Strategic Research Agenda of the NERIS Platform

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

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Contents

1. FOREWORD

Implementing of the European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery (NERIS Platform) was launched in June 15, 2010. Vision of the Platform was published in 2011 (http://www.eu-neris.net/).

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 developments 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 members have the common vision that "*by 2015, the self-sustaining association for development of the joint European approach in responding to and recovering from nuclear and radiological emergencies exists, and by 2020, all European countries being members of the association are sharing common views and common approaches and are using compatible technology and methods for consequence management of the emergencies*".

Since August 2012, the NERIS Platform is registered as a legal association under the French Law from the 1st of July 1901. In March 2014, 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. This 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 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 other international forums, taking into account the lessons identified from the Fukushima accident.

The first version of this SRA has been produced by the Management Board of the Platform after the R&D Workshop in September 2011 in Brussels. 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).

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 NERIS Platform **(**The European Platform on Preparedness for Nuclear and Radiological Emergency Response and

Recovery) was established in June 2010 in Helsinki. 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 will address all notable trends, arrangements and capabilities in the area of response to and recovery from nuclear and radiological emergencies.

2. INTRODUCTION

There are hundreds of nuclear reactors and other nuclear facilities in Europe. Being aware that every man-made facility or equipment 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 to nuclear facilities, there are in Europe 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.

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 broadly adequate 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, are still needed in emergency management. The multi-national project EURANOS, funded by the European Commission and 23 European countries in 2004 – 2009 (http://www.euranos.fzk.de/index.php), resulted in significant progress in development of pan-European arrangements in emergency management. EURANOS integrated 17 national emergency management organisations and 33 research institutes to bring together best practice, knowledge and technology to enhance the preparedness for Europe's response to and recovery from any radiation emergency and long term contamination, although with focus on accidents at NPP's.

Nuclear and radiological safety and security have common goals and the systems and measures used to achieve these goals need to be complementary. In spite of the fact that remarkable improvements have been achieved in management of nuclear and radiological emergencies, a well-coordinated approach in management of nuclear and radiological accidents and unauthorized acts is essential to assure an equal protection of European citizens in an emergency situation regardless of their place of residence. Involvement of different stakeholders to contribute to the efficiency of the protection and to maintain the public confidence in decision makers and authorities is necessary.

Competent authorities responsible for civil defence and public security in different European countries should have access to consistent technical and cognitive methods and tools, and information should pass without any technical or administrative constraints from country to country. To achieve this, a close co-operation between competent authorities and R&D society is necessary. The development has led to the situation where national arrangements, both technical and organisational ones, are still quite incompatible. The used national systems and methods to monitor radiation, to communicate monitoring results and implemented protective measures to

other countries, and the bases for protective measures are not coherent enough in Europe. Joint European arrangements are needed both in safety and security related emergency issues.

Emergency preparedness remains an essential part of an in-depth approach to nuclear safety and security (i.e., prevention, mitigation, response, and long-term recovery) and is important for improving the efficiency of the protection strategy and building of public confidence. It is also important to acknowledge that the constantly changing society will set new demands also to nuclear and radiological emergency preparedness and recovery, and that new ideas and assessments that can substantially improve our knowledge base for tackling the problems constantly emerge and need integration in the European emergency management systems. 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. Moreover, responding effectively to a radiological emergency situation will always be difficult and subject to much criticism with the benefit of hindsight. This has inevitably given a strong social and political dimension to any nuclear or radiological emergency situation (i.e. public concern, political reaction, etc.). Indeed, the greatest challenge facing emergency and post accident management is how to operate effectively within this broader social and political context. On the technical side, the Fukushima accident for instance also demonstrated through the range of contaminants that were released - and those that were not, compared with, e.g., the Chernobyl accident - that improved consideration of release process-dependent source terms is essential to bring European decision making in line with the state-of-the-art knowledge level. The role of reference values to be adopted by the authorities for managing the different phases of the accident has proven to be crucial for allowing the dynamics of the recovery. In addition, the Fukushima accident has reinforced the need for involving all the concerned stakeholders to deal with the short and long-term consequences of the accident.

3. FRAMEWORK OF THE STRATEGIC RESEARCH AGENDA (SRA)

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. The expertise required and issues addressed extend beyond the realm of pure science and technology. Key issues in emergency

management and recovery are understanding the situation, timing of different protective actions, communication between various actors, mass media and the public and transparency of the decisions taken at different levels.

SRAs by definition must comprise the full range of research topics, and their importance and timing, which play a role in the realization of the specific vision. It has to be decided which approach is appropriate for getting a vision-oriented but unbiased SRA, which covers the most essential needs for developing and implementing the required emergency management and recovery procedures at different levels.

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

Vision of the NERIS Platform is that by 2015, the self-sustaining association for development of the joint European approach in responding to and recovering from nuclear and radiological emergencies exists, and by 2020, all European organizations being members of the association are sharing common views and common approaches and are developing and using compatible technology and methods for consequence management of the emergencies. The NERIS Platform is already a legal entity under the French legislation since August 2012. The goal is now that this legal association is, by 2015, self-sustaining in financial terms. Currently, 21 organisations are already supporting part of the necessary budget of the NERIS Platform.

The member organizations identify the future research and development needs in this area and the Platform itself is also able to send project proposals to the financing societies, e.g. to the European Commission in its future Framework Programmes. In this perspective, the current participation of the NERIS Platform to the management board of the OPERRA project is a key step in this direction. The longer term vision means that the SRA shall include topics producing such outputs, which can be taken into operational use as broadly as possible in Europe. The longer term vision also includes an idea that the future R&D projects will produce compatible methods and tools so that data and information exchange between the European organizations and countries in emergency management and recovery would not encounter unnecessary barriers and constraints.

For the development of this SRA, consideration has been given to the results and achievements made so far. A good basis for this is the output of the broad EURANOS project (http://www.euranos.fzk.de/index.php), in which several of the NERIS partners participated in 2004 – 2009. The SRA shall also tackle the development of international recommendations in radiation protection and how they could be implemented in the best possible way in national emergency management procedures and how the existing Decision Support Systems could be adapted to the new approach for management of emergency response and recovery. This revised version of the SRA also includes the results of the European research project NERIS TP as well as the first lessons learned from the Fukushima accident. In addition, the current researches under development within the European research project PREPARE are also contributing to the evolution this SRA.

This revised version has been produced by the R&D committee which met twice in October 2012 and September 2013. This version will be submitted for consultation to NERIS members and other NERIS partners.

3.2. Identifying, characterizing and prioritizing of topics of SRA

Before the brainstorm Workshop in September 2011 in Brussels, a list of research topics was produced without any advance discussion and prioritizing to stimulate the workshop participants for inspirational discussion and debate about their experiences in existing practices of emergency management situation in Europe. The list contained 24 identified topics and they formed the basis for the discussions. Unauthorized acts with nuclear and radioactive materials have created a new concern and they have brought a security related aspects also into the emergency management discussion, in addition to the traditional safety related issues. Also experiences from the accident at Fukushima 1 power plant in Japan in March 2011 influenced the list of topics. 35 Participants from 25 organizations in 13 countries and the European Commission attended the Workshop. The discussions were arranged in three break-out sessions focusing on the following areas:

1. New challenges in atmospheric & aquatic modelling – Needs for improvement.
2. New challenges for better dose assessments and decision support based on improved knowledge: source term, scenarios, etc.
3. New challenges in stakeholder involvement and local preparedness and communication strategies.

These areas have been adopted to structure the SRA. In the following meetings of the NERIS R&D Committee in October 2012 and September 2013 these areas have been revisited and confirmed.

The Area 1 deals with dispersion of radioactive materials (in solid or gas form) in the atmosphere or in water systems. Most of the challenges in atmospheric dispersion are related, on one hand, to dispersion in urban and confined environments, and on the other hand on very short- or very long-duration releases (explosions and Fukushima type releases). Malicious explosion with radioactive materials in an urban environment is an extremely difficult and current topic. The existing dispersion models are developed mainly for traditional accident scenarios of nuclear power plants. New programming techniques and more efficient algorithms enable today modelling of different urban environments and very short-duration releases. Development of rapid data assimilation techniques and inverse modelling are associated with all kind of dispersion modelling and need to be included in the future R&D. The same applies very much to source term estimation because today the greatest uncertainties are associated with source terms. The Fukushima accident proved the importance of dispersion of radionuclides in coastal environment. The current models are not sufficient powerful to predict dispersion in aquatic systems and there is a real need to develop site-specific models to major nuclear facilities in Europe. Contamination of drinking water with radionuclides in intentional or accidental releases is also an area where there are today big gaps in our knowledge.

The Area 2 deals with development of existing Decision Support Systems (DSS). In addition, beyond the development of the existing DSS, the feedback from the Fukushima accident has highlighted the importance of improving the decision-making processes. The DSS are in central role when consequences of intentional or accidental releases of radioactivity into the environment are estimated. The systems include several environmental models like dispersion and dose

assessment models, so they are closely related to topics in the Area 1 and in more general radioecology studies. Source term estimations are of primary importance. Particularly, an identification of release-process specific parameters for physicochemical characterization of the source term from different types of nuclear releases is decisive for the radiological consequences of dispersed contaminants (deposition, solubility, migration, forced removal of contaminants). This needs to be integrated throughout the European decision support systems. Coupling of DSS with Command and Control (C2) systems is something we are lacking today. So far decisions are taken on a strategic level requesting e.g. sheltering or evacuation without any glue if these actions can be carried out. Developing computational models to simulate the recommendations on the operational/tactical level can close this gap and link the crisis centre better to the commander in chief locally. The use of knowledge data bases developed in the previous European Framework Programmes, e.g. handbooks for inhabited areas, foodstuffs, drinking water, and TMT (http://www.euranos.fzk.de/index.php, http://www.tmthandbook.org/), needs more efficient training to provide better support for decision making. The handbooks themselves also need revision for consideration of malicious dispersion scenarios. The Fukushima accident proved that Decision Support Systems have to be applicable world wide, even if there is no effect in your own country, since every country need to protect their own citizens in the accident country. Also politicians, media and the public need reliable information. The Fukushima accident also demonstrated the need for a European platform where data and information of governmental and non-governmental organizations in one country would be available to other European countries. This kind of access/exchange platform is necessary in a rapidly developing emergency situation in order to achieve more coherent decisions in different European countries. Concerning the improvement of decision making processes, the recent analyses of the management of the consequences of the Fukushima accident point out the importance of refining the existing framework at the local, regional and national levels. Various issues have to be address to better structure the decision processes, to develop accurate information, to favour efficient use of existing DSS and tools and to allow a better allocation of resources for reaching efficient protective strategies responding to the expectations of the various stakeholders in emergency and recovery phases.

The Area 3 deals with stakeholder involvement, local preparedness and communication strategies in an emergency and recovery situations. In this area, communication and information issues are of great importance due to requirements for huge amount of information and measurements, use of modern social media through Internet, and possible contradictory information being available. The nuclear accident at Fukushima demonstrated on one hand that new European stakeholders were engaged in decision making to protect European citizens in Japan. Foreign governments advised different protective actions to their citizens, which created confusion within the public. Iodine tablets were sold out in Europe without any reasonable reason, some countries introduced restrictions on food import, many embassies relocated from Tokyo, etc. All these confusing actions derived at least partially from misinformation delivered by the Western media. On the other hand, the follow-up of the management of the consequences of the Fukushima accident in Japan leads to revisit the existing framework for public participation and ways for improving the implementation of protection strategies.

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

Research and development in the field of emergency management and recovery at the European level calls for co-operation between authorities, emergency centres, research organisations and the academic community in different countries, as well as interactions with key concerned stakeholders. The goal of R&D co-operation is to enhance European countries' capability to response to and recover from nuclear or radiological emergencies in a coherent way.
The SRA does not contain specific projects but broader areas where further research and development are needed. Seven Key Topics are identified and grouped in three research areas as follows:

New challenges in atmospheric & aquatic modelling – Needs for improvement

1. Key Topic 1: Atmospheric dispersion modelling
2. Key Topic 2: Aquatic dispersion modelling

New challenges for better dose assessments and decision support based on improved knowledge: source term, scenarios, etc.

3. Key Topic 3: Improvement of existing Decision Support Systems
4. Key Topic 4: Data mining, information gathering and providing information to stakeholders and mass media
5. Key Topic 5: Improving the decision-making processes

New challenges in stakeholder involvement and local preparedness and communication strategies.

6. Key Topic 6. Stakeholder engagement and dialogue
7. Key Topic 7: Social media/networking technology

These topics or research challenges and their relation with the FP7-projects NERIS-TP and PREPARE and relation to the other European platforms in radiation protection on low dose (MELODI), radioecology (ALLIANCE) and dosimetry (EURADOS) or other European networks are described in the tables on the following pages.

During the R&D Committee meeting of 2013 research priorities were defined. A refinement of the priority setting was later done on the basis of additional feedback from the R&D Committee and Management Board members of NERIS. Six high priority and seven priority sub-topics were in this way defined (indicated in the tables).

4.1. Key Topic 1: Atmospheric dispersion modelling

Research area: New challenges in atmospheric & aquatic modelling – Needs for improvement

Objective: To make more reliable and precise forecasts on atmospheric dispersion of radioactive materials in different environments
Expected outcome: Decision Support Systems (DSSs) with extended capabilities.

Research sub-topics for Atmospheric dispersion modelling	Description	Project addressing the topic or Priority (only for new topics)
1.1 Modelling approaches for complex settings (urban or confined spaces).	Models for intentional or accidental atmospheric releases of radiological or nuclear material in complex environments (e.g. urban, near range). Combination of complex (CFD – Computational Fluid Dynamics) modelling with simple models. Development of generic guidance on the use of ADM models and the emergency management actions adequate for particular scenarios in complex environments.	Priority
1.2 Data assimilation and inverse modelling	Development and / or integration of computational tools in existing DSSs for assimilation of atmospheric measurements (e.g., gamma radiation dose rates, concentration) and/or inverse modelling to estimate unknown source term (location, emission rate) in urban areas and in open spaces.	Prioity, Partly PREPARE

Research sub-topics for Atmospheric dispersion modelling	Description	Project addressing the topic or Priority (only for new topics)
1.3 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 sizes, chemical transformations).	Partly PREPARE
1.4 Fine tuning modeling parameters & algorithms	Extension of capability of dispersion models in DSSs to treat phenomena that currently are not considered, in particular wet deposition by snow	**High priority**
1.5 Optimised use of new meteorological instruments	Optimised use of new meteorological instruments and data, with application e.g. in the placement of mobile units	
1.6 Long-duration releases.	Updated models able to simulate very long-duration releases (e.g. one month to one year) to air by automatic update of meteorological data, restart of dispersion models and user update of source term information	Partly PREPARE, link with radioecology ALLIANCE

4.2. Key Topic 2: Aquatic dispersion modelling

Research area: New challenges in atmospheric & aquatic modelling – Needs for improvement

Objective: Enabling forecasts on aquatic dispersion of radioactive materials in different environments (urban hydrology systems and coastal waters).

Expected results:

- Capability of existing DSSs to assess the vulnerability of urban hydrology systems to nuclear emergencies regarding the freshwater supply system and waste water contamination from deposited radionuclides.
- Implementation and operational use of coastal models into existing DSSs to estimate dispersion of radioactivity in coastal waters and radioactivity levels in fish and sea-food in the (possibly long) emergency phase of an accident with a nuclear installation.

Research sub-topics for Aquatic modelling	Description	Project addressing the topic or Priority (for new topics)
2.1 Urban hydrology		
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. Interest to use Post-Fukushima data to validate new models.	**High priority,** link with radioecology ALLIANCE
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.	
2.2 Models for coastal areas	Development and implementation of re-locatable hydrodynamic 3D models of coastal circulation for real time predictions of transport of radioactivity in the coastal zone, including long-lasting releases	PREPARE

Research sub-topics for Aquatic modelling	Description	Project addressing the topic or Priority (for new topics)
2.3 Coupling with weather forecast models for running in the automatic mode of a DSS	Coupling with weather forecast models to provide forcing for wave models for running in the automatic mode of a DSS, and with sediment transport models	PREPARE
2.4 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	Partly in PREPARE
2.5 Finite volume models	For prolonged emergency phase of a nuclear installation accident and for long-term assessment, the existed compartment models should be transformed into finite-volume models fully driven by time and space averaged hydrodynamic, sediment transport and ecosystem models to predict dose from food ingestion, inhalation (sea spray and re-suspended particles), and beach sediments (beach occupancy, boating, swimming) in coastal areas	

4.3. Key Topic 3: Improvement of existing Decision Support Systems

Research area: New challenges for better dose assessments and decision support based on improved knowledge: source term, scenarios, etc

Objective: To get a better analysis of the radiological situation and support the decision making in all phases (emergency and recovery phases)
Expected results:

- Better source term input to the dispersion models
- Improved radioecological modelling
- DSS better customised to local information
- Better response to malevolent acts
- Better analysis and response in the different exposure situations established by ICRP

Research sub-topics for Improvement of Decision Support Systems	Description	Project addressing the topic or Priority (for new topics)
3.1 Better quantification of source term	Particularly, the identification of release-process specific parameters for physicochemical characterization of the source term from different types of nuclear accidents	Link to SARNET, (Severe Accident Research NETwork)
3.2 Customising of the existing environmental models into the regional circumstances in Europe (close co-operation with the Radioecology Alliance)	Customising of the existing environmental models into the regional circumstances in Europe (close co-operation with the Radioecology Alliance), revision and update of parameters used in the radioecological models (FDMT, AgriCP, FDMF, FDMA)	Priority
3.3 Measurements of Chernobyl contaminants on different surfaces (and if possible Fukushima-measurements)	A limited program for resuming measurements of Chernobyl contaminants on different surfaces (and if possible Fukushima-measurements)	

Research sub-topics for Improvement of Decision Support Systems	Description	Project addressing the topic or Priority (for new topics)
3.4 Local radioecological models	Development of local radioecological models interlinked with monitoring information and the more global and food chain dose models, integrated in general DSS. Investigate the capability of such models to be operated by a local farmer or local community	**High priority,** linked with the radioecology Alliance
3.5 Improvement of existing DSS for radiological emergencies	Improvement of existing DSS with radiological capabilities (explosions in large buildings, underground stations, uncertain source term information, hidden sources etc.)	Priority
3.6 Multiple stressors	Models able to tackle multiple stressors in the assessment of countermeasure strategies and in relation to malicious dispersion (CBRNE)	Priority
3.7 Tailor the output of DDS'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	
3.8 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	

4.4. Key Topic 4: Data mining, information gathering and providing information to stakeholders and mass media

Research area: New challenges for better dose assessments and decision support based on improved knowledge: source term, scenarios, etc

Objective: Foster the information exchange between all interested stakeholder and provide means for a transparent decision making process

Expected results:

- Information exchange platform for all relevant organisations in Europe
- Lessons learned from historic events are available for decision making in new incidents

Research sub-topics for Data mining	Description	Project addressing the topic or Priority (for new topics)
4.1 Analytical platform for data and information exchange	Access/exchange platform collecting and distributing results from governmental and non-governmental organisations	PREPARE
4.2 Development of a knowledge data base	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 Development of information material of general nature on radiation emergencies, countermeasures and recovery	Partly in PREPARE
4.3 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	Priority

4.5. Key Topic 5: Improving the decision-making processes

Research area: New challenges for better dose assessments and decision support based on improved knowledge: source term, scenarios, etc

Objective: Improved decision processes

Expected results:

- Better structured decision processes of the different categories of stakeholders (including public authorities at national and regional levels, local governments, professionals and inhabitants)
- More accurate information to the emergency and recovery stakeholders
- Efficient use of existing DSS and tools
- Better allocation of resources and improvement of the efficiency of protective strategies during emergency and recovery phases

Research sub-topics for Improving the decision-making process	Description	Project addressing the topic or Priority (for new topics)
5.1 Assessment of and communication on uncertainties	Investigation of data uncertainties (model or monitoring results) and how they can be communicated, e.g. in model results and in DSS to help decision-makers to understand the radiological situation. This includes also work on model sensitivity, validity of model results and inter-comparisons of models and measurements	**High priority**
5.2. Coupling of DSS with Command and Control (C2) systems	Coupling of the existing strategic DSS such as ARGOS and RODOS to Command and Control (C2) systems	Priority
5.3 Robust decision making	Structuring the decision processes and the protective strategies at national, regional and local levels with the help of formal decision aid tools, such as multi-criteria analysis and on the basis of feedback from stakeholder processes. Development of guidance on the use of DSS in the various phases	**High priority**

Research sub-topics for Improving the decision-making process	Description	Project addressing the topic or Priority (for new topics)
	of an event based on feedback from stakeholder processes and from Fukushima experience in emergency response and recovery.	
5.4 Serious gaming	Development of serious gaming tools to train the emergency actors	Priority
5.5 Revision of European handbooks	Revision of European handbook sections (creation of addendum) for consideration of malicious dispersion scenario	Priority
5.6 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 the local level, compatible to locally used software tools and national ones (notably GIS)	Priority**,** partly NERIS TP (only started), continuation of the EURANOS CAT 3 activity
5.7 Countermeasure strategy preparedness	Development of sustainable preparedness strategy at local, national and European level, based on the analysis of countermeasures for relevant accident scenarios, ensuring that parameters governing the radiological consequences can be identified in time to enable optimized remediation.	Partly NERIS TP, Priority

Research sub-topics for Improving the decision-making process	Description	Project addressing the topic or Priority (for new topics)
5.8 Health surveillance	Development of procedures for health surveillance, including sampling of population and dose reconstruction, and involvement of stakeholders Link to MELODI/EURADOS	Priority (possible collaboration with MELODI and EURADOS)
5.9 Monitoring strategies	Optimised use of monitoring resources, including mobile units and trans-border issues. Use of new monitoring technologies. 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) Link to EURADOS.	**High priority** (possible collaboration with EURADOS)

4.6. Key Topic 6: Stakeholder engagement and dialogue

Research Area: New challenges in stakeholder involvement and local preparedness and communication strategies

Objective: Improve the acceptability 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

Research sub-topics for Stakeholder engagement	Description	Project addressing the topic or Priority (for new topics)
6.1 Defining stakeholders and framing problems	Identifying roles, 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	Priority
6.2 Stakeholder engagement database	Database on experiences of stakeholders engagement in preparedness and response highlighting lessons learned and guidances for best practice, taking into account the national context	Priority, Partly NERIS TP
6.3 Public participation and dialogue	Develop guidance on information and participation of population, increasing effectiveness if multiple source of information may compete or conflict.	PREPARE

6.4 Contaminated goods	Studies on the issue of trade and exchange of goods from contaminated territories in the perspective of a sustainable development	PREPARE

4.7. Key Topic 7: Social media/networking technology

Research Area: New challenges in stakeholder involvement and local preparedness and communication strategies

Objective: To better understand the ways in which media and social media are used in the flow of information and communication.

Expected results:

- Improved preparedness for media and social media communication

Research sub-topics for Stakeholder engagement	Description	Project addressing the topic or Priority (for new topics)
7.1 Public behaviour response analysis	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	Priority
7.2 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 and according to its needs in the course of nuclear emergency and post-emergency contexts	PREPARE
7.3 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	PREPARE

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

This chapter should be revised to take into account the recent developments in radiation protection research in Europe. Also need to include ICRP, CRPPH and IAEA

In 2003, the European Commission introduced the concept of Technology Platform (Commission of the European Communities, 2003) in order to enhance R&D activities in Europe. The aim is to increase coherence and co-ordination at the level of the various stakeholders involved in the development and deployment of key technologies and methods in Europe. NERIS Platform was created to promote this idea in the management of nuclear and radiological emergencies and recovery. NERIS Platform creates close co-operation relationships with other platforms in the areas of radiation protection and nuclear safety in Europe. It is of special importance to follow development in the areas of nuclear technology, radioecology and biological effects of exposure to ionizing radiation. Also co-operation with the European radiation and nuclear safety authorities is of vital importance in achieving the objectives of the NERIS Platform. Therefore NERIS will closely follow the work done in the following platforms and networks.

European Radioecology Alliance, (https://wiki.ceh.ac.uk/display/star/) was created in 2011 to strengthen European R&D in the area of radioecology. Radioecological studies are of special importance to management of nuclear or radiological emergencies, because the Decision Support Systems (DSS) used in emergency management include several environmental models whose reliability 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.

SNETP (**S**ustainable **N**uclear **E**nergy **T**echnology **P**latform, http://www.snetp.eu/) was officially launched in 2007. SNETP addresses the three main objectives; 1) maintain the safety and competitiveness of today's electricity generation technologies, 2) develop a new generation of more sustainable reactor technologies – so-called Generation IV fast neutron reactors with closed fuel cycles, and 3) develop new applications of nuclear power such as the industrial scale production of hydrogen, desalination or other industrial process heat applications. SNETP aims to support fully through R&D programmes the role of nuclear energy in Europe's energy mix, its contributions to the security and competitiveness of energy supply, as well as to the reduction of greenhouse gas emissions. Nuclear energy production and new applications of nuclear power are

the main potential sources of radioactivity releases into the environment, although the risk of major releases is getting smaller and smaller. In management of nuclear emergencies, the source term assessment is a key issue, and the best assessments to be adopted in the DSS's will be got from those working with nuclear technology. NERIS will exploit this knowledge in its own R&D work.

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 15 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 will closely follow the work of MELODI and will investigate how new findings of MELODI could be implemented in the European emergency management procedures.

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.

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 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 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

The first version of the Strategic Research Agenda (SRA) of the NERIS Platform was written based on the ideas identified in a brainstorm workshop in September 2011. The NERIS R&D Committee revised this first SRA version, resulting in a second version of the SRA with tables identifying the most important research items. Research priorities were identified as well as the relation with other European radiation protection networks (MELODI, radioecology ALLIANCE and EURADOS) and current FP7 EU projects addressing part of the topics.

8. REFERENCES

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