NERIS

European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery

# Strategic Research Agenda of the NERIS Platform

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NERIS

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## 1. FOREWORD

The NERIS Platform (The European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery) was established in June 2010 in Helsinki. The vision of the Platform was published in 2011 (http://www.eu-neris.net/).The Platform was established to be a forum where joint European arrangements for nuclear and radiological emergencies can be developed and improved in the future. The Platform addresses all notable trends, arrangements and capabilities in the area of response to and recovery from nuclear and radiological emergencies.

Since August 2012, the NERIS Platform is registered as a legal association under the French Law of the 1st of July 1901. Today, the NERIS association comprises 49 organisations, with 21 supporting organisations and is driven by a management board of 10 organisations. The participating organisations represent stakeholders with a wide range of backgrounds, e.g. authorities, emergency centres, research organisations and the academic community.

The main objectives of the NERIS Platform are to improve the effectiveness of current European, national and local approaches for preparedness concerning nuclear or radiological emergency response and recovery, promote more coherent approaches in Europe through the establishment of networking activities, maintain and improve know-how and technical expertise among all interested stakeholders in Europe by developing a supranational training programme, and to identify needs for further research and development and address new and emerging challenges.

The Platform intends to enhance confidence in the solutions, reduce overlapping work, produce savings in total costs of research and implementation, and make better use of existing competences and research infrastructures in Europe.

The NERIS Strategic Research Agenda (SRA) provides the basis for priorities regarding R&D (research & development), in particular the Key Topics to be dealt with in order to achieve the Vision. This document therefore communicates the future research & development needs, but will also be an instrument for creating synergies, co-operation and coordination internally between the NERIS participants and externally with activities taking place within the European Joint Programming for Radiation Protection Research and within other international forums.

## 2. INTRODUCTION

A total of 183 nuclear power reactors are operational in Western, Central and Eastern Europe today [1]. In addition to this, many other nuclear facilities, such as research reactors are located in Europe and radioactive transports are organized on a regular basis. Being aware that every man-made facility, equipment or activity is always at risk for malfunction or an accident, it is more than likely that bigger or smaller nuclear incidents and accidents will happen also in the future. Significant efforts are achieved for the safety of nuclear installations in Europe, but when the risk comes true it will have multidimensional consequences in the society. The accident at the nuclear plant Fukushima Daïchi has reinforced the concern of all stakeholders on this issue and calls for improving the safety as well as the preparedness for managing short and long term consequences of nuclear events. In addition, it demonstrated that accidents at large distances from Europe, 448 nuclear power reactors are operational worldwide [1], call also for response within Europe to protect European Citizens in the affected regions, to provide assistance to the affected countries and to monitor economic activities such as the import of contaminated goods.

Apart from nuclear facilities, there are thousands of smaller installations using radioactive sources and materials. Of course incidents and accidents in connection with them would have more limited radiological consequences compared with big nuclear facilities. However, sources could possibly be stolen or bought by persons with malicious intent, and applied in devices purposely designed to harm people and create anxiety and disruption, which links safety with security.

Nuclear and radiological safety and security have common goals and in the past 25 years, major progress has been made at the International, European, national and regional levels in the management of response to and recovery from nuclear and radiological emergencies. Notwithstanding the provisions now in place in most European countries and internationally, complacency would be misplaced and continuing vigilance remains important. Improvements, of a technical, organisational or political nature supported by important R&D efforts are still needed in emergency management. In addition, general technological evolutions such as the increasing computer power, the growth of social networks, big data and the availability of low cost radiation monitoring capabilities bring challenges for emergency management, not existing a decade ago.

The accident at the Fukushima 1 nuclear power plant in Japan in March 2011 proved that an event regarded as almost impossible was possible and a very small risk became reality. Fukushima accident also demonstrated that consequence assessments and actions were needed also in Europe although the accident itself happened far away from Europe. In connection of remote accidents European authorities and decision makers have to react to protect their own citizens staying close to the accident site. The more coherent the decisions are in different European countries the more confidence they arouse among the public.

Europe is a heterogeneous array of independent and sovereign countries having different cultural and political background and polity. The countries also have different threats as far as nuclear or radiological emergencies are concerned depending on their geographical location and distance from major nuclear installations. Therefore attempts to implement Europe-wide arrangements, in operational way, in the use of compatible systems and tools in radiation monitoring, decision making, and in communication between different actors is very complex. Interactions with scientific, technologic, economic and social areas and involvement of competent authorities at national and European levels are necessary. Thus, a full set of competencies is needed to address the challenges of conducting necessary actions in a nuclear or radiological emergency and recovery at local, national, regional and European levels.

R&D in the field of nuclear emergency preparedness, response and recovery including different disciplines is in the above mentioned context of utmost importance to further improve the operational management of nuclear and radiological threats.

## 3. FRAMEWORK OF THE STRATEGIC RESEARCH AGENDA (SRA)

An integral part of the mission of NERIS is to identify gaps and needs for further research and developments and addressing new and emerging challenges in the field of preparedness for nuclear or radiological emergency response and recovery. The Strategic Research Agenda (SRA) of NERIS, coordinated by the NERIS R&D Committee, identifies the research areas and topics important for improving the nuclear and radiological emergency management in the preparedness, response and recovery phase of an accident. An overview of the different phases considered and related terminology used within the SRA is given in Figure 1.

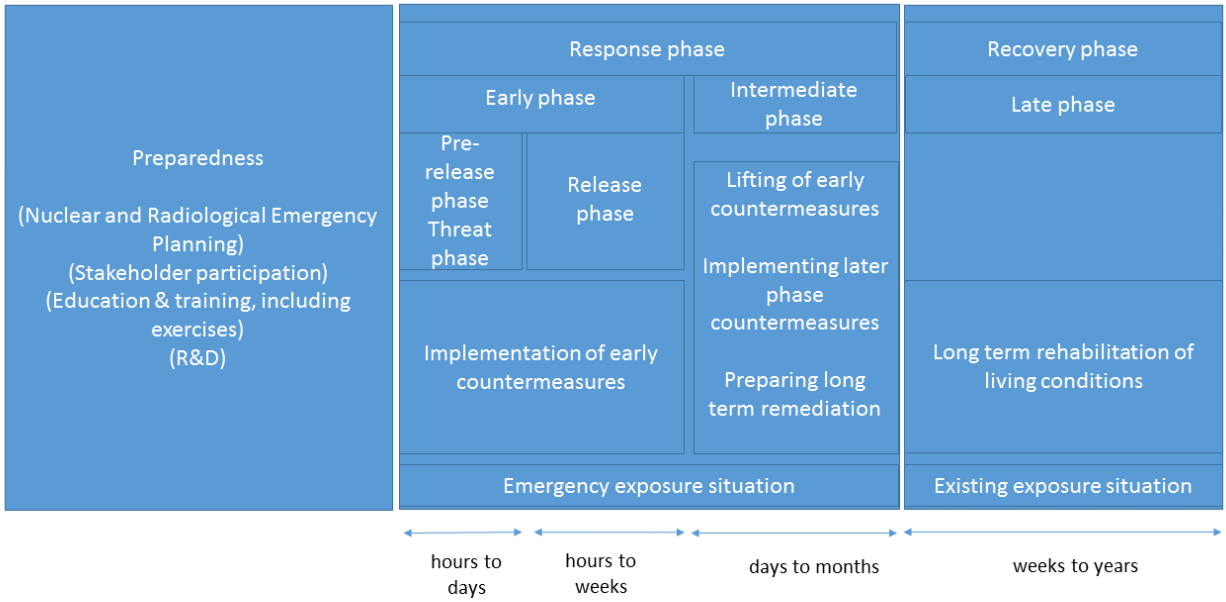


*Figure 1. The different phases and terminology used in emergency management and recovery. It has to be noted that different phases can take place in different locations at the same time, and some phases can be missing depending on the nuclear or radiological event.*

The NERIS SRA has a clear focus on **off-site** emergency preparedness, response and recovery, however not excluding links with on-site emergency preparedness and response. Emergency management has many different perspectives, but as a radiation protection platform, the NERIS SRA focuses on the radiation related aspects of nuclear and radiological emergency management, but including non-radiological factors such as socio-economical and ethical aspects and not excluding links with other perspectives.

The following threats were identified. These are in general considered as potential nuclear and radiological events for which emergency preparedness, response and recovery is required:

- Incidents and accidents (including criticality accidents) in Nuclear Installations (Power generation, research reactors, *etc.*), radioactive waste repositories;
- Transport accidents of radioactive material;
- Lost sources;
- Terroristic threats involving radioactive material/ionizing radiation;
- Military installations and operations (including submarines);
- Satellite return with radioactive source;
- Other events involving the non-controlled exposure or spread of radioactivity (Hospitals, Medical & Industrial Isotope Production Facilities, Space Weather, *etc.*)

Decision support systems, such as ARGOS and JRodos have been developed over the past decades and are regularly updated with new tools, developments and demands from end-users. They focus on simulation models for all phases of an emergency, impact assessment, countermeasure strategies, consequence assessment and application at various levels of decision making (local to national). Stakeholder engagement related to the evaluation of countermeasure strategies is an important aspect for the realisation of management options in the simulation models.

### 3.1. Process of development of the Strategic Research Agenda (SRA)

A short history of the NERIS SRA development is given in Annex 1. The current version of the NERIS SRA is based on:

- Discussions within the NERIS R&D Committee meetings. The actual composition of the NERIS R&D Committee can be found on the NERIS website ( http://www.eu-neris.net/ );
- Results and insights gained by past and running European projects [4] [5];
- Identified operational challenges: e.g. linked to the European Basic Safety Standards and international recommendations such as the ICRP. Operational and general challenges are also addressed in the NERIS working groups.
- Discussion and outcome of the NERIS working groups. Currently, the following NERIS working groups are defined (see http://www.eu-neris.net/ ):
  - Working Group N°1 on the practical implementation of the ICRP recommendations on emergency and rehabilitation;
  - Working Group N°2 on processes and tools for emergency and rehabilitation preparedness at community level;
  - Working Group N°3 on contaminated goods;
  - Working Group N°4 on Information, Participation and Communication;
- Findings from work presented at the NERIS Workshops, especially the 2015 Milano Workshop and the 2017 Lisbon Workshop [6] [7];
- Findings from work presented and meetings during the 2016 Radiation Protection Week in Oxford.

The current update of the NERIS SRA is largely done in context of the 'CONCERT-European Joint Programme for the Integration of Radiation Protection Research' under Horizon 2020 (http://www.concert-h2020.eu/ )

### 3.2. Identifying, characterizing and prioritizing of topics of SRA

Topics included in this version of the SRA are largely based on the previous version (SRA version 2 of April 2014) but with an important change in how they are structured. The current structure starts from the definition of areas which are identified as equally important for further development in view of the overall goals defined in the previous sections. In this way 3 key areas are defined with in total 10 key topics. An overview is given below, a detailed discussion of the key topics is found in the next section.

#### Research area 1. Challenges in radiological impact assessment during all phases of nuclear and radiological events

Within this area all research challenges are grouped to improve the radiological impact assessment in all phases of a nuclear or radiological event. It includes improvements in modeling, monitoring and the combination of both (data assimilation for e.g. source term estimation) for human dose and environmental impact assessment. This includes research related to real-time impact assessments during the response phase, dose reconstruction in a later phase, Uncertainty quantification of the impact assessment and visualization is an integral part of it.

### Research area 2. Challenges in countermeasures and countermeasure strategies in emergency & recovery, decision support & disaster informatics

This research area covers all challenges related to decisions on and implementation of protective actions during an emergency. It comprises countermeasures and countermeasure strategies including lifting of countermeasures and transition from emergency to existing exposure situation, formal decision support, including multi criteria analyses and disaster informatics, the study of the use of information technology in the preparation, mitigation, response and recovery phase of a nuclear or radiological disaster.

### Research area 3. Challenges in setting-up a trans-disciplinary and inclusive framework for preparedness for emergency response and recovery

The third research area focuses on the overall emergency response and recovery framework, including reference levels, stakeholder engagement, the involvement of the public, communication research and non-radiological perspectives such as health, ethical and societal aspects. Within this area also multi-disciplinary research to cope with incomplete information, typical for emergency situations, and improve decisions under high uncertainty is integrated.

## 4. KEY TOPICS OF THE STRATEGIC RESEARCH AGENDA (SRA)

### Research area 1. Challenges in radiological impact assessment during all phases of nuclear and radiological events

The following key topics and subtopics are defined:

| Area 1. Key topics | Sub-topics |
|---|---|
| **Key topic 1. Improved modelling** | Atmospheric transport and dispersion modelling (ATM/ADM) |
| | Hydrological transport modelling |
| | Dose modelling |
| | Environmental modelling |
| **Key topic 2. Improved monitoring** | Monitoring techniques and strategy |
| | Data collection & sharing |
| | Optimisation |
| **Key topic 3. Data assimilation** | Improved source term estimation |
| | Improved impact assessment |
| | Big Data, Data fusion |

## Key topic 1. Improved modelling

**Objective:** To make more reliable and accurate forecasts on dispersion of radioactive materials in different media, human radiation doses and effects on the environment

**Expected results:** Models and Decision Support Systems (DSSs) with extended capabilities.

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent & running projects and other SRA's |
|---|---|---|
| **Atmospheric transport and dispersion modelling (ATM/ADM)** | ATM/ADM at different scales and complexity is the basis for the impact assessment of releases to the atmosphere as well in the planning phase (preparedness), the response phase and for dose reconstruction. It includes forward (prognostic) modelling as well as inverse modelling (e.g.; source term reconstruction). Currently following challenges are identified:<br>• **Modelling approaches for complex settings (urban or confined spaces):** development of models for the intentional or accidental releases of radiological or nuclear material in complex environments (E.g.; urban, near range). Combination of complex (e.g.; CFD-Computational Fluid Dynamics) modelling with more simple approaches.<br>• **Non-conventional emissions:** extension of capability of dispersion models in existing DSSs to treat detailed information for particular types of sources (e.g.; explosions, two-phase, aerosol sprays, fires, general short-term releases), and to simulate dispersion of particular substances (aerosol, phase-changing, particles with spectrum of different size, chemical transformations).<br>• **Fine-tuning modelling parameters and algorithms:** Extension of capability of dispersion models in DSSs to treat phenomena that currently are not considered, in particular wet deposition by snow. | PREPARE,<br>HARMONE,<br>CONFIDENCE |

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent & running projects and other SRA's |
|---|---|---|
| | • **Uncertainty quantification:** ensemble calculations, Quantification / assessment of ATM/ADM uncertainties: uncertainties due to input meteorological data, through the use of e.g., meteorological ensemble forecasts (CONFIDENCE project); uncertainties due to other input data (source term, physical properties of dispersed material, etc.); uncertainties due to modelling assumptions / approximations / parameterizations; uncertainties due to natural variability of the atmosphere / assessment of probability density functions / highest or most probable expected values for concentration, exposure, etc.; ensemble dispersion modelling | |
| **Hydrological transport modelling** | Dispersion modelling in different hydrological systems is the basis for impact assessments of liquid releases and atmospheric releases with deposition resulting in aquatic contaminations in the planning phase (preparedness), response phase, for reconstruction and for guiding recovery. Currently following challenges are identified:<br>• **Urban hydrology**<br>  ○ Contamination of urban fresh water supply: Development and implementation in existing DSSs of models to predict the activity concentrations in the urban fresh water supply system due to contamination of freshwater basins from radioactive cloud<br>  ○ Waste water from urban decontamination: Development and implementation in existing DSSs of models to estimate the activity concentration in the waste water due to washout of deposited radionuclides in urban areas<br>  ○ Better representation of wash-off processes linked to actual or prognostic information on precipitation events (plus essentially the same for food producing areas). | PREPARE |

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent & running projects and other SRA's |
|---|---|---|
| | • **Models for coastal areas:** Development and implementation of relocatable hydrodynamic 3D models of coastal circulation for real time predictions of transport of radioactivity in the coastal zone<br>• **Coupling with weather forecast models:** Coupling with weather forecast models to provide forcing for wave models for running in the automatic<br>• **Runoff to sea:** Coupling with runoff (land to sea) models for the emergency phase calculations in the case when the power installation is located near the coast – combination with deposition maps of fall-out on the land near the coast | |
| **Dose modelling** | Dose models aim at estimating the dose to humans (retrospective and/or predictive: e.g.; first year dose) in different environments (urban, forest, …) and conditions (normal living, applying certain countermeasures, …).<br>• Intercomparison between different models<br>• Evaluation of dose models along available data from past accidents<br>• Extending dose modelling to a wider range of radiological events | HARMONE: ERMIN<br><br>Link EURADOS |

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent & running projects and other SRA's |
|---|---|---|
| **Environmental modelling** | Modelling the behaviour and the effect of radioactive substances in the biosphere. It comprises source term and release, transport through the abiotic part of the biosphere, food chains, intake and distribution in humans and the effect of radiation on living organisms. Here are excluded the atmospheric and hydrological dispersion.<br><br>Currently following challenges are identified:<br><br>• **Customising of the existing environmental models into the regional circumstances in Europe (close co-operation with the Radioecology Alliance):** revision of model parameters as FDMT[1] (partly performed in the HARMONE project)<br>• **Local radio-ecological models:** Development of local radio-ecological models interlinked with monitoring information and the more global and food chain dose models, integrated in general DSS<br>• **Multiple stressors:** Models able to tackle multiple stressors in the assessment of countermeasure strategies and in relation to malicious dispersion (CBRNE) | PREPARE<br><br>TERRITORIES<br><br>Link ALLIANCE |
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[1] FDMT software : Food Chain and Dose Module for Terrestrial Pathways

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent & running projects and other SRA's |
|---|---|---|
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[2] FDMT software : Food Chain and Dose Module for Terrestrial Pathways

## Key topic 2. Improved monitoring

**Objective:** Improve monitoring capabilities and efficiency in emergency and post-emergency/existing situations

**Expected results:**

- Optimized monitoring and monitoring strategies
- Improved link between modelling efforts and monitoring efforts

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and current running projects and other SRA's |
|---|---|---|
| **Monitoring techniques & strategies** | • **The further development and integration of techniques and methods** for the measurement of radiation and radioactivity, such as drones, small detector devices and smartphone apps, retrospective dosimetry, etc …will become very important in the next decades in nuclear and radiological emergencies.<br>• **The further development and integration of existing techniques** of key importance, such as whole body, thyroid, lung counting<br>• **Optimised use of monitoring resources**, including mobile units and trans-border issues. Use of new monitoring technologies.<br>• **Development of processes and tools for integrating the monitoring results** from experts and lay people into a common operational picture (monitoring crowdsourcing) Information fusion (radiological and non-radiological) | Eurados |
| **Data collection** | • **Data collection for model validation:** Availability of data are crucial for validating models, such as for example a program for resuming measurements of Chernobyl contaminants on different surfaces (and if possible Fukushima-measurements). Other data from routine releases, small incidents or obtained by controlled experiments (e.g.; RDD's) for model validations. Implementation of new experimental campaigns.<br>• Establish an **overview** of / **guidance** on which data should be collected **for recovery operations** to be considered.<br>• **New meteorological data:** optimised use of new meteorological instruments (E.g.; Lidar, ..) with evaluation of application to improve modelling | Harmone, |

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and current running projects and other SRA's |
|---|---|---|
| **Optimisation** | • **Optimized use of specific monitoring resources** for nuclear and radiological emergencies (early warning networks, mobile teams, laboratories, …), in function of protective actions and decision support.<br>• **Optimization of early warning networks and other monitoring resources**, including aerial surveys taking into account new technologies, such as the potential use of drones. | DETECT |

## Key topic 3. Data assimilation

**Objective**: Source term estimation based on monitoring and inverse modelling, combining monitoring and modelling effort to decrease uncertainty on impact assessments

**Expected results**: better source term reconstruction and operational data assimilation techniques, reduced uncertainty allowing improved protective actions and countermeasure strategies.

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| **Improved source term estimation** | • **Rapid analytical tools:** Development of rapid analytical tools in combination with mobile and automated equipment to assess source terms and contamination levels in a short time frame<br>• **Advanced source term estimation methods:** Further development of advanced operational source term estimation computational methods – including unknown source location - combining inverse modelling with data assimilation of observations. Of special interest are operational data assimilation methods for estimation of unknown source location and strength in urban (i.e., complex) environments. Research is needed on the effects of modelling and measurement uncertainties that enter in the data assimilation methods.<br>• **Combined ensemble dispersion modelling with data assimilation** | |
| **Improved impact assessment** | • **Data assimilation models:** Development of operational data assimilation methods and models for doses and concentrations (aiming at "correcting" parameters other than source term). In particular for areas without dense monitoring and in the time when monitoring is still limited: quantification of uncertainties in the assessed concentrations and doses depending on the amount and quality of available observations; integration of such methods in DSS. | |
| **Big data, data fusion** | • **Employment of advanced Information Technology instruments** to develop computational structures (e.g., platforms, aggregators) that would allow storing, processing and combining large volumes of heterogeneous and of different origins data (modelling, observational) for purposes like unknown source term estimation, radiological impacts assessment, etc. | |

## Research Area 2. Challenges in countermeasures and countermeasure strategies in emergency & recovery, decision support & disaster informatics

The following key topics and subtopics are defined:

| Area 2. Key topics | Sub-topics |
|---|---|
| **Key topic 4. Countermeasures and countermeasure strategies** | Countermeasures/management options |
| | Development of protection strategies or portfolios |
| | Implementation and monitoring of countermeasures, including lifting of countermeasures |
| | Consequence assessment and optimisation of countermeasure strategies |
| **Key topic 5. Formal decision support** | Decision making, methods and tools |
| | Decisions under high uncertainty |
| **Key topic 6. Disaster informatics** | Analytical platform |
| | Knowledge database |
| | New generation Decision Support Systems |
| | Virtual and augmented reality |

## Key topic 4. Countermeasures and countermeasure strategies

**Objective:** Development of flexible and user friendly simulation models that allows the definition of sensible countermeasure strategies by combining individual management options. In addition improvement of understanding of processes related to countermeasures (e.g. movement of contamination, parameter selection for different environment). Models have to be improved to allow also for estimation of termination of countermeasures based on criteria that have to be defined. Identification, characterisation and assessment of the response of the actions (management options) and strategies to mitigate the consequences of a radiological or nuclear threat.

**Expected results:** Improved countermeasure models fit for purpose

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| **Countermeasures & countermeasure strategies** | • **Revision of the European handbooks:** Generic revision and revision of European handbook sections (creation of addendum) for consideration of malicious dispersion scenario's<br>• **Countermeasure strategy preparedness:** Development of sustainable preparedness strategy at local, national and European level, based on the analyses of countermeasures for relevant accident scenarios, ensuring that parameters governing the radiological consequences can be identified in time to enable optimized remediation | |
| **Implementation and monitoring of countermeasures, including lifting of countermeasures** | • **Development of tools for the usage at the local level:** Analyse the need of the local actors in respect to local-national interaction, for implementation of mitigating actions in response and recovery phases. Based on the work under NERIS-TP, prepare a list of requests and define priorities for tools development for the usage at local level, compatible to locally used software tools and national ones (notably GIS)<br>• **Timeline of implementation**<br>• **Termination and withdrawal of protective measures**: Development of framework and guidance for setting up criteria to lift in particular early phase countermeasures. This includes guidelines for returning people but also compensations schemes. | |

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| | • **Feedback on decision / action effectiveness:** Feedback on the use of methods and tools to monitoring of situation and evaluate the effectiveness of protective actions. simple measurement strategies are needed to secure that CMS implementation is optimised in practice. If this is not done, a 'paper-optimised' strategy may well fail completely in practice. | |
| **Consequence assessment and optimisation of countermeasure strategies** | • **Consequence assessment:** Establishment of evaluation criteria and their metrics to estimate the consequences of the action alternatives; qualitative and quantitative methods; consideration of the uncertainty.<br>• **Optimisation:** Development and application of criteria and methods to optimise the management options and/or the protective strategies. | |

## Key topic 5. Formal decision support

**Objective:** Improvement of the decision making process by using tools to structure the process and support the selection of appropriate options

**Expected results:** new methods and tools that can be used by decision makers at all levels of the decision making process

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| **Decision-making, methods and tools** | Structuring the decision processes at national, regional and local levels with the help of formal decision aid tools, such as multi-criteria analysis.<br><br>Development of guidance on the use of DSS based on feedback from stakeholder processes and from Fukushima experience in emergency response and recovery | |
| **Decision under high uncertainty** | **Assessment and communication of uncertainties:** Investigation of data uncertainties (model or monitoring results), how they are transferred in chains of successive models and how they can be communicated or presented, e.g. in model results and in DSS to help decision-makers to understand the radiological situation.<br><br>This includes also work on model sensitivity, validity of model results and inter-comparisons of models and measurements | CONFIDENCE |

## Key topic 6. Disaster informatics

**Description:** Study of the use of information and technology in the preparation, mitigation, response and recovery phases of disasters and other emergencies.

**Objective:** Development of databases and methods to support decision making when little information is given and assessments with simulation models are very uncertain. This should be based on historic experience and/or scenarios that can be processed by DSS. Further to this, a coupling of the strategic tools (e.g. DSS) with tools from first responders (e.g. Command and Control) that have to carry out recommendations is of interest.

**Expected results:** Knowledge databases and tools that use existing knowledge to support decision making when little information is available and also supports the first responder in considering resources when recommending countermeasures.

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| **Analytical platform** | • **Access/exchange platform** collecting and distributing results from governmental and non-governmental organisations | PREPARE |
| **Knowledge database** | • **Development of a knowledge database** with scenarios and response, including lessons learned from historic events and decision support tools developed in international handbooks such as the European handbooks<br>• **Development of information material** of general nature on radiation emergencies, countermeasures and recovery based on lessons learnt from past events | Partly in PREPARE |
| **DSS interface, output and coupling** | • **Tailor the output of DSS's to the user's needs:** Modification of existing interface of DSS's to allow easy selection of specific output in particular calculation points and export of results to other formats<br>• **Coupling** of the existing strategic DSS such as ARGOS and RODOS **to Command and Control (C2) systems** | |
| **Virtual and augmented reality** | • **Serious gaming:** Development of serious gaming tools to train the emergency actors | |

## Research area 3. Challenges in setting-up a trans-disciplinary and inclusive framework for preparedness for emergency response and recovery

The following key topics and subtopics are defined:

| Area 3. Key topics | Sub-topics |
|---|---|
| **Key topic 7. Emergency response and recovery framework, including reference levels** | Implementation of BSS including reference levels and relation with operational levels |
| | Long term management |
| | Contaminated goods |
| **Key topic 8. Stakeholder engagement, involvement of the public & communication** | Stakeholder engagement processes including the public |
| | Citizen Science |
| | Communication |
| **Key topic 9. Integrated emergency management – non-radiological aspects (health surveillance, ethical aspects, economic issues, etc.)** | Health Surveillance |
| | Ethical aspects |
| | Socio-economic factors |
| | Integrated surveillance and monitoring |
| | Radiological protection culture for emergency preparedness and post-accident management |
| **Key topic 10. Uncertainty and incomplete information handling** | Dealing with uncertainties |

## Key topic 7. Emergency response and recovery framework, including reference levels

**Objective:** Development of radiological decision criteria and implementation frameworks to improve and ensure the sustainability of emergency response and recovery management, addressing societal and ethical issues

**Expected results:** Operational radiological decision criteria and guidance for implementation taking into account societal and ethical issues, and management framework for improve sustainable emergency response and recovery.

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| **Implementation of BSS including reference levels and relation with operational levels** | • Development of socially and scientifically robust Operational Intervention Levels (OILs) and radiological decision criteria for the transition and longer-term management<br>• Investigate the potential of simulation models to set up possible radiological decision criteria and reference levels early in the emergency to support decisions such as temporary or permanent relocation<br>• Development of methodology and tools to better address actual and future risks and vulnerabilities and their management in the implementation of countermeasures<br>• Adapt decision support systems to implement results from the screening<br>• Development of governance approaches at local, national and international levels to better integrate radiation protection into a broader environmental protection framework | |

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| **Long term management** | • Develop long term, sustainable communication models and stakeholder engagement frameworks to improve public health and well-being<br>• Development of decision criteria for lifting of countermeasures and transition from emergency to existing exposure situations<br>• Test the guidance on communication and participatory processes in stakeholder groups and improve the framework | |
| **Contaminated goods** | • Further analysis on the implications of trade and use of goods from contaminated territories in the perspective of a sustainable recovery<br>• Development of simulation models that allows the quantification of potential doses from usage of contaminated goods<br>• Development of guidance on management strategies for goods, addressing health, societal, economic and ethical issues | |

## Key topic 8. Stakeholder engagement, involvement of the public & communication

**Objective:** Improve the efficiency and social robustness of emergency response. Ensure that stakeholders are involved in decisions that impact on their lives

**Expected results:**

- Maintain the inclusion of social aspects of emergency response and stakeholder engagement
- Greater recognition of the importance of stakeholder and public engagement
- Improve understanding of the factors and criteria for successful stakeholder engagement
- Improved preparedness for media and social media communication

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| **Stakeholder engagement processes including the public** | • **Defining stakeholders and framing problems:** Identifying roles, constraints, responsibilities and cooperation among European/national/regional/local levels in order to improve the Preparedness Plans for each phase of the emergency and post-accident<br>• **Stakeholder engagement database:** Database on experiences of stakeholder engagement in preparedness and response highlighting lessons learned and guidance for best practice, taking into account the national context<br>• **Public participation and dialogue:** Develop guidance on information and participation of population, increasing effectiveness if multiple source of information may compete or conflict<br>• **Analysis of societal needs for an evaluation of legal instruments and governance frameworks** supporting access to information, public participation and access to justice in relation with RP issues | |

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| | • **Examination, assessment and design of stakeholder and public participation tools and methodologies** for emergency and post-accident emergency situations. Roles and rules of stakeholders in the engagement process. Motivational factors, ethics and link between theory and practice<br>• Preservation of knowledge and experience of local stakeholders' (e.g.; local community, schools, citizens) involvement and participation. Community research and tracing for development of participation culture in relation to different exposure situations | |
| **Citizen Science** | • Potential and pitfalls of citizens involvement in knowledge production for radiological risk governance | |
| **Communication** | • **Assessment of the mechanisms by which the public gains information:** Investigate the conditions and means for pertinent, reliable and trustworthy information to be made available to the public in due time according to its needs in the course of nuclear emergency and post-emergency contexts<br>• **Trustworthiness of information: Development and usage of social media and other information sources in emergency response:** how social media can be used to improve emergency response and better communicate and cooperate with the public<br>• **Role of social media link:** Links between perception of radiological risk and radiation protection behaviour, or individual strategies to cope with perceived risk in relation to radiation exposure, using both cross-sectional and longitudinal studies focusing on one or more of these aspects:<br>o different exposure context (workers, population living in areas affected by radiological contamination);<br>o different time scales (e.g.; different generations); | PREPARE |

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| | ○ cultural context;<br>○ socio-economic issues of behaviour change.<br>○ Social and traditional media impact on perception of radiological risk and general well-being linked to radiation exposures. This includes the influence of citizen journalism on radiation protection behaviour in different exposure situations and developing models for integrating scientific journalism in radiation protection?<br>• Developing long term communication models to improve radiation protection culture and public well-being in long term exposure situations.<br>• Use and perception of technical information and risk estimates in communication with various publics (lay people, experts, informed civil society).<br>○ Media communication about ionizing radiation, in particular low radiation doses and related uncertainties in the field of radiological protection including inter-media agenda setting in different exposure situations. | |

## Key topic 9. Integrated emergency management – non-radiological aspects (health surveillance, ethical aspects, economic issues,…)

**Objective:** Better addressing non-radiological aspects for developing guidance and framework to improve emergency response and recovery management

**Expected results:** Improved knowledge on the role of non-radiological aspects in emergency response and recovery, and procedures and guidance for the development of an integrated approach.

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| **Health Surveillance** | • Development of procedures for health surveillance including sampling of population and dose reconstruction and involvement of stakeholders<br>• Socio-psychological and economic aspects of medical follow-up after accidental or other exposures. | SHAMISEN, link with MELODI |
| **Ethical aspects** | • Ethical aspects of crisis situations, particularly ethical questions of evacuation, and post-accident management ("emergency ethics" vs. "normal ethics"), and the transition from emergency to existing radiation exposure situations.<br>• **Compensation:** Ethical perspective of compensation for damage incurred due to various situations of radiation exposure and differences among countries.<br>• Ethical basis and values underpinning risk communication about ionizing radiation exposures | |
| **Socio-economic aspects** | • **Public behaviour response analyses:** Understand how the population reacts and which information related to the behaviour of the population can be used by local-national tools to improve the response<br>• **Assessment of factors important for social trust in emergency situations:** Development of methods and procedures for analysing the information flow related to social trust including traditional information sources as well as social media and modern IT-based structures | |

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| | • Comprehensive approaches to studying the perception of radiological risk and environmental remediation actions in post-accident and existing exposure situations<br>• The interplay of psychological aspects associated with radioactivity, social environment and radiation protection behaviours.<br>• Perception of radiological risks from low doses of radiation, accounting for cultural differences in routine, emergency and other exposure situations.<br>• Development of socio-economic valuation and multi-criteria decision aid methods to formally structure the evaluation and integration of radiological and non-radiological factors for different ionising radiation exposure situations | |
| **Integrated surveillance and monitoring** | • Investigate connections between issues of health surveillance, human dose assessment, environmental monitoring and food monitoring from the point of view of institutions and local populations in the emergency and recovery phases<br>• Investigate connections between these different dimensions of surveillance, healthcare and the development of radiation protection culture<br>• Develop guidance on the way to set up comprehensive surveillance and monitoring systems articulating health, body, environment and food surveillance and healthcare, taking into account the potential of citizen-based monitoring<br>• Test the guidance with local and national stakeholders on the way to set up comprehensive surveillance and monitoring systems articulating health, body, environment and food surveillance and healthcare, taking into account the potential of citizen-based monitoring | |

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with recent and running projects and other SRA's |
|---|---|---|
| **Radiological protection culture** | • The role of RP culture, in particular<br>o The contribution of RP culture in the implementation and improvement of the protection "system";<br>o How RP culture can improve health and well-being of populations?<br>Practical achievements from developing / building a RP culture (impact on level of exposure, protective actions, decision making processes,…)<br>• Development of tools, methods, processes to build, maintain and transmit RP culture<br>o Needs and concerns of stakeholders regarding RP culture, with attention to the development of participatory tools and low dose exposure situations.<br>o Development of tools / methods / processes to enhance RP culture in specific fields: emergency and late phase nuclear accident preparedness, NORM activities, Radon exposure, paediatric imaging<br>o Processes to maintain/ transfer RP culture through generations;<br>o Guidance for enhancing RP culture for specific publics (communities around nuclear installations, schools, patients, pregnant women, medical doctors) | |

## Key topic 10. Uncertainty and incomplete information handling

**Objective:** Improve the capabilities to perform sensible and robust decisions under high uncertainty. This includes communication and visualisation of uncertainties in models results but also the consideration of how uncertainties are used when making decisions

**Expected results:** Improved communication tools to present uncertainties in model results and tools and methods to include this information in the decision making process.

| Sub-topic | Description and current research challenges within this (sub)topic | Relation with current projects and other SRA's |
|---|---|---|
| **Dealing with uncertainties** | • Investigating overall uncertainties and how they can be communicated, e.g.; in model results and in decision support systems to help decision makers to understand the radiological situation.<br>• Investigate media communication about ionizing radiation, in particular low radiation doses and related uncertainties in the field of radiological protection including inter-media agenda setting in different exposure situations.<br>• Investigate how local actors and non-institutional stakeholders make sense of uncertainty in their own decision-making processes and what governance mechanisms can facilitate these processes.<br>• Identify information that should be considered for decision making in the various phases of an emergency;<br>• Investigate how decisions taken under high uncertainty can be communicated to media and general public<br>• Develop tools and methods for a two-way communication of uncertain information between experts and non-experts<br>• Develop education and training material for decision makers on uncertainty management<br>• Review the developments from the first decade and develop further needs for improved communication of uncertainties<br>• Investigate to which extent serious gaming can be used in communication of uncertainties | CONFIDENCE<br><br>TERRITORIES |

# 5. CROSS-CUTTING ISSUES

## 5.1. Safety and security related activities

Radiation and nuclear safety and radiation and nuclear security have a common goal — the protection of people, society and the environment. In both cases (safety and security), such protection is achieved by preventing a large release of radioactive material. Many of the principles to ensure protection are common, although their implementation may differ. Moreover, many elements or actions serve to enhance both safety and security simultaneously. For example, the containment structure at a nuclear power plant serves to prevent a significant release of radioactive material to the environment in the event of an accident, while simultaneously providing a robust structure that protects the reactor from a terrorist attack. Similarly, controls to limit access to vital areas not only serve a safety function by preventing or limiting exposures of workers and controlling access for maintenance to qualified personnel, but also serve a security purpose by inhibiting unauthorized access by intruders.

The IAEA defines safety and security in the following way (IAEA 2007).

- **(Nuclear) safety:** "The achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards."
- **(Nuclear) security:** "The prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities."

Stemming from their different historical roots, the areas of safety and security have long been treated within separate research communities with their own terminologies and methods. But since almost all systems today are connected to global networks, safety and security have become very much interdependent, meaning that safe systems also need to be secure and vice versa. Recent terrorist events have served as a catalyst for the development of an array of new nuclear security arrangements. Although concern about malicious acts involving nuclear installations is not new, recent terrorist events have demonstrated that an attack on a nuclear facility might be attempted and that terrorists have formidable capabilities and dedication. This has led to an increased focus on defences against terrorists at nuclear facilities, as well as at other critical infrastructures. The development of revised security arrangements arises at a time when the public expects high standards of nuclear safety and security to be met. The challenge in meeting these expectations is predicted to grow in light of the interest in the new construction of nuclear power plants. In the Seventh Framework Programme (FP7) of the European Commission, security related research is centred in the Security Programme and radiation and nuclear safety research in the Euratom Programme (http://cordis.europa.eu/fp7/home_en.html ).

As noted above, the fundamental goal of safety and security actions is the same — the protection of people, society and the environment. The acceptable risk is presumptively the same whether the initiating cause is a safety or a security event. Moreover, the philosophy that is applied to achieve this fundamental objective is similar. Both safety and security typically follow the strategy of defence in depth — that is, the employment of layers of protection. The fundamental nature of the layers is similar. Priority is given to prevention. Second, abnormal situations need to be detected early and acted on promptly to avoid consequent damage. Mitigation is the third part of an effective strategy. Finally, extensive emergency planning should be in place in the event of the failure of prevention, protection and mitigation systems. The steps taken to provide protection against malicious acts incorporate specific features to ensure physical protection, but also rely on provisions that may have been installed for safety reasons.

NERIS Platform follows and recommends the R&D activities both in the safety and security areas and encourages scientists in these areas to collaborate with each other to achieve the best possible impact of research in nuclear and radiological emergency management.

## 5.2. Collaboration with other platforms

The NERIS Platform creates close co-operation relationships with other research platforms in the areas of radiological protection and nuclear safety in Europe. It is of special importance to follow R&D and collaborate in the areas of radioecology, biological effects of exposure to ionizing radiation and epidemiology, and dosimetry and medical issues. This is guaranteed by the integration and active involvement of NERIS in the 'CONCERT-European Joint Programme for the Integration of Radiation Protection Research' under Horizon 2020. NERIS also signed in 2013, a Memorandum of Understanding with the European research platforms in the domain of radiation protection (MELODI, ALLIANCE and EURADOS). In addition, for developing and implementing its SRA, NERIS has established interactions with different European and International organisations involved in radiation protection. The main research platforms and organisations interacting with NERIS are the following:

**European Radioecology Alliance**, (http://er-alliance.eu/ ) was founded in 2009 to strengthen European R&D in the area of radioecology. Radioecological studies are of special importance to assessment and management of nuclear or radiological emergency response and recovery, notably for developing Decision Support Systems (DSS) and addressing scientific issues associated with environmental contamination and countermeasure strategies. Reliability of environmental models used in emergency and recovery depends on radioecological parameters incorporated in the models. The Radioecology Alliance focuses not only on radiological protection of humans, but also on protection on wildlife. This aspect has to be taken into account in nuclear and radiological emergencies.

**MELODI** (Multidisciplinary European Low Dose Initiative, http://www.melodi-online.eu/ ) is an European Platform dedicated to low dose radiation risk research, founded in 2010 as a registered association with currently 30 members. MELODI aims at identifying R&D priorities for Europe in its field of competence and seeking the views of stakeholders on the priorities for research, keeping them informed on progress made, and contributing to the dissemination of knowledge. Since MELODI focuses on better understanding the health effects of exposure to low dose ionising radiation, its work is directly linked with the work of NERIS when protective measures in response to and recovery from nuclear and radiological emergencies are discussed. NERIS closely follows the work of MELODI and investigates how new findings of MELODI could be implemented in the European emergency management procedures.

**EURADOS** (European Radiation Dosimetry Group, http://www.eurados.org) is a network of more than 60 institutions and more than 500 scientists from the European Union, Switzerland, Eastern and Central Europe. It serves the promotion of research and development and European cooperation in the field of the dosimetry of ionizing radiation. The scope of EURADOS includes the fields of radiation protection, retrospective dosimetry, environmental radiation monitoring, radiobiology, radiation therapy, diagnostic and interventional radiology. Its activities promote technical development and its implementation into routine and contribute to compatibility within Europe and conformance with international practices. Dosimetry and monitoring issues are part of the management of emergency and recovery. NERIS follows the current developments in this field to improve preparedness.

**EURAMED** (European Alliance for Medical Radiation Protection Research), created in 2015, represents a consortium of associations involved in the application of ionising radiation in medicine, with the goal of jointly improving medical care and its radiation protection issues through sustainable research efforts. The main objective of this collaboration is improve the application of ionising radiation in medical care by developing and exploring common research strategies and by actively promoting the translation of results into clinical practice. Several topics have to be considered with EURAMED for better addressing medical

issues in the case of a nuclear accident. NERIS is currently engaging a discussion with EURAMED in this perspective.

**HERCA** (association of the Heads of European Radiological protection Competent Authorities, http://www.herca.org/) is a collaboration forum of the European radiation protection authorities, founded in 2007. HERCA has recognized the need for a more harmonised approach with regard to the management of nuclear and radiological emergency situations as a top priority. HERCA has also recognised that the events at the Fukushima Daiichi NPP in March 2011 dramatically illustrate that similar needs for a common understanding and, whenever possible, a common approach in the field of nuclear emergency response also exist for accidents happening even at great distance from Europe. National radiation protection authorities are the key players in nuclear and radiological emergencies and therefore the objectives of HERCA and NERIS are common. NERIS is the forum where new methods and tools are developed and the radiation protection authorities, among the others, take care of implementing them. Therefore it is of primary importance that these two forums work closely together.

**UNSCEAR** (The United Nations Scientific Committee on the Effects of Atomic Radiation, http://www.unscear.org/unscear) was established by the General Assembly of the United Nations in 1955. Its mandate in the United Nations system is to assess and report levels and effects of exposure to ionizing radiation. Specific reports on Chernobyl and Fukushima follow-up are prepared regularly by UNSCEAR, which are of interest for NERIS.

**ICRP** (International Commission on Radiological Protection, http://www.icrp.org), created in 1928, helps to prevent cancer and other diseases and effects associated with exposure to ionising radiation, and to protect the environment. ICRP is an independent, international organisation with more than two hundred volunteer members from approximately thirty countries across six continents. These members represent the leading scientists and policy makers in the field of radiological protection. ICRP has developed, maintained, and elaborated the International System of Radiological Protection used world-wide as the common basis for radiological protection standards, legislation, guidelines, programmes, and practice. NERIS is recognised as liaison organisation by ICRP and participates each year to the exchange meetings to identify the main challenges for the application of the radiological protection system in emergency and recovery situations.

**IAEA** (International Atomic Energy Agency, https://www.iaea.org) was created in 1957 in response to the deep fears and expectations generated by the discoveries and diverse uses of nuclear technology. Widely known as the world's "Atoms for Peace" organization within the United Nations family, the IAEA is the international centre for cooperation in the nuclear field. The Agency works with its Member States and multiple partners worldwide to promote the safe, secure and peaceful use of nuclear technologies. Specific developments have been made following the Chernobyl and Fukushima accidents and regular meetings are organised, leading to publications and recommendations for the management of emergency and recovery. NERIS interacts regularly with IAEA to exchange information and identify areas where NERIS researches can be disseminated.

**IRPA** (International Radiation Protection Association, http://www.irpa.net) is the international association of the national societies of radiation protection. It aims to provide a medium whereby those engaged in radiation protection activities in all countries may communicate more readily with each other and through this process advance radiation protection in many parts of the world. NERIS interacts more specifically at the occasion of the international and regional congresses, providing an opportunity to present and discuss the results of research developments among the community of radiation protection experts.

## 6. WAY FORWARD

Vision of the NERIS Platform is that all European organizations being involved in nuclear emergency management and recovery are sharing common views and common approaches and are developing and using state-of-the-art compatible technology and methods for consequence management of the emergencies. This vision presumes commitment of all key players in a joint European approach and existence of necessary technology and methods to be applied in response to and recovery from an emergency situation. Mission of the NERIS Platform is to encourage European, national, regional and local authorities, technical support organisations (TSOs) and other players to co-operate to achieve this vision. The aim is to get national players in different European countries to act in a coherent way in order to avoid confusion and to enhance confidence among the population. Role of the European Commission and other bodies having a mandate to establish binding arrangements in management of nuclear and radiological emergencies and recovery have a central role in achieving more coherent European approach.

The NERIS Platform itself shall have a clear vision of what development is needed to achieve a functioning European emergency response and recovery arrangements. The Strategic Research Agenda should include these needs. The SRA is a living document, this is the third update and the platform should and the Platform shall update it at more or less regular intervals. The Key Topics in the future research and development are identified in this SRA and the Platform will go all out for getting these topics in the appropriate European research programmes in the coming years. Of course, engagement of the European Commission in the process is extremely important.

## 7. CONCLUSION

A new structure of the NERIS SRA was introduced. Ten key topics are defined in three research areas. The three areas are seen as equal important to achieve the overall goals in nuclear emergency preparedness, response and recovery. All defined key topics require further R&D, specific challenges are largely based on the previous versions of the NERIS SRA, but substantial changes are made to take into account the progress made in the different R&D projects which has been recently finished. Priorities are not defined in this document, and all challenges are identified as important. Further prioritization has been done in NERIS statements, in the context of CONCERT or in the NERIS roadmap. The relation with other European radiation protection platforms (MELODI, radioecology ALLIANCE, EURADOS, and EURAMED) and EU projects addressing part of the topics have been indicated.

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## 9. ANNEX 1. THE EVOLUTION OF THE NERIS SRA

Organisations that participated in the EURANOS project decided, at the end of the project, to create a unique European Platform on nuclear and radiological emergency response and recovery combining researchers, operational communities and relevant stakeholders.

The first version of the NERIS SRA has been produced by the Management Board of the Platform after the R&D Workshop in September 2011 in Brussels. The workshop was organized as a brainstorm along three main research areas proposed based on the EURANOS experience. Consultations on a draft version of the SRA have been performed with the NERIS members before and after the R&D Workshop and the SRA was accepted at the third General Assembly in May 2012. The revised second version includes the discussions and contributions from the R&D committee (meetings in October 2012 and September 2013).

## 10. ANNEX 2. NERIS RELATED RESEARCH PROJECTS

### FP7-project PREPARE (Innovative integrative tools and platforms to be prepared for radiological emergencies and post-accident response in Europe) - Finished

The European research project PREPARE ended in January 2016 and brought together 46 partners from Europe and Japan. The objective was to close gaps identified after the Fukushima accident. Following results have been obtained:

- Atmospheric modelling
  - First prototype of inverse source term estimation modules (released quantities, isotopic composition, height) through data assimilation of near or far field measurements
  - Improvements in the speed of calculation allowing to use them for long lasting releases
  - Improved deposition modelling of particles with spectrum of different sizes and densities
- Aquatic modelling
  - Improved models for coastal areas
  - Improved run-off modelling, however still very limited
- Data mining, information gathering and providing information to stakeholders and mass media
  - Analytical Platform for data exchange
  - Knowledge data base – so far limited to the early phase, but work in HARMONE will deal with the later phase
  - Trustworthiness of information
- Stakeholder engagement and dialogue
  - Contaminated goods
- Social media/networking technology
  - Public behaviour
  - How the public obtains information
  - Factors important for trust

### OPERRA-project CATHyMara (Child and Adult Thyroid Monitoring after Reactor Accident) - Finished

The Cathymara project aims at setting-up guidance for monitoring the internal contamination in the case of a large scale nuclear accident, with a focus on the measurement of I-131 content in the thyroid, especially for children and includes:

- Evaluation of existing response capabilities for thyroid monitoring in Europe in case of a large scale accident;
- Harmonization of measurement practices and establishment of a robust protocol in case of the need to monitor children;
- Setting-up the basis for a sustainable network of responders, including trained but non-specialized operators;

- Studying to what extent the total committed effective dose (internal dose) can be evaluated from I-131 measurements and the development of emergency oriented dose assessments methods;
- Developing the optimal monitoring strategy, including guidelines and recommendations.

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

The HARMONE project started December 1, 2015 and aimed 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 included 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.

### OPERRA-project SHAMISEN (Nuclear energy situations – Improvement of medical health surveillance) - Finished

The aim of the project is to build upon the experience and feedback from Chernobyl, Fukushima and other emergency situations to develop recommendations for health surveillance and medical follow-up of affected populations for:

1. Dose assessment in support of emergency response, clinical decision-making in the aftermath of a radiation accident, and long-term follow-up of exposed populations;
2. Improvement of living conditions of affected populations, responding to their needs, and engaging them in surveillance programmes without generating unnecessary anxiety; and
3. Improvement of population estimates of radiation-induced risk both for radiation protection and for communication with affected populations, if and where feasible.

Five complementary subtasks (ST) have been executed: ST1 focuses on learning from radiation accidents; ST2 looks at the needs of populations by way of case-studies; ST3 will develop recommendations for health surveillance aimed at improving living conditions of affected populations and knowledge on health effects; ST4 focuses on cross-cutting issues (stakeholder engagement, ethics, and economics of health surveillance); and ST5 is dedicated to efficient project management.

### 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.

### 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), will be 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.