NERIS ROADMAP

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Introduction

As part of the CONCERT WP2 activities, it is expected to develop a roadmap for NERIS. This roadmap has also to be considered for the elaboration of a common roadmap of the 5 research platforms involved in CONCERT.

For this purpose, the initial work was the development of the two scenarios with societal concern related to NERIS issues:

- Facing the consequences of a nuclear or radiological major accident or incident: how to optimize society's preparedness, and short term/long term response?
- Facing the threat of a radiological terrorist act: How to minimize consequences?

These scenarios allow to identify research priorities, in line with the on-going update of the SRA. The aim of the roadmap is to develop research endpoints for three time periods:

- 0 – 5 years (related to CONCERT topics)
- 6 – 10 years (any new research program)
- > 10 years (is there a combination of research and operational needs)

The identification of the research needs has to cover emergency and recovery issues. The following definitions are provided to clarify the goals of each situation.

Emergency situation

The IAEA has defined (IAEA Safety Standards) the main goals of nuclear and radiological emergency response:

- to regain control of the situation;
- to prevent or mitigate consequences at the scene;
- to prevent the occurrence of deterministic health effects (tissue reactions) in workers and the public;
- to render first aid and manage the treatment of radiation injuries;
- to prevent, to the extent practicable, the occurrence of stochastic health effects in the population;
- to prevent, to the extent practicable, the occurrence of adverse non-radiological effects on individuals and among the population;
- to protect, to the extent practicable, the environment and property;
- to prepare, to the extent practicable, for the resumption of normal social and economic activity.

Recovery situation

According to ICRP, the main goals for the recovery situations are defined hereafter:

- The management of an existing exposure situation, corresponding to recovery, following a nuclear accident relies on the implementation of an integrated and complex rehabilitation programme that considers numerous dimensions.
- The radiological protection part of this programme is characterised by strategies that include actions implemented by:
    - The authorities at national and local level
    - As well as self-help protective actions taken by the affected population either under their own initiative or within a framework provided and supported by the authorities.

Based on this, 3 major challenge Areas are defined in the updated NERIS SRA:

1. Challenges in radiological impact assessment during all phases of nuclear and radiological events
2. Challenges in countermeasures and countermeasure strategies in emergency & recovery, decision support and disaster informatics
3. Challenges in setting-up a trans-disciplinary and inclusive framework for preparedness for emergency response and recovery

For each of the challenges, Key topics and subtopics– as introduced in the SRA - are defined and will be populated with research needs for three time intervals: up to five years, 6 – 10 years and beyond 10 years. The last category was chosen as the Roadmap aims to define long-term research needs and thus a time frame longer than 10 years has to be discussed.

For the better structure of research “Vision” has been defined for each subtopic within the particular Key topic for each of the challenges that can be seen as our goal for that research area.

Roadmap NERIS Challenge Area 1

Challenges in radiological impact assessment during all phases of nuclear and radiological events

- **Key topic 1: Improved Modelling**
  - Atmospheric transport and dispersion modelling (ATM/ADM)
  - Hydrological modelling
  - Dose models
  - Environmental models
- **Key topic 2: Improved Monitoring**
  - Monitoring techniques and strategies
  - Data collection and sharing
  - Optimisation
- **Key topic 3: Data assimilation**
  - Improved source term estimation
  - Improved impact assessment
  - Big Data, Data fusion

Challenges and achievement in	Vision
Radiological impact assessment during all phases of nuclear and radiological events	
Key topic 1: Improved Modelling	
Atmospheric transport and dispersion modelling (ATM/ADM)	ATM/ADM modelling suite that is tested and validated, applicable in all environments (urban, agricultural, forests, etc.) world-wide, including uncertainties
Hydrological modelling	A hydrological model suite that is applicable to inland and coastal areas in Europe, that has improved food chain models and that is closely linked to atmospheric and hydrological boundary conditions worldwide
Dose models	A suite of models for assessing the exposure of the public, of emergency workers and helpers during all phases of the event and based on all available data; including dynamic behaviour of the exposed population
Environmental models	A suite of radioecological models that is fit for purpose in emergency management at all levels including inhabited areas

Key topic 2: Improved Monitoring	
Monitoring techniques and strategies	New devices, techniques and guidelines for monitoring in Europe being harmonised for cross-border application and monitoring information supplied by professionals, NGOs and lay people; Harmonised monitoring strategies for Europe for all phases and for all types of radiological and nuclear events
Data collection & sharing	Comprehensive data base of radiological data for model validation and open for wider use.
Optimisation	Optimise all potential emergency scenarios based on monitors and modelling capabilities
Key topic 3: Data assimilation	
Improved source term estimation	Improved capabilities to estimate source locations and source terms with ATM/ADM as defined in Key Topic 1 and advanced data assimilation
Improved impact assessment	Improved capabilities to assess the radiological situation In all phases of an accident or incident (e.g. medical follow-up or other long-term actions)
Big Data, Data fusion	Combined tools for improved decision making using Big Data capabilities within Decision Support Systems in connection to Challenge Area 2

Key topic 1: Improved Modelling (for more detailed description of topics and subtopics please refer to the SRA)

Challenges and achievement in	1-5 years	6-10 years	>10 years
Atmospheric transport and dispersion modelling ATM/ADM **VISION**: ATM/ADM modelling suite that is tested and validated, applicable in all environments (urban, agricultural, forests, etc.) world-wide, including uncertainties	• Investigate fluid dynamics modelling and its applicability to nuclear emergency management • Improve models and tools for urban and confined areas • Better quantification of uncertainties from all origins in the ATM/ADM models including operational application of ensemble approaches for uncertainty assessment in ATM/ADM models in collaboration with meteorological services	• Quantification / assessment of ATM/ADM uncertainties applying big data and improved mathematical techniques for complex mathematical approaches	• CFD models and ensemble modelling combined with advanced methods for inverse modelling (in connection to key topic 3) • Non-conventional emissions (explosions, aerosol sprays, fires, etc.)
Hydrological modelling **VISION**: A hydrological model suite that is applicable to inland and coastal areas in Europe, that has improved food chain models and that is closely linked to atmospheric and hydrological boundary conditions worldwide *In close collaboration with ALLIANCE*	• Improvement in marine food web modelling • Urban run-off models • Urban water supply models • Improvement of local coastal models	• Development of mechanism to adapt hydrological models to local conditions • Better approaches for surface runoff • Combination of all components of aquatic modelling into one comprehensive modelling suite • Development of test procedures for such a complete model suite to discuss uncertainties	• Subdivision of dispersion and radiological part (as in atmospheric dispersion). • Link to global hydrological models, improved run-off models • Comprehensive aquatic model suite fit for emergency management and validated with reduced uncertainty

Challenges and achievement in	1-5 years	6-10 years	>10 years
Dose models **VISION:** A suite of models for assessing the exposure of the public, of emergency workers and helpers during all phases of the event and based on all available data; including dynamic behaviour of the exposed population	• Dose assessment (including reconstruction of doses) based on all available environmental monitoring data • Individual dose assessment considering the real behaviour of the population and the efficacy of protective actions and remedial measures in reducing doses • Improved assessment of thyroid doses, their uncertainties, in particular among those exposed in utero, when newly born and in infancy, based on an analysis of thyroid measurement data and internal dose reconstruction • Implementation of shielding factors for new house types characteristic of modern urban areas, with new construction materials (e.g. much glass), and material factor dependence *In close collaboration with EURADOS*	• Dose assessment combining input from environmental monitoring and individual monitoring (e.g. personal dosimeters, thyroid monitoring, whole body counting, bio-dosimetry) • During the long term and recovery phases, the assessment and reconstruction of doses of the affected individuals addresses: i) the needs of individuals and society, including communication about the exposure situations; ii) development and possible adaptation of appropriate health surveillance programs and associated social care [from SHAMISEN] • Develop practical guidance to populations who wish to make their own measurements, recommending reliable equipment and resources (e.g., apps, social media, information centres) [from SHAMISEN]	• (Highly) individual dose assessment

Challenges and achievement in	1-5 years	6-10 years	>10 years
Environmental models **VISION**: A suite of radioecological models that is fit for purpose in emergency management at all levels including inhabited areas *In close collaboration with ALLIANCE*	• Improved database for radioecological models • Identify regional parameters and values characterising the radionuclide behaviour and the transfer soil-to-plant and raw- to-product in poorly studied environments (Mediterranean climate, arctic and sub-arctic, complex systems as agro-pastoral, forestry,..) • Consider appropriate uncertainty estimation in the model – propagation of uncertainties in environmental model chains • Implementation of shielding dose rate factors for new house types characteristic of modern urban areas, with new construction materials (e.g. much glass), and material factor dependence	• Development of a local model for assessing individual farms • Incorporating the behaviour of hot particles in radio ecological models • Investigate multiple stressors together with ALLIANCE	• Linking of local and global models for better decision making

Key topic 2: Improved Monitoring (for more detailed description of topics and subtopics please refer to the SRA)

Challenges and achievement in	1-5 years	6-10 years	>10 years
Monitoring techniques and strategies **VISION**: New devices, techniques and guidelines for monitoring in Europe being harmonised for cross-border application and monitoring information supplied by professionals, NGOs and lay people; Harmonised monitoring strategies for Europe for all phases and for all types of radiological and nuclear events	• Development of low cost monitors for nuclide specific information for wider use • Improve reliability of low cost monitors for lay people • Investigate the capabilities of drones as part of a strategy • Improve existing monitoring techniques such as whole body, thyroid, lung counting – together with EURADOS • Improved concept combining modelling and monitoring approaches • Investigation of techniques for measurement/characterisation of radionuclides that can not be measured by dose rate or gamma emission • Methods for local determination of environmental parameters governing radionuclide migration	• Improve monitoring capabilities based on the investigation on drones and cheap nuclide specific monitors • Integrate monitoring from lay people into strategies and decision tools • Investigate the capabilities of autonomous moving monitors, such as drones as part of a strategy	• Optimise monitoring techniques and develop European wide guidelines for monitoring and the integration of monitoring data of all kind into decision support systems (e.g. dose impact assessment, source term reconstruction, OILs) • Develop methods and guidance for harmonisation in Europe

Challenges and achievement in	1-5 years	6-10 years	>10 years
Data collection and sharing **VISION**: Comprehensive data base of radiological data for model validation and open for wider use.	• Data collection for model validation & development, based on historical and new data • Good radiation background information and variability of background • Overview of / guidance on which data should be collected for recovery operations to be considered • Optimised use of new meteorological instruments with evaluation of application to improve modelling (Lidar's)	• Data collection for model validation & development, based on historical and new data • Robust system for collecting and sharing data campaigns	• Data collection for model validation & development, based on historical and new data
Optimisation **VISION**: Optimise all potential emergency scenarios based on monitors and modelling capabilities	• Reach back for analysing radiation measurements from intervention teams • Development of methods and tools that allows to optimise the placement of monitoring stations (both fixed early warning networks and mobile systems) • Investigate the interlink with dispersion modelling capabilities to optimise your monitoring network	• Further optimization of monitoring resources • Enhance the linkage between monitoring (mobile and stationary) and simulations in air and water to optimise monitors and possibly also monitoring strategies	• Develop procedures and optimisations methods based on scenarios for different emergencies

Key topic 3: Data assimilation (for more detailed description of topics and subtopics please refer to the SRA)

Challenges and achievement in	1-5 years	6-10 years	>10 years
Improved source term estimation **VISION**: Improved capabilities to estimate source locations and source terms with ATM/ADM as defined in Key Topic 1 and advanced data assimilation	• Rapid analytical tools for estimation of unknown source locations and source terms using data assimilation and inverse methods • Advanced source term estimation methods combined with methods for assessing the plant status and it's future development • Link with plant status experts (NUGENIA)	• First combined ensemble dispersion modelling with data assimilation and inverse methods • Source term (location and strength) estimation in urban areas	• Combined ensemble dispersion modelling and data assimilation methods operational for DSS
Improved impact assessments **VISION**: Improved capabilities to assess the radiological situation In all phases of an accident or incident (e.g. medical follow-up or other long-term actions)	• Combine modelling and monitoring for a better radiological consequence assessment (considering uncertainty as explicit parameter)	• Refine the assimilation approach to better estimate the dose of individual people for dose reconstruction and medical treatment	• How to combine bio-dosimetric approaches with others in an emergency situation for to make individual impact assessments for large groups of people
Big Data, Data fusion **VISION**: Combined tools for improved decision making using Big Data capabilities within Decision Support Systems in connection to Challenge Area 2	• Development computational structures (e.g., platforms, aggregators) that would allow storing, processing and combining large volumes of heterogeneous and of different origins data	• Develop test procedures to optimise the processing of large information • Improve the structure and content to be applicable for decision making under high uncertainty	• Combine Big Data platforms with Decision Support Systems

Roadmap NERIS Challenge Area 2

Challenges in countermeasures and countermeasure strategies in emergency and recovery, decision support and disaster informatics

- **Key topic 4: Countermeasures & countermeasure strategies**
  - Countermeasures/management options
  - Implementation of countermeasures, lifting of countermeasures, transition from emergency to existing exposure situation
- **Key topic 5: Formal decision support**
  - Decision making methods and tools
  - Decisions under high uncertainty
- **Key topic 6: Disaster informatics**
  - Analytical platform
  - Knowledge databases
  - New generation Decision Support Systems (DSS)
  - Virtual and augmented reality

Challenges and achievement in	Vision
Challenges in countermeasures and countermeasure strategies in emergency and recovery, decision support and disaster informatics	
Key topic 4: Countermeasures & countermeasure strategies	
Countermeasures/management options	Improved understanding of countermeasures to better build and implement countermeasure strategies (preparedness, response, recovery)
Implementation of countermeasures, lifting of countermeasures, transition from emergency to existing exposure situation	Methodological framework for the implementation and lifting of countermeasures based on monitoring (e.g. Operational Intervention Levels), modelling (Decision Support Systems) and guidance on optimisation supporting ICRP recommendations (including stakeholder interaction, see challenge 3)
Key topic 5: Formal decision support	
Decision making methods and tools	Formalised methods and tools that structure and improve the decision making process in all phases of an accident /incident
Decisions under high uncertainty	Formalised methods that support robust decision making under high uncertainties

Key topic 6: Disaster Informatics	
Analytical platform	Establish the analytical platform as part of the emergency management toolbox
Knowledge databases	Knowledge databases becoming operational allowing to support decision making in all phases of an accident/incident
New generation Decision Support Systems (DSS)	New generation Decision Support Systems for integrated decision making (tactical, operational, strategic)
Virtual and augmented reality	Suite of new training facilities for first responders, decision makers and other stakeholders that can be used for preparedness and testing

Key topic 4: Countermeasures and Countermeasure strategies (for more detailed description of topics and subtopics please refer to the SRA)

Challenges and achievement in	1-5 years	6-10 years	>10 years
Countermeasures and countermeasure strategies **VISION:** Improved understanding of countermeasures to better build and implement countermeasure strategies (preparedness, response, recovery)	• Investigate the need for improvement of European handbooks (footnote) • If needed improve European handbooks • Investigate enhancing the new guidance handbook developed under the HARMONE project as part of OPERRA (footnote) • Review and investigate if new protective actions and strategies for remediation and restoration can be derived from the Fukushima experience (also other new countermeasures for other surfaces, such as glass, and for a range of 'new' radionuclides) • Investigate the uncertainties in the spatio-temporal behaviour and response to countermeasures • Generation of information sheets for countermeasures implementers (including 'self-help' volunteers)	• Development of electronic versions that are linked to knowledge databases and Big Data structures • Improve concepts and parameters of existing countermeasure models such as ERMIN and AGRICP implemented in JRODOS and ARGOS • Improve user-friendliness of tools • Develop a better estimation of factors that characterise countermeasures and countermeasure strategies (effectiveness, costs, non-radiological effects, …) as function of environment, region and affected population • Consider countermeasures strategies for other incidents than large scale nuclear accidents	• Development of intelligent wizards that propose optimised countermeasures / countermeasure strategies based on available information from a DSS

Challenges and achievement in	1-5 years	6-10 years	>10 years
Implementation of countermeasures, lifting of countermeasures, transition from emergency to existing exposure situation **VISION**: Methodological framework for the implementation and lifting of countermeasures based on monitoring (e.g. Operational Intervention Levels), modelling (Decision Support Systems) and guidance on optimisation supporting ICRP recommendations (including stakeholder interaction, see challenge 3)	• Analyse European, national and local countermeasure strategies, their implementation and lifting conditions • Review the experience in implementing and lifting countermeasures in Fukushima and Chernobyl • Investigate preparedness scenarios for recovery • Develop monitoring strategy to support countermeasure implementation • Develop Operational Intervention levels for the use in the decision making process – review the proposal from IAEA for NPP scenarios and revise, add if necessary • Develop OIL's for non-nuclear scenarios in cooperation with the IAEA • Develop catalogues and check-lists to facilitate timely implementation • Develop means to review the result of the countermeasure strategies selected	• Develop criteria and methods to determine the start and end of countermeasures. Take all relevant factors into account • Start work on the better definition of the transition phase and the methodological and technical needs for preparing the recovery phase • Implement appropriate OILs into Decision Support Systems to be compared with monitoring information and investigate optimisation possibilities for that selection	• Development of the methodological framework

Key topic 5: Formal decision support (for more detailed description of topics and subtopics please refer to the SRA)

Challenges and achievement in	1-5 years	6-10 years	>10 years
Decision making methods and tools **VISION**: Formalised methods and tools that structure and improve the decision making process in all phases of an accident /incident	• Investigate the added value of multi-criteria analysis for decision support, in particular in pre-planning and the recovery phase • Development of methods and guidelines to address the planning and decision making during the transition phase • Development of structured analysis to look for the preferences and needs of stakeholders and its introduction into the decision making process • Development of training and support material for decision makers	• Develop multi-criteria analysis tools that are fit for purposes • Support the structuring process in decision making • Development of guidance material for "good decision making practice" Development of structured methodologies to define generic scenarios for preparedness and planning taking into account different driving forces (technical, societal, economic, environmental..)	• Review the progress and develop a research program for the way forward
Decisions under high uncertainty **VISION**: Formalised methods that support robust decision making under high uncertainties	• Improve multi-criteria analysis with uncertainty handling • Investigate the importance of uncertainties in the decision making process in all accident/incident phases • Investigate the scenario planning as tool to support the decision making under uncertainty • Develop methods and tools for the local stakeholders to manage daily life under conditions with high uncertainty	• Combination of agent based simulation systems with multi-criteria Analysis for uncertainty handling to better quantify the preferences of all stakeholders • Develop methods and criteria to support when using uncertainties in decision making • Development of training and support material for decision makers	• Investigate more complex decision analysis tools for use under high uncertainty aiming to move towards big data applications

Key topic 6: Disaster informatics (for more detailed description of topics and subtopics please refer to the SRA)

Challenges and achievement in	1-5 years	6-10 years	>10 years
Analytical platform **VISION**: Establish the analytical platform as part of the emergency management toolbox	• Investigate the usability of the existing analytical platform • Test and improve the existing analytical platform	• Expand the capability of the analytical platform based on findings from exercises and applications	• Investigate combination of the analytical platform with big data approaches
Knowledge databases **VISION**: Knowledge databases becoming operational allowing to support decision making in all phases of an accident/incident	• Extend the knowledge database with more scenarios for all phases of an accident/incident • Develop more focused similarity approaches	• Investigate how big data analysis can be used for the knowledge database • Develop tool or mechanism to collect relevant information from the internet (e.g. Twitter, Facebook and other media) • Usage of all relevant information from whatever sources (e.g. Twitter, Facebook, scenarios)	• Expand knowledge databases and big data functionalities to develop a focal point for decision support. • Investigate if this approach can complement existing DSS
New generation Decision Support Systems (DSS) **VISION**: New generation Decision Support Systems for integrated decision making (tactical, operational, strategic)	• Improve user interfaces of existing Decision Support Systems for the various phases of an accident/incident • Develop new interfaces of DSS's to comply with improved decision making methods • Investigate the need for re-engineered DSS to deal with uncertainty	• If necessary, investigate concepts and advanced informatics approaches to modularise Decision Support Systems for application in different phases including uncertainty handling • Coupling of the existing strategic Decision Support Systems such as ARGOS and RODOS to Command and Control (C2) systems	• Develop new generation of Decision Support Systems based on advanced informatics approach

Challenges and achievement in	1-5 years	6-10 years	>10 years
Virtual and augmented reality **<u>VISION</u>**: Suite of new training facilities for first responders, decision makers and other stakeholders that can be used for preparedness and testing	• Review and investigate the usability of serious gaming and augmented reality in radiation protection research • Development of serious games and augmented reality for preparedness	• Explore the usage of serious gaming and augmented reality for training of the decision making processes • Develop appropriate tools to train decision makers and other stakeholders	• Develop better training tools for responders, decision makers and other stakeholders by combining virtual and augmented reality tools with Decision Support Systems .

Roadmap NERIS Challenge Area 3

Challenges in setting-up a trans-disciplinary and inclusive framework for preparedness for emergency response and recovery

- **Key topic 7. Emergency response and recovery framework, including reference levels**
  - Implementation of BSS including reference levels and relation with operational levels
  - Longer term management
  - Contaminated goods
- **Key topic 8. Stakeholder engagement, involvement of the public & communication** (presentation of and addressing uncertainties)
  - Stakeholder engagement processes including the public
  - Citizen Science
  - Communication
- **Key topic 9. Integrated emergency management – non-radiological aspects** (health surveillance, ethical aspects, economic issues…)
  - Health surveillance
  - Ethical aspects
  - Socio-economic aspects
  - Integrated surveillance and monitoring
  - Radiological protection culture
- **Key topic 10. Uncertainty and incomplete information handling** (presentation of uncertainties)
  - Dealing with uncertainties

Challenges and achievement in	Vision
Setting-up a trans-disciplinary and inclusive framework for preparedness for emergency response and recovery	
Key topic 7: Emergency response and recovery framework, including reference levels	
Implementation and development of BSS including reference levels and relation with operational levels	Harmonised framework to support countries in applying the BSS and key decision criteria such as OILs
Longer term management	Better guidance for long term management of contaminated areas including societal aspects
Contaminated goods	Guidance framework to better manage goods from contaminated areas

Key topic 8: Stakeholder engagement, involvement of the public & communication (presentation of and addressing uncertainties)	
Stakeholder engagement processes including the public	Guidance framework for establishing a successful stakeholder engagement process
Citizen Science	Guidance framework for establishing a successful integration of citizen science in radiological risk governance
Communication	Guidance framework for efficient communication for different exposure contexts, time scales, cultural and socioeconomic contexts
Key topic 9: Integrated emergency management – non-radiological aspects (health surveillance, ethical aspects, economic issues…)	
Health surveillance	Guidance framework for justification and improvement of health surveillance
Ethical aspects	Guidance framework for including ethical aspects in decision making in all phases of an emergency
Socio-economic aspects	Guidance framework for including socio-economic aspects in decision making in all phases of an emergency
Integrated monitoring and surveillance	Guidance framework for an integrated surveillance and monitoring programme articulating health surveillance, environmental monitoring, human dose assessment and food monitoring
Radiological protection culture	Guidance framework for establishing a sustainable Radiation Protection Culture in all relevant areas of radiation protection including means to support education and training as well as supervision
Key topic 10: Uncertainty and incomplete information handling (presentation of uncertainties)	
Dealing with uncertainties	Guidance framework and advanced tools to better identify, address and communicate uncertainties

Key topic 7: Emergency response and recovery framework, including reference levels
(for more detailed description of topics and subtopics please refer to the SRA)

Challenges and achievement in	1-5 years	6-10 years	>10 years
Implementation and development of BSS including reference levels and relation with operational levels **VISION**: Harmonised framework to support countries in applying the BSS and key decision criteria such as OILs	• Review OILs developed under RA2 and refine and adapt according to societal factors • Development of socially and scientifically robust Operational Intervention Levels (OILs) for the transition and longer-term management • Investigate the potential of simulation models to set up a possible reference levels early in the emergency to support decisions such as temporary or permanent relocation • Define success criteria for the application of countermeasures, methodology and tools to better understand actual and future risks and vulnerabilities	• Adapt decision support systems to implement results from the screening in the first period (0-5 years) • Support the operational application of the BSS and OILs with further scientific research • Define success criteria for the application of countermeasures • Incorporate risk-reduction strategies into governance and local decision-making	• Development of scientific based guidance how to best use OILs and intervention levels in the operational application of the BSS • Implement this guidance into decision support systems • Integrate Radiation protection into a broader environmental protection framework

Challenges and achievement in	1-5 years	6-10 years	>10 years
Longer term management **VISION**: Better guidance for long term management of contaminated areas including societal aspects	• Develop long term, sustainable communication models and stakeholder engagement frameworks to improve public health and well-being • Develop criteria for lifting of countermeasures and transition from emergency to existing situations	• Developing guidance documents how to best use policy formulation tools mathematical models and stakeholder engagement framework for a sustainable recovery	• Test the guidance in stakeholder groups and improve mathematical tools and stakeholder engagement framework
Contaminated goods **VISION**: Guidance framework to better manage goods from contaminated areas	• Studies on the implications of trade and use of goods from contaminated territories in the perspective of a sustainable recovery • Development of simulation models that allows the quantification of potential doses from usage of contaminated goods	• Analysis of different management strategies – including health, economic and ethical issues	• Develop management procedures for Europe based on the simulation models

Key topic 8: Stakeholder engagement, involvement of the public & communication (presentation of and addressing uncertainties) (for more detailed description of topics and subtopics please refer to the SRA)

Challenges and achievement in	1-5 years	6-10 years	>10 years
Stakeholder engagement processes including the public **VISION**: Guidance framework for establishing a successful stakeholder engagement process	• 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. • Assessment and design of stakeholder participation tools and methodologies for preparedness, emergency and recovery situations. Rules and roles of stakeholders in the engagement process. Motivational factors for, ethics of and link between theory and practice of stakeholder engagement	• Further development of database on experiences of stakeholder engagement in preparedness and response highlighting lessons learned and guidance for best practice, taking into account the national context. • Develop guidance on information and participation of population, increasing effectiveness if multiple source of information may compete or conflict	• 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. • 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 **VISION**: Guidance framework for establishing a successful integration of citizen science in radiological risk governance	• Investigate the potential and pitfalls of citizens involvement in knowledge production and data sharing for radiological risk governance • Determine factors influencing the trust between different actors	• Development of guidance for successful integration of citizen science in radiological risk governance	• Initiate a platform for sustainable application of citizen science in radiological risk governance

Challenges and achievement in	1-5 years	6-10 years	>10 years
Communication **VISION**: Guidance framework for efficient communication for different exposure contexts, time scales, cultural and socioeconomic contexts	• 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. • Use and perception of technical information and risk estimates in communication with various publics (lay people, experts, informed civil society). • 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	• Development and usage of social media and other information sources in emergency response and recovery: how social media can be used to improve emergency response and better communicate and cooperate with the public • Investigate in detail the impact of social and traditional media 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 • Investigate the links between perception of radiological risk and radiation protection behaviour, or individual strategies to cope with perceived risk in relation to radiation exposure	• Development of a framework that considers research from the first decade and develop plans guidance for operators, regulators, decision makers and journalists

Key topic 9: Integrated emergency management – non-radiological aspects (health surveillance, ethical aspects, economic issues…) (for more detailed description of topics and subtopics please refer to the SRA)

Challenges and achievement in	1-5 years	6-10 years	>10 years
Health surveillance **VISION**: Guidance framework for justification and improvement of health surveillance	• Development of procedures for health surveillance including sampling of population and dose reconstruction, the concerns of both institutional decision-makers and populations, and with involvement of stakeholders.	• Investigate in detail socio-psychological and economic aspects of medical and health follow-up after accidental or other exposures. • Investigate the results from the health surveillance program in Fukushima aiming to identify positive or negative components of the program	• Development of necessary guidance documents for better health surveillance approaches
Ethical aspects **VISION**: Guidance framework for including ethical aspects in decision making in all phases (preparedness, emergency and recovery)	• Investigate the ethical aspects of emergency management and recovery, particularly ethical questions of evacuation, and the transition from emergency to existing radiation exposure situations • Investigate the ethical basis and values underpinning risk communication about ionizing radiation exposures	• Investigate the ethical perspective of compensation for damage incurred due to various situations of radiation exposure and differences among countries	• Expand the ethical aspect to all questions of decision making and provide guidance how to deal with it

Challenges and achievement in	1-5 years	6-10 years	>10 years
Socio-economic aspects **VISION**: Guidance framework for including socio-economic aspects in decision making in all phases (preparedness, emergency and recovery)	• Understand how the population reacts and how socio-economic factors can be used by local-national tools to improve the response • Investigate possible compensation schemes and other economic support for the recovery phase	• Development of comprehensive approaches to studying the perception of radiological risk and environmental remediation actions in post-accident and existing exposure situations. • Investigate the perception of radiological risks from low doses of radiation, accounting for cultural differences in routine, emergency and other exposure situations. • Development of guidance for economic supports for the improvement of living conditions of the population	• Investigate in detail the interplay of psychological aspects associated with radioactivity, social environment and radiation protection behaviours • Development of socio-economic valuation and multi-criteria decision aiding methods to formally structure the evaluation and integration of radiological and non-radiological factors for different ionising radiation exposure situations

Challenges and achievement in	1-5 years	6-10 years	>10 years
Integrated surveillance and monitoring **VISION**: Guidance framework for establishing a comprehensive surveillance and monitoring system addressing health surveillance, human dose assessment, environmental monitoring and food monitoring in meaningful way for local populations	• 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 post-emergency phase • Investigate connections between these different dimensions of surveillance, healthcare and the development of radiation protection culture • Investigate possible connections between institutional surveillance and independent initiatives	• 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	Implement and test 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
Radiological protection culture **VISION**: Guidance framework for establishing a sustainable Radiological Protection Culture in all relevant areas of radiation protection including means to support education and training as well as supervision	• Investigate the role of Radiation Protection (RP) culture, in particular its contribution to the protection system and the improvement of if it can improve health and well being • Development of tools, methods, processes to build, maintain and transmit RP culture in all aspects of emergency management with due consideration of the needs of stakeholders	• Development of guidance for enhancing RP culture for specific publics (communities around nuclear installations, schools, patients, pregnant women, medical doctors) • Development of appropriate education and training means	• Development of procedures how to use the RP culture in the operational world and develop mechanisms to quantify a successful implementation of RP culture

Key topic 10: Uncertainty and incomplete information handling (presentation of uncertainties) (for more detailed description of topics and subtopics please refer to the SRA)

Challenges and achievement in	1-5 years	6-10 years	>10 years
Dealing with uncertainties **VISION**: Guidance framework and advanced tools to better identify, address and communicate 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. • 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. • 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.	• Identify information that should be considered for decision making in the various phases of an emergency; • Investigate how decisions taken under high uncertainty can be communicated to media and general public • Develop tools and methods for a two-way communication of uncertain information between experts and non-experts • Develop education and training material for decision makers on uncertainty management	• Review the developments from the first decade and develop further needs for improved communication of uncertainties • Investigate to which extent serious gaming can be used in communication of uncertainties