving process-based understanding of radioecology in Europe, which needs to be supported by adequate funding, allowing European scientists to be leaders in the field. This topic has synergies with MELODI, NERIS and EURADOS, since dose assessment is a key step in the radiological impact/risk characterisation.
Multidisciplinarity; Reference to the strategic research agendas (SRA)	This topic is multidisciplinary because it connects radioecology, radiation protection, dosimetry, ecotoxicology, physics and biogeochemistry. The topic has links with European research platforms: -ALLIANCE (Sep 2013): p.14-22; Challenge 1; research lines: 3.1.2.1; 3.1.2.2.; 3.1.2.3; and 3.1.2.4; p.32, Challenge 3, research line 3.3.2.1. - NERIS (April 2014): p. 12: key topic 1.6; p. 13: key topic 2.1; p. 16: key topic 3.4; p. 18: key topic 5.1; p.23: cross cutting issues. -EURADOS (May 2014): p.6: vision 3 and 5.
Impact: decreased uncertainty	A deeper scientific understanding at the fundamental research level of the environmental processes involved in the transport and transfer of radionuclides will reduce uncertainties and hence robustly support decision making in various exposure situations. The knowledge gained will allow providing guidance for selecting the level of refinement for models according to the targeted uncertainty.
Impact: increased radiation protection	The topic will contribute to improve the radiation protection system, since it will allow to accurately predict exposure to humans and wildlife in planned, existing and emergency exposure situations, within continental and marine ecosystems that may interact between each other and with atmosphere.
Impact: increased quality and reliability	Uncertainties and lack of predictive power in risk assessments are major contributors to the public's reduced credibility of radiological sciences. Therefore, the acquisition of new scientific knowledge to reduce the uncertainties of the dose assessments, allowing more robust predictions and improved human and wildlife impact/risk assessments, will improve credibility with stakeholders.
Feasibility	There is a strong European radioecology research base with access to modelling, international databases, long-term collaborations with international organisations and first-class facilities.

Priority title	**Development of models/tools, and datasets for their calibration and validation and guidance to select and evaluate the effectiveness of different remediation strategies in long-lasting exposure situations (*e.g.*, nuclear accidents, NORM/TeNORM)**
Priority description	Management approaches in emergency and existing exposure situations can range widely in complexity. Although significant knowledge exists for a wide range of exposure situations, it tends to be fragmentary rather than forming an integrated strategy capable of dealing with complex, dynamically changing conditions. The need for integrated and graded management approaches and the appropriate tools to implement them over the entire spectrum of possible exposure scenarios, and thus ensuring that socio-economic facets are taken into account in the rehabilitation of the impacted areas, are primary drivers for radioecological research in the coming decades. The events at Fukushima after the NPP accident exemplify these problems and the existing deficiencies. There is a need for sound, fundamental and progressive science to yield maximum benefits from these efforts. Research is needed to guide the development/selection of models and assessment tools for medium to long-term predictions. There is a parallel need to generate and make available field data for their validation. Appropriate models (from empirical to process-based) should be developed to help compare radiological effects from various remediation measures, including those reducing radionuclide transfers into the food chain and/or those improving ecosystem services. For relevant radionuclides, models need to be applied to design remediation strategies to the major components of the ecosystems. Regarding more specifically post-accident exposure situations, the research to be done ought to complement the OPERRA-2014 HARMONE, CONFIDENCE and TERRITORIES (CONCERT 1st Call on going project), Regarding NORM/TeNORM sites research is needed to give answers to the specific requirements of the EURATOM Basic Safety Standards (BSS); this is only partially tackled in TERRITORIES.
European relevance	This topic has synergies with NERIS and EURADOS, in the establishment of priorities for pre-accident recovery preparedness, and expand beyond by dealing with medium- to long-term transfer processes and by tackling remediation issues. The topic is relevant to implement the requirements from the EURATOM BSS in relation to NORM/TeNORM. The priority is designed up-front to address specific BSS requirements for long-lasting exposure situations / remediation strategies in complement to TERRITORIES.
Multidisciplinarity; Reference to the strategic research agendas (SRA)	Multidisciplinarity is assured through topical links between radioecology, radiation protection/dosimetry, ecotoxicology, physics and biogeochemistry. -ALLIANCE (Sept 2013): p. 30-37- challenge 3- research lines 3.3.2.1 to 3.3.2.6; p.14-22: challenge 1- research lines 3.1.2.1 to 3.1.2.4. -NERIS (Apr 2014): p. 12: key topic 1.6; p. 16: key topic 3.4; p. 19: key topic 5.7; p.23: cross cutting issues -EURADOS (May 2014): p.6: vision 3 and 5.
Impact: decreased uncertainty	Scarcity of data is one of the major sources of uncertainty. The databases developed will contribute to the reduction of uncertainties in the impact/risk characterization in long-term radiological assessments, making remediation strategies more credible and robust, and offering the possibilities of comparing a range of strategies. The use of calibrated and validated models will also contribute to reduce uncertainties.
Impact: increased radiation protection	The predictions obtained in the assessment models are often key constituents in decisions made about emergency response, waste management, environmental remediation, and mitigation. The availability of more accurate validated models will increase the confidence in the radiological impact/risk assessment process, and therefore will contribute to the improvement of the radiation protection system through robust evaluation of the best remediation strategies to minimise exposures to the public and the environment.
Impact: increased quality and reliability	The use of validated models will improve the predictive accuracy and precision of the radiological impact assessments, with a greater confidence in the results. Moreover, justification of nuclear industry activities is increased if robust remediation approaches exist and are well evaluated before things go wrong.
Feasibility	The expertise and technological resources needed exist and are well consolidated at the European level to make this research highly feasible.

Priority title	**Biomarkers of exposure and effects in living organisms, as operational outcomes of a mechanistic understanding of intra- and inter-species variation of radiosensitivity under chronic low dose exposure situations, with a focus on the added value for both human and non-human radiological protection**
Priority description	The issue of biological effects of low doses of ionising radiation is still of major concern for both human and environmental radiation protection, as highlighted after the Fukushima accident, especially with the aim of quantifying (and reducing if needed) the magnitude of risk to individuals (human and endangered species) and populations (human and biota) health at low doses/dose rates. We need urgently to complement the system of radiation protection to be able to face the wide biodiversity and biological responses to radiation (from molecules to ecosystems) in a credible and robust way. A key for success is to explore intra- and inter-species causes of radiosensitivity variation. This requires reliable quantification of radiosensitivity *in vitro* and ideally also *in vivo*. This will help to screen out candidates for biomarkers to be used as early warning tools after *ad hoc* validation. Research is required to contribute to the identification of the primary mechanisms of radiation induced effects at the molecular level and their propagation up to the individual level, including consequences for physiological functions (*e.g.*, reproduction). This will be evidenced by evaluating suitable biomarkers of exposure and biomarkers of effects. A comparative and "lab-field-modelling"-combined approach for a number of exposure conditions and/or a number of species will enhance the understanding of the toxicity profiles as a response to exposure conditions. Dose-response relationships will be established making the best use of "omics" analytical methods, possibly combined with the use of a system biology approach, to provide evidence of linkage between metabolic pathways and associated biomarkers of effects. Research could expand to the use of genetic and epigenetic changes as biomarkers by implementing innovative approaches to test changes in the genome (*e.g.*, mutation rates and types) and the epigenome (*e.g.* epigenetic tags) through generations.
European relevance	This topic, synergistic with MELODI, was highly scored in the OPERRA e-survey. It presents a high potential for multidisciplinarity beyond the radiological protection community since it highlights similarities that radioecology has with ecotoxicology, stress ecology and human radiation biology. The topic is indirectly relevant to NERIS in that biomarkers potentially also useful in health surveillance, are looked for. The research is also relevant to EURADOS as accurate dosimetry is a prerequisite for any robust dose-response relationships. Impact on risk communication is expected by providing answers to burning questions emerging from public perception of the consequences of the Fukushima and the Chernobyl accidents. Outcomes will support emerging policy in the field of radioprotection of the environment, mentioned in the EURATOM Basic Safety Standards.
Multidisciplinarity; Reference to the strategic research agendas (SRA)	This topic will complement human and environmental radiation protection frameworks in a consistent way and will contribute to an improved and efficient integration of both protection frameworks. -MELODI (Aug 2015): p.12-17: chapter 4.2, 4.3. -ALLIANCE (Sept 2013): p.23-30: challenge 2 – research lines 3.2.2.1, 3.2.2.2; 3.2.2.4; p.33: challenge 3-research line 3.3.2.2. -NERIS (Apr 2014): p.18: key topic 5.1; p.20: key topic 5.8; p.23: cross cutting issues. -EURADOS (May 2014): p.7-13: vision 1 topics 1, 2, 3; p.22-25: vision 3 topic 1
Impact: decreased uncertainty	This research should provide the basis for the development of biologically-based extrapolation models which are the key to tackle the wide species diversity and would be useful for risk assessors by helping reducing uncertainty in predictions of effects (and ultimately risk).
Impact: increased radiation protection	Identification of such biomarkers will be relevant to humans or non-human species radiation protection. Acquired knowledge will highlight and feed the various extrapolations needed when assessing radiological risk to humans or non-human species, and will provide robustness in effects predictions and decision making.
Impact: increased quality and reliability	By encouraging openness to other disciplines and innovative hypothesis-driven approach to understand underlying mechanisms, this research topic will contribute to increasing acceptability of the radiation protection system and aid in risk prediction, management and communication.
Feasibility	A wide range of methods and approaches exists to make this research highly feasible, along with effect database (*e.g.*, FREDERICA).

Priority title	**Multiple stressors and modulation of radiation effects in living organisms**
Priority description	Exposure to multiple stressors may directly or indirectly modulate radiation effects in living organisms. Even though studying a contaminant in isolation is necessary to understand the underlying mechanisms resulting in the observed effects, this does not allow to predict potential interactions among the many stressors to which organisms are actually exposed and the resulting effects. Interactions can reduce overall damage or augment single stressor effects. Hence, the presence of co-stressors may alter the level at which organisms are likely to show radiation effects. From a risk point of view, knowing how co-contaminants/stressors might influence the radiosensitivity of organisms is therefore a pressing need. Research is required to contribute to the mechanistic understanding of how radiation effects in living organisms are modulated in the context of multiple stressors. Emphasis is on environmentally relevant combinations of stressors that interact such that synergistic effects are likely to occur with exposure to radiation or radionuclides. The occurrence of synergisms will have to be investigated at realistic radiation levels and realistic concentrations/conditions of other stressors. Given the multitude of potential stressors and combinations that exists in real exposure conditions, the approach to prioritise hypotheses, select stressor combinations and conditions is quintessential. Projects should be directed to the mechanistic understanding of the site where interactions occur: at the level of exposure, where interactions can take place in various processes (*e.g,*. uptake, internal distribution of the radionuclides), or at the level of effect (where interactions could be observed at the primary site(s) of disturbance or in regulation and signal transduction of the response of the organism following exposure). Dynamic and biology-based methods and approaches (*e.g.*, DEBtox, gene expression pathways) could contribute to mechanistic understanding. Multiple stressor research will benefit from field based studies and the evaluation of the results in a risk assessment context. The question of the robustness of screening values in a multiple stressor context should be considered.
European relevance	This multidisciplinary complex topic can build on the achievements of the STAR Network of Excellence and was selected as a high importance synergistic topic by ALLIANCE, MELODI and EURADOS. The research on this topic will help reduce uncertainties by taking into account environmentally relevant exposure conditions. The research is relevant to EURADOS as accurate dosimetry is a prerequisite for any robust dose-response relationships. Impact in communication to the public is expected by improving the capability of demonstrating the impact of ionising radiation in comparison to other environmental stressors.
Multidisciplinarity; Reference to the strategic research agendas (SRA)	This topic will support chemical and radiological environmental protection frameworks in a consistent way and will improve consistency for any environmental impact assessment. This research is highly multidisciplinary in nature and will benefit from interacting with ecotoxicology and biochemistry. -MELODI (Aug 2015): p.17: synergistic topic 1. -ALLIANCE (Sept 2013): p.27: challenge 2 – research line 3.2.2.3; p.34: challenge 3- research line 3.3.2.3. -NERIS (Apr 2014): p. 16: key topic 3.6; p.23: cross cutting issues.-EURADOS (May 2014):): p.7-13: vision 1 topics 1, 2, 3; p.22-25: vision 3 topic 1
Impact: decreased uncertainty	This research will complete the scientific foundation for fully integrating environmental and human protection frameworks under one generalised system (*i.e*. consistent between radiation and chemicals on one hand and human and environment on the other hand), which would be of much interest to regulators, industry and the public.
Impact: increased radiation protection	This research will demonstrate if radiation protection standards are robust and protective enough. Will provide robustness to any risk assessment, associated decisions and communication.
Impact: increased quality and reliability	Gaining knowledge on low dose effects under realistic exposure conditions and explaining clearly important and relevant results obtained to the public are needed to give people the power of informed choice and of making decisions knowing the level of risks associated to their living conditions for them and the future generations. Being able to clearly demonstrate the role of ionising radiation in comparison to any other environmental stressor is a must for being successful.
Feasibility	This research needs to implement an innovative approach and as such, is risky.

Annex 2. Overview of recently finished and started EU projects in research areas closely related to the ALLIANCE SRA.

COMET project (Coordination and iMplementation of a pan-European instrument for radioecology)

The EC FP7 COMET was funded to strengthen the pan-European research initiative on the radiological impact on man and the environment by facilitating the integration of the Research and Development activities in radioecology. COMET contributed to the realisation of the ambitions of the European Radioecology ALLIANCE by working on joint programming and implementation, building upon the foundations laid in this respect by the FP7 STAR NoE and the European Radioecological ALLIANCE (ALLIANCE).

An important research contribution within COMET was improving models for risk assessment and for emergency and post-accident situations. This focused on improving parametrisation of key processes controlling the transfer of radionuclides, with a specific emphasis on dynamic and mechanistic modelling approaches. The research was initially conducted within topical working groups on marine transfer modelling, forest radioecology, human food chain, NORM, wildlife transfer modelling and on particle behaviour. After an open call under the umbrella of OPERRA, these groups were complemented by two projects, FRAME (The impact of recent releases from the Fukushima nucleaR Accident on the Marine Environment) and RATE (RAdioactive particle Transformation procEsses), in which additional investigations on the mechanisms for radionuclide transfer in the Fukushima marine environment and on particle behaviour, respectively, further reduced the uncertainties associated with key transfer processes.

COMET dealt also with epigenetic changes and their possible role in adaptation and transgenerational effects by increasing understanding of the effects of chronic low-dose radiation and the possible contribution of epigenetic mechanisms to long-term and trans/multi-generational effects. It performed laboratory controlled exposure experiments to test hypotheses on the role of epigenetic changes in the alteration of physiological functions on laboratory models and field studies on autochthonous species to investigate epigenetic changes in wildlife within contaminated areas. Lastly, COMET promoted the exchange of knowledge and expertise by disseminating COMET activities, facilitating discussion of topical radioecological issues between researchers and users and developing training packages to maintain and enhance professional competence.

OPERRA-project HARMONE (Harmonising Modelling Strategies of European Decision Support Systems for Nuclear Emergencies)

The HARMONE project started December 1, 2015 and aims to reduce scientific, methodological and operational gaps identified in the strategic research agendas of the four European Platforms in the area of radiation protection and issued as TOPIC 2 of the OPERRA-2014 Call: “Spatial and temporal environmental modelling and human dose assessment after a nuclear accident”. This includes the following work activities

- Development of a knowledge data base and guidance that allows, according to the first event description, to propose a first management strategy to reduce doses and highlights potential issues for the dose assessment.
- Refinement of simulation models for all exposure pathways to obtain a better assessment of the total dose. This would include also a methodology for the regionalisation of the model to have assessments on all relevant scales.
- Development of guidelines for dose monitoring to back-up the first two steps and facilitate the refinement of the simulations.

In this respect, the HARMONE project addresses the following areas and topics of the NERIS SRA and the ALLIANCE SRA

- Aquatic modelling (NERIS key topic 2; ALLIANCE Challenge 1)

    - Test of runoff models and identify gaps therein
- Improvement of existing Decision Support Systems (NERIS key topic 3; ALLIANCE Challenge 3)
    - Support the customisation of the food chain and dose models to European conditions
    - Refinement of simulation models, e.g. introduce snow in the ADM, snow melting in ERMIN
- Data mining, information gathering and providing information to stakeholders and mass media (NERIS key topic 4; ; ALLIANCE Challenge 3)
    - Knowledge data base for the later phase scenarios
- Improving the decision making process (NERIS key topic 5; ; ALLIANCE Challenge 3)
    - Development of generic guidance on countermeasure strategies
    - Some ideas on monitoring strategies for model support

HARMONE is limited in resources and therefore will not result in new developments but more in the refinement of existing ones.

CONCERT CALL 1 - CONFIDENCE COping with uNcertainties For Improved modelling and DEcision making in Nuclear emergenCiEs

The H2020 CONFIDENCE Project aims to address existing gaps in several areas of emergency management and long-term rehabilitation. It concentrates on the early and transition phases of an emergency, but considers also longer-term decisions made during these phases. The work-programme of CONFIDENCE aims to understand and if possible with the given resources to reduce and cope with the uncertainty of meteorological and radiological data and their further propagation in decision support systems, including atmospheric dispersion, dose estimation, foodchain modelling and countermeasure simulations models. Consideration of social, ethical and communication aspects related to uncertainties is also considered. First attempts will be made to combine simulation with monitoring to help gaining a more comprehensive picture of the radiological situation. Decision making principles and methods will be investigated to understand the need for uncertainty handling in the decision making process. A comprehensive education and training programme is linked with the research activities.

CONFIDENCE is partially dealing with the two priorities from ALLIANCE :

-Environmental availability and impact of radionuclides in terrestrial, freshwater, estuarine, brackish and marine ecosystems (including human and non-human foodwebs) and their interactions with atmosphere, incorporating physical, chemical and/or biological processes. Validated process-based model with robust parameterisation, characterisation of variability and uncertainty, and guidance to obtain fit-for-purpose models which can satisfy the goals of fundamental research.

-Development of models/tools, and datasets for their calibration and validation and guidance to select and evaluate the effectiveness of different remediation strategies in long-lasting exposure situations (e.g. nuclear accidents, NORM/TeNORM).

CONCERT CALL 1 - TERRITORIES To Enhance unceRtainties Reduction and stakeholders Involvement TOwards integrated and graded Risk management of humans and wildlife In long-lasting radiological Exposure Situations

The TERRITORIES project targets an integrated and graded management of contaminated territories characterised by long-lasting environmental radioactivity, filling in the needs emerged after the recent post-Fukushima experience and the publication of International and European Basic Safety Standards. A graded approach, for assessing doses to humans and wildlife and managing long-lasting exposure situations (where radiation protection is mainly managed as existing situations) is being developed through reducing uncertainties to a level that can be considered fit-for-purpose. The overall outcome will be a first attempt to provide an umbrella framework, that will constitute the basis to produce, and disseminate, novel guidance documents for dose assessment, risk management, and remediation of

NORM and radioactively contaminated sites as the consequence of an accident, with due consideration of uncertainties and stakeholder involvement in the decision making process.

TERRITORIES is partially dealing with the two priorities from ALLIANCE

-Environmental availability and impact of radionuclides in terrestrial, freshwater, estuarine, brackish and marine ecosystems (including human and non-human foodwebs) and their interactions with atmosphere, incorporating physical, chemical and/or biological processes. Validated process-based model with robust parameterisation, characterisation of variability and uncertainty, and guidance to obtain fit-for-purpose models which can satisfy the goals of fundamental research.

-Development of models/tools, and datasets for their calibration and validation and guidance to select and evaluate the effectiveness of different remediation strategies in long-lasting exposure situations (e.g. nuclear accidents, NORM/TeNORM).