5th NERIS Workshop

"Key challenges in the preparedness, response and recovery phase of a nuclear or radiological emergency "

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Book of Abstracts

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Session 1 – Radiological impact assessment during all phases of nuclear and radiological events

The effect of terrain modeling on simulated dose rates

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Atmospheric dispersion can be modelled in various ways e.g. using Gaussian models, particle models, CFD models etc. The main difference between these models is the way atmospheric conditions and site geometry is treated. One expects that if these two factors are more accurately modelled, the accuracy of the prediction of concentration-based quantities increases, especially in the near range of the source. The aim is to verify how sensitive the prediction of dose rates is to the chosen dispersion model.

The subject of this study is the Belgian Reactor 1 (BR1) at the SCK•CEN site in Mol (Belgium). Dose rate data in seven measurement stations around BR1 were collected in the first half of 2017 in the context of the NERIS ADM experiment [1]. Increased dose rate levels are picked up regularly due to Ar-41 emissions during the routine operation of BR1. Three types of dispersion models were included in the study: a Gaussian plume model (both with a low and a high roughness parameterization), a Lagrangian particle model [2] and an Eulerian finite element vegetation canopy model. The stochastic differential equation that describes the particle trajectories in the particle model was derived from the advection-diffusion equation. The canopy model describes the wind field and the dispersion process above and inside the canopy, hereby taking a non-uniform leaf distribution over height and the sparsity of the vegetation cover into account. Besides the stack releases from the BR1 also hypothetical ground releases were considered. Despite the predicted concentration distributions differed significantly, the dose rate predictions were found to be quite robust, both for the stack and the ground releases. All the models predicted more than 75 % of the dose rate measurements within a factor two. More pronounced differences were observed between the Gaussian models and the canopy model for the ground releases, but the dose rate predictions were all within a factor ten. The results suggest that dose rate measurements, or in extension fluency rate measurements of individual radionuclides (spectroscopy), at the near range are an excellent tool for estimating the source term.

Radiological effects and assessment of a "dirty bomb" scenario on a microscale in urban areas

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In present times there is a fear that terrorists might thread population or a state to enforce their illegal demands. An often discussed possibility is to disperse radioactive substances by means of explosive material somewhere in public or in military areas (dirty bomb- or RDD- (Radiological Dispersive Device) scenario). These areas consist generally of urban structures, with a range of smaller buildings like housing areas up to complex buildings like areas in the centre of big cities or e.g. military camps.

A decision support model (LASAIR [Lagrangian Simulation of the Inhalation and Dispersion of Radionuclides]) has been developed to simulate atmospheric dispersion of radionuclides after an accidental release and assist in such a case of malevolent threads to provide quick and relevant information on the radiation exposure. The microscale model with a model domain of 20 km x 20 km and smallest grid size of 5 m is based on a well-accepted mathematical procedure (Lagrange-particle procedure), with a state of the art turbulence parameterisation (developed in 2017).

For adequate consideration of urban effects, the dimensions of houses or buildings have to be taken into account as they might change the wind direction and wind speed as well as generate additional mechanical turbulence which influences the dispersion. Therefore LASAIR uses the free system Open Street Map from which the two dimensions or sometimes even three dimensions of buildings can be extracted. In an operational mode, these data can be gained via the internet within a few minutes. Based on this, a diagnostic wind field model (lprwnd) together with the Lagrangian particle model (LASAT, [Lagrange Simulation von Aerosol-Transport]) computes the atmospheric dispersion.

The combined wind field and dispersion model LASAIR is able to assess the radiation exposure after explosion or short term releases with special consideration of the radiation dose from inhalation, cloud- and ground-shine as well as activity concentration and deposition as a function of time. The model is especially dedicated for operational use but can be applied as well for analysis of building structures in order to provide a maximum of shelter against attacks.

The presentation gives an overview on the model and especially on the influence of simple urban structures (e.g. urban areas, nuclear facilities, military camp) to the dispersion of radioactive substances and related radiation exposure.

Session 2 – Radiological impact assessment during all phases of nuclear and radiological events (Cont.)

Novel Stochastic and Deterministic Models for Polydisperse Flows Resulting from a Radiological Dispersal Device

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Accurate prediction of the dispersal of particles resulting from the detonation of a radiological dispersal device (RDD) presents many modelling and numerical challenges, especially when urban environments are considered. Certain modelling challenges occur due to the presence of a range of particle sizes generated in the fragmentation process and the associated fireball. Furthermore, radioactive particles in such flow situations transition from a granular-phase regime near the explosion site to a dilute-phase farther away. Capturing the transport of contaminants from the initial blast wave is integral to achieving accurate predictions, especially for regions near the explosion site where the blast dynamics dominates. However, performing such calculations over a wide range of particle sizes and spatial scales is computationally challenging. Formulation of efficient and accurate computational models is required to provide predictive tools useful to first responders and emergency planners.
This talk discusses two recently proposed models for the simulation of RDD flows. The first model, called Multi-Cloud Radiological Explosive Source (MCREXS), is stochastic and combines a particle-based, mechanistic model with a standard Gaussian puff model to calculate the dispersion of the contaminant in atmosphere. The former model is used to characterize the distribution of radioactive material near the source of the explosion, where the blast wind effects are important, while the latter is used to model the transport of the contaminant in the environment over large areas. The particle transport in the near-field of the explosion site is computed based on a Lagrangian description of the particle phase and a reconstructed-Eulerian field for the carrier phase. The information inferred from this physics-based model is then used as a starting point for a subsequent standard Gaussian puff model to calculate the dispersion of the radioactive contaminant.

Despite great predictive capabilities, the MCREXS model may become prohibitively expensive when the number of particles and/or simulation runs required for reliable results becomes large. In contrast, the second proposed approach, called Polydisperse Gaussian Model (PGM), is deterministic and thus more computationally affordable. It represents an extension of the well-known maximum-entropy ten-moment model from rarefied gas dynamics with an addition for the treatment of the range of particle diameters. This model allows for anisotropic variance of particle velocities in the phase space and directly treats correlations between particle diameter and velocity. The resulting system comprises fifteen first-order hyperbolic balance laws that are quite simple mathematically and solvable using standard high-performance algorithms.

Numerical results are presented to illustrate the predictive capabilities of the models, including comparisons against measurements from the 2012 DRDC Suffield full-scale RDD experiments.

Uncertainty of atmospheric dispersion prediction

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DMI (Denmark)

In the early phase of a nuclear power plant accident with possible off-site consequences, resulting from e.g. core melt and breach of containment, accurate prediction of the atmospheric dispersion of radionuclides is of utmost importance. However, two large sources of uncertainty exist: one associated with the meteorological data employed for atmospheric dispersion model prediction, and one related to the source term, i.e. the amount of radionuclides released and the temporal evolution of the release. In the NKS-B project AVESOME (Added Value of uncertainty Estimates of SOurce term and MEteorology), a methodology is developed for quantitative estimation of the variability of atmospheric dispersion modelling resulting from both sources of uncertainty. With modern supercomputing facilities available e.g. at national meteorological services, the proposed methodology is well suited for real-time assessment and implementation in nuclear decision support systems (DSSs).

The AVESOME methodology adapts well to the RApid Source TErm Prediction (RASTEP) system, which provides a statistical ensemble of possible source terms and associated probabilities. In the near future, source terms derived within the EU project FASTNET will also become available, describing different release scenarios.

In the presentation, the AVESOME methodology is described, and the resulting implementation in the ARGOS nuclear DSS is addressed as well as impacts on real-time emergency preparedness and management.

Source term prediction in case of a severe nuclear accident

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IRSN (France)

In case of a severe nuclear accident, the estimation of the source term requires both a sound and fast estimation. A sound source term estimation can only be done if the severe accident progression and phenomena are fully known, but many uncertainties or errors affect the accuracy of the assessment: epistemic uncertainties, mostly related to the physical phenomena modelling; stochastic uncertainties, related to the accident itself (systems reliability, human factors, irreducible lack of knowledge in scenario progression…); errors or biases can come from inaccuracies in the plant modelling. A sound estimation requires then that these uncertainties are modelled and propagated, we present here the effort currently ongoing at IRSN for that objective.

Such estimations have been done in the framework of CONFIDENCE and FASTNET H2020 projects, where several thousands of calculations have been performed using ASTEC (Accident Source Term Evaluation Code) : an ensemble of source terms has been extracted from the constructed database for a given accident scenario and used as input by the WP1 of the CONFIDENCE project. It was then propagated through atmospheric dispersion and dose calculation tools, in order to assess the impact of source term uncertainties (along with meteorological ones) on environmental consequences.

Although ASTEC has been profitably used for emergency preparedness (firstly, for the development of calculations grids, and also as a reference tool upon which fast tools developed at IRSN are validated), ASTEC calculations take too much time to be performed in emergency response context. As a consequence, in the framework of FASTNET project, surrogate model techniques have been investigated so that the assessment of different variables of interest, among which the source term, can be assessed quickly, based on ASTEC calculations. Bayesian networks have been used for that purpose and provide very fast assessment, with a reasonable accuracy. These developments will also be presented.

Atmospheric transport and dispersion modelling study of the I-131 detected in Jan/Feb 2017 in Europe

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SCK.CEN (Belgium)

In January and February 2017, several low-level detections of I-131 have been made in Europe. These detections were exchanged by radionuclide experts via the informal Ring-of-Five network. To date, the origin of the I-131 is not fully understood, although research pointed out that multiple sources might have contributed to the detected I-131, together with the specific meteorological situation characterized by strong low-level temperature inversions (Masson et al, 2018). Such temperature inversions lead to poor dispersion conditions, so that any tracer released nearby the ground will accumulate inside the planetary boundary layer.

A recent paper by Masson et al (2018) assessed potential sources of the detected I-131 and made a quantitative estimate of the effect of the meteorological conditions on the I-131 concentrations. We use their findings to perform an atmospheric transport modelling study, using the Lagrangian particle model Flexpart. Activity concentration time series are constructed for different detection stations in Europe. The relative importance of each source is discussed, and simulated activity concentrations are compared with observations exchanged via the Ring-of-Five network. Furthermore, the role of the meteorological conditions are assessed by comparing simulated and observed temperature profiles. These results are then compared with vertical cross sections of I-131 concentrations as simulated by Flexpart.

Masson, Olivier, et al. "Potential Source Apportionment and Meteorological Conditions Involved in Airborne 131I Detections in January/February 2017 in Europe." Environmental science & technology 52.15 (2018): 8488-8500.

Improving European decision support reliability and robustness to manage scenarios involving contamination of inhabited areas

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DTU (Denmark)

In recent years, various efforts have been made to enable the European standard decision support systems for management of contaminated areas to address uncertainties in different parts of the dose estimation framework, in order to provide more robust prognoses. Under the European research project CONFIDENCE, the ERMIN model for dose estimation in contaminated inhabited areas was revisited in this context. Although rough indications of parametric uncertainties associated with some ERMIN parameters have previously been indicated, it was clear that an effort was needed to systematically improve on the quality of these parameter uncertainty indications, taking the latest information into account and considering a wider range of case specific parametric options, thus reducing the overall prognostic uncertainty.

Some of the important parameters encompassed by the work are the factors expressing the relative initial contamination levels after different modes of deposition on the various types of surface in an inhabited area complex, while others dealt with the retention and migration with time after the deposition of the same contaminants on/in different types of inhabited area surface, and the occupancy, that is the fractions of time spent by people in different locations outdoors and indoors in the environment, as dwellings can, depending on their construction, protect inhabitants well against contamination present on surfaces in the outdoor environment.

The presentation gives an account of the findings, outlining their implications for prognoses. For example, on some man-made materials, particularly the caesium cation is retained to a much greater extent than on other during early natural run-off and wash-off processes. However, on a range of for example roof paving materials, the subsequent weathering over the following several decades can be expected to be identical within a very narrow variation range. Recent studies of the migration of also other contaminants and other types of surface have given completely different results. The processes in ERMIN are thus refined with an increased number of different cases, rather than treating everything the same with an inadvertantly unnecessarily huge uncertainty. Also the representation of the process of vertical contaminant migration in soil has been improved considerably by introducing parameters reflecting different soil characteristics in the decisive convection-dispersion model. The improvements are particularly targeted for predictions of residual doses in justification and optimisation of recovery countermeasure strategies, but are for example also very useful for preparedness planning, teaching and drilling purposes.

Seasonality influence in the elaboration of risk maps associated to the transfer of radioactivity through the food chain

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The uncontrolled release of radionuclides, as a result of nuclear or radiological accidents may affect large areas due to the accumulation of radionuclides in soils. The transfer of the radioactive contamination through the food chain can give rise to public health and socioeconomic consequences and therefore, have a clear implication in the way of life of the affected population. The risk posed by these releases, at any specific place, is a function of factors such as the amount and composition of the radionuclides released, their atmospheric dispersion and deposition pattern, the radiological vulnerability of the affected area (in terms of its potentiality to transfer the contamination to the population), but also the socioeconomic structures affected (number of persons potentially exposed, land use agricultural and husbandry production) and the policies that may affect the afore mentioned.

The ANURE (Assessment of the NUclear Risk in Europe-A case Study in the Almaraz Nuclear Power Plant, Spain) Project has developed a methodology, integrating all the factors considered previously, to elaborate risk maps associated to the transfer through the food chain, identifying those areas of most concern and where recovery actions should be applied as a priority.

A further step in the methodology has been accomplished to identify the season of the year and the magnitude of the release that would pose a greater risk due to the food chain exposure. For this purpose, a statistical analysis of the seasonal variations of the activity concentrations in different relevant food stuffs, prepared for consumption, has been carried out. The values have been estimated with JRODOS-FDMT from a set of daily simulations, over a period of five consecutive years, of a severe accident with off-site consequences. This paper shows the methodology developed and results obtained.

Session 3 – Radiological impact assessment during all phases of nuclear and radiological events (Cont.)

Radiological impact assessment in preparedness and response phase for nuclear emergency management in Greece

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As required in the new European BSS Directive (EC Directive 2013/59/Euratom), a national assessment of the radiological or nuclear emergencies that may potentially affect the territory and population of a member state forms the basis on which the protection strategies and emergency management system should be developed. As there are no nuclear power plants in the country, the assessment includes the case of a hypothetical accident at a fictitious nuclear power plant at a distance representative of the location of the nearest nuclear power plant (Emergency Preparedness Category IV according to IAEA).

Two independent sets of calculations - scenarios are presented each with a different release date and different source term assumption i.e. either a Fukushima-like source term or a release suggested in the approach used by latest IAEA emergency preparedness and response guidance. Different models (JRODOS and US NOAA HYSPLIT) are used for each set. As it has been shown from the accidents in Fukushima and Chernobyl, the impact from a severe nuclear accident might range from a relatively local contamination to contamination of large areas in a very complicated pattern that is very difficult to be predicted. Similar conclusion is drawn from our calculations: weather conditions proved to play a very significant role, compared to the role of the distance from the plant; a radiologically significant impact cannot be ruled out even in relatively long distances (greater than 300km).
The prevailing option, under discussion at the moment, in the development of the protection strategy seems is an over conservative approach based on the implementation of precautionary measures for the protection of the public, such as food restrictions and suggestions for minimising contact with the environment. To compensate for the large uncertainties in spotting the contaminated areas, in particular for large distances from the plant, these precautionary actions would be proposed for a very extensive part of the country, taking into account any available source of information or assessment, such us dispersion modelling and air gamma dose rate measurements. However, in order to refine the response in a more appropriate manner, a more reliable estimation of the actual contamination, based on measurements, should be performed, as soon as possible. The potential needs regarding the radiological impact assessment and the associated radioactivity measurement campaign and the related challenges for a non-nuclear country in accomplishing such a task in a reliable and quick manner are discussed.

Acknowledgements: We thank Milagros Montero Prieto of CIEMAT for her contribution in selecting the releases dates for the calculations with JRODOS. This work has been partly benefited by the work performed in the context of the project CONFIDENCE which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 662287.

Lessons learnt from the gamma-based monitoring stations of RARE (Radiological Alert network of Extremadura, SW spain): development and real-time performance

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The ambient dose rate has been adopted by the International Commission on Radiological Protection (ICRP) as a fundamental parameter in the field of dosimetry (Council Directive 1996/29/EUROATOM). The above mentioned parameter is usually continuously monitored, using Geiger-Müller or ionization chamber detectors, by early warning radiological networks around the world. They have several advantageous capabilities owe to their sensitive and fast response, easy operation, relatively low cost and robustness. However, their main drawback is based on the impossibility to individually identify and quantify each of the natural and/or man-made radioisotopes that produce alterations of the natural background. In fact, in the case of a nuclear accident, to know the radioisotopes released to the environment (atmospheric and/or aquatic media) and their activities is a crucial support to take decisions about the protection not only of civilian population but also of emergency teams. In this communication, the homemade gamma-based atmospheric and water monitoring systems currently working in the Radiological Alert Network of Extremadura (RARE, SW Spain) which is composed by 17 monitoring stations, a mobile laboratory and a drone are briefly presented. They are based on $LaBr_3(Ce)$ and NaI(Tl) detectors, and their constructions have required important mechanical, electronic and communications developments. Moreover, in order to accomplish with their early warning function, new software tools have been required, including an intelligent system to issue the necessary warnings when radiological anomalies or technical problems are identified in the monitoring stations. After about five years of operation, the capabilities of the gamma-based RARE monitoring stations are considered highly satisfactory, although some shortcomings have emerged and the approaches to deal with them are also presented.

Passive dosimetry measurements used in the aftermath of a radiological accident in the framework of "PREPAREDNESS" EMPIR project

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The measurement of ambient dose equivalent rate using passive dosimetry in the aftermath of a radiological accident was studied to evaluate the current status of application of passive detectors for radiation protection.

This work is carried out in the framework of Preparedness EMPIR Project "Metrology for mobile detection of ionising radiation following a nuclear or radiological incident" and it focus on the activities of the work package 4 "Passive Dosimetry".

In Europe, about 100 dosimetry services exist from measuring bodies (such as governmental offices, companies, institutions associated with a research facility or a hospital, etc.). They have in common that they use passive area dosemeters (dosemeters without electronic inbuilt) for environmental monitoring. A survey by the European Radiation Dosimetry Group showed that some of these services are neither traceable to primary dosimetric standards nor accredited. Due to the lack of international standards, a variety of different measurement procedures and uncertainty calculation methods are used. The application of passive detectors for radiation protection is not trivial. For nuclear and radiological accidents, the feasibility of follow-up surveillance using passive dosemeters could be of wide interest to confirm the environmental radiological data by active detectors in long-term monitoring after a nuclear accident.

The literature overview showed that there are a very few studies dealing with specific topics on passive dosimetry measurements in the aftermath of a radiological accident.
Some articles are focused on radiation measurements and the dosimetric results with passive dosimetry systems are summarized and not described in deep. A lot of publications studied thermoluminescence property for retrospective dosimetry after an accident and sometimes the results were compared with standard passive dosimetry (environmental or personal TLDs). Most of the papers are dealing with characterisation and comparison of the different passive dosimetry methods for the use in environmental monitoring as well as for their application to terrestrial wildlife assessment. Summary works on environmental monitoring with TLD were published for the area next to nuclear sites.

In conclusion if solid state systems are used for long term environmental monitoring, the traceability and harmonisation of these systems is needed to obtain reliable data. Currently there is a lack of systematic data, recommendation and protocols for the use and the most appropriate types of passive dosimetry systems in the aftermath of the radiological incident. Therefore, this EMPIR "Prepardness" Project aims at the implementation of stable and reproducible procedures to measure ambient dose equivalent rates by passive dosimetry and the improvement of the necessary metrological infrastructure in Europe.

Voluntary radiation measurement team to enhance the radiation measurement preparedness in Finland

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A large scale nuclear or radiological emergency like a severe accident at a nuclear power plant, use of a nuclear weapon or a radiological dispersion device could threat the functioning of the whole society. Radiation and Nuclear Safety Authority (STUK) has together with The National Defense Training Association of Finland (MPK) and National Emergency Supply Agency (NESA) launched a co-operation program to enhance the national radiation measurement preparedness by recruiting, training and equipping a voluntary radiation measurement team. The team will be equipped with diverse and modern measurement tools and it improves Finland's radiation measurement capacity in situations that require plenty of information on radiation in order to ensure safety and to support official decision making. The focus lays primarily on the measurement of potentially contaminated people. In later phase the measurement of the surroundings and infrastructure will become important.

The voluntary radiation measurement team will consist of about 40 persons divided into three measurement groups and one supporting group. The team will be capable to independently carry out its duties, for example, to determine the radiation situation, to check the contamination of people and vehicles as well as to support other organizations with radiation measurements.

The recruiting of the volunteers was started in 2017. A pilot training program for 20 persons, lasting for two weekends, was arranged in the spring 2018 and the training continued with a larger group of volunteers in the autumn. The pilot courses were successful. The participants were very motivated and enthusiastic. The background of the volunteers is diverse. There are different kinds of tasks available for the volunteers, from a member of monitoring patrol to more challenging tasks like trainer or the operative leader in the volunteer organization. Further recruitments as well as equipping the team will continue.

Session 4 – Setting-up a transdisciplinary and inclusive framework for preparedness for emergency response and recovery

European scenario-based stakeholder discussion panels, to test their engagement in the decision making process during the transition phase of a nuclear emergency

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In the course of a nuclear emergency, the transition and recovery phases present particular challenges that require understanding among response organisations and authorities. During the transition to recovery phase, efforts are made to withdraw the emergency response, establishing specific plans for recovery and rehabilitation of the affected areas. The success of the recovery plans is measured by the ability of the recovery strategies and actions to address the stakeholders' main concerns and be implemented in a timely manner.

Stakeholder discussion panels have been set up in nine European countries, in the framework of the project CONFIDENCE – WP4 (Transition to long-term recovery, involving stakeholders in decision-making processes) to establish and assess the processes for national dialogue with stakeholders during the transition to recovery phase, based on representative contamination scenarios. The discussions have been focussed on what to do and how to proceed in such contamination scenarios and how to evaluate the potential consequences of decisions and their impacts on achieving acceptable living conditions. These discussions were mindful of the inherent uncertainties associated with the real consequences of the contamination scenario, the strategies to be implemented and the potential socio-economic impacts on the affected population.

The main objective of the panels is to facilitate stakeholders' involvement and to provide valuable input in the process of decision making to improve preparedness for and response during the transition phase.

A summary and the main conclusions from European stakeholders' panels under the CONFIDENCE-WP4 are presented here.

The local Radiological Emergency Programs in Spain: The Valencia region Program

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In Spain, the responsibilities of managing different kinds of nuclear or radiological emergencies is shared between different authorities depending on the level and type of accident. In case of an accident in a Nuclear Power Plant, the authorities responsible of decision making are the Spanish Nuclear Security Council (CSN) and the Emergency Military Unit (UME). For other kind of accidents, the responsibility may fall on the regional government if it has accepted the transfer of these responsibilities. The Valencia region has the particular characteristic of holding the Cofrentes Nuclear Power Plant and of having accepted the transfer of authority for minor nuclear or radiological emergency situations as fire and other accidents in factories or installations containing radioactive material, managing orphan sources or illicit traffic of radioactive material, satellite falling, road accidents involving nuclear material transport and actions and steps to take after a hypothetical radiological terrorists attack. The Valencia region is also responsible of the environmental survey of Cofrentes NPP and the surveillance and security control of all the radiological and radioactive installations in its territory. The University of Valencia cooperates with the local authority in the measurements of environmental radioactivity around the Cofrentes NPP and in developing the recently approved Radiological Emergency Program and is a counselor for decision making. In this talk we describe the interplay and synergy between both activities and the new challenges arising from the Radiological Emergency Plan.

Delphi study to support the involvement of stakeholders in the decision-making process during the transition phase of a nuclear emergency

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The preparedness for the recovery of acceptable living conditions after a nuclear emergency requires the involvement of stakeholders as soon as possible. Even during the transition phase their interests and points of view should be considered to incorporate them into the decision-making process.

Under the CONFIDENCE-WP4 framework, a stakeholders' Delphi study was set up to explore consensus amongst relevant stakeholders from different European countries. Delphi method has proven a popular tool for identifying and prioritizing issues in diverse research fields. It is a structured technique for eliciting and combining responses from different experts or stakeholders. The final aim was to obtain a prioritization of the stakeholder preferences and needs that could be useful in the decision-making tools.

We obtained a sample of 71 stakeholders from 6 EU countries: Spain, The Netherlands, Greece, Ireland, Slovak Republic and Belgium. Participants were public authorities, researchers, industry representatives, members of associations and professionals from other fields. The questionnaire was developed *ad hoc* to assess different concerns, relevant issues to be addressed during the transition phase of a nuclear emergency, objectives of the restoration plan and main challenges of this emergency phase.

Preliminary findings indicated that health and society were the primary concerns of participants. Food control, public trust and risk communication were highlighted as the main issues to be addressed during the transition phase; while other-goods control appeared as less important. In the same sense, to minimize the impact in the living conditions of the population was emphasized as the main objective that the restoration has to pursue. Communication with the affected population seemed to be the most important challenge during the transition phase. High level of agreement was found among participants. Despite the limited sample sizes, some differences seemed to exist among the participants from different countries while no significant differences were found by the professional field.

The stakeholders' Delphi technique constitutes a promising approach to facilitate constructive dialogue and consensus building among diverse, antagonistic and hierarchical stakeholder groups.

Stakeholders feedback on mobile Apps and devices for dose and health measurements after nuclear accident (SHAMISEN SINGS project)

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1. *ISGlobal, Barcelona, Spain*

Dozens of individual mobile devices and Apps on radiation dose measurements, and thousands on health and well-being parameters, already exist and are available for their use by various stakeholders. These devices could also be suitable in emergency and recovery phases after a nuclear accident. One of the aims of WP1 of the SHAMISEN-SINGS project (CONCERT, EU-funded) [1,2] is to obtain feedback from stakeholders (including general public) regarding their awareness of already existing Apps and mobile devices for dose measurements and health/well-being and their opinion on the usefulness of such devices.
We developed a special survey of 'Stakeholders Needs and Feedback' to determine whether stakeholders (including general public) knew about such devices and Apps. For those who had previously used such devices, we asked them to assess their usefulness, user-friendliness and overall experience. We asked about people's willingness to use such mobile Apps or devices in the future and their expectations and concerns regarding their eventual application.

The Survey questionnaire was elaborated with the participation of all partners and experts of the SHAMISEN-SINGS Consortium, and has been translated from English to six languages: Spanish, Italian, Russian, Ukrainian, French and Japanese. The survey was anonymous (on-line Google Forms) and disseminated via specially created leaflets with QR codes, publication in the SHAMISEN SINGS website (Stakeholders' feedback part) [3], in the ISGlobal blog ("Your voice is important!"[4]), and other means (local stakeholders meetings, conferences, university courses and mails).

At the end of the survey (overall from April to November 2018, although each version had its own collection period), we received a total of 394 replies, covering adult participants of SHAMISEN Consortium countries (Spain, Italy, Belarus, Ukraine, France, Norway and Japan), as well as other countries such as Ireland, UK, Canada, USA, Peru, Mexico, Uruguay, Croatia, Czech Republic, and Belgium among others.

Details on the stakeholders' feedback on awareness, practical use and future expectations on this kind of mobile Apps and devices will be presented.

Funding: SHAMISEN-SINGS is part of CONCERT. This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 662287.

Formal and informal participation in emergency Preparedness and Response: a purposeful mapping exercise

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Formalized, top-down government imperatives to involve relevant stakeholders (e.g., local communities) in emergency preparedness and response (EPR) co-exist with informal, "uninvited," or unruly forms of stakeholder involvement. The latter may comprise public protests, grassroots citizen science activities, or individual actions taken up by private citizens or consumers. Contrary to formal participatory activities, they are not institutionally sanctioned and are generally not considered as viable or legitimate emergency responses in their own right. In addition, with the exception of public protests, they are not well documented and remain under-researched. In an effort to shed light on these informal participation practices, to better understand their real and potential implications for emergency management, and to appreciate their role in a complex "ecology of participation", we conducted a purposeful mapping exercise for Belgium. Contrary to conventional review methods found in the social sciences, purposeful mapping expands the possibilities within research syntheses by connecting individual cases, identifying knowledge gaps and knowledge clusters and providing evidence for policy-relevant questions. Different sampling strategies are used to include previously unconsidered or marginalized stakeholders and participation forms, by searching online resources, academic and grey literature, and by using data from other research projects and transcripts of discussions with emergency actors. The aim is to account for variety and difference, given the observation that emergency preparedness and response today is increasingly characterized by diversity and complexity. This contribution will present preliminary results from our mapping study and will discuss the implications within a broader research framework designed to: i) clarify why, when and how stakeholders engage in radiation protection; ii) develop novel approaches to analyzing stakeholder interactions; iii) draw lessons for participatory engagement for decision makers and other stakeholders.

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Session 5 – Setting-up a transdisciplinary and inclusive framework for preparedness for emergency response and recovery (Cont.)

Changes in nuclear and radiological threats and hazards from a Norwegian perspective

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In 2018, the Norwegian Radiation and Nuclear Safety Authority (DSA) published an updated assessment on nuclear and radiological threats and hazards. It is generally recognised that nuclear or radiological events may occur in the future, with severe consequences nationally and internationally. Radioactive deposition, contamination and exposure to ionising radiation may have impact, health, the environment and other public interests. Uncertainty or fear of such an event having occurred may also have consequences for health and public interests. Management of such events in order to minimise consequences will be demanding, both in the short and in the long term.

The nature of nuclear and radiological threats and hazards has changed during the last years. In the assessment, the most important issues addressed by the DSA are:

- Russian and NATO military activities in the High North and visits by nuclear-powered NATO vessels to Norway
- The situation in Ukraine
- National and international terrorism, criminality, orphan sources, etc.
- Russian nuclear-powered icebreakers operating close to Norway
- Transport of spent nuclear fuel and other radioactive waste along the coast of Norway
- Floating nuclear power plant
- Removal of radioactive waste from Andreev Bay in Russia
- Civilian nuclear power industry and reprocessing facilities
- Closure of the research reactor in Halden (HBWR)

In addition, Norwegian authorities are again assessing scenarios related to the use of nuclear weapons in or in proximity of Norway.

The changes and developments in nuclear and radiological threats and hazards over the last years raise new challenges for the ongoing work on national nuclear emergency preparedness and response.

Ensuring Radiation Safety in Slovenian-Croatian Cross-Border Region

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Jožef Stefan Institute (Slovenia)

The aim of the contribution is presentation of the ENRAS (ENsuring RAdiation Safety) INTERREG (**Interreg V-A Slovenia-Croatia)** project, which has just started.

The project addresses the common challenge of inadequate emergency preparedness and safety in case of nuclear and radiological emergency interventions for the first facilitators´ units (fire brigades) by setting up a new common training system and by signing an agreement on the establishment of a new cross-border structure to promote cross-border cooperation in the field of radiological security.

As part of the project, we will, as a new approach, carry out joint training of intervention workers (firefighters) at the locations of residence of the intervention units in order to qualify them for intervention in case of such accidents. This approach will for the first time bridge the gap between the existing capacities, experience and knowledge of the project partners and the knowledge and capabilities of first responder intervention teams intended for mediation in nuclear and radiological accidents.

With the approach of establishing common benchmark measurements for intervention workers from Slovenia and Croatia and the establishment of a permanent cross-border structure that will take care of coordinated cross-border operation in the event of such accidents, the project will further link both countries and surpass their existing practices at the national level.

With the approaches achieved, the project will lay the foundations for improved cooperation also in the wider region.

The results of the assessment will be presented and discussed in the presentation. Further work on assessing the source term using inverse modelling based on a Bayesian optimisation approach is currently ongoing and will be also presented.

Nuclear and Radiological Emergency Preparedness in Spain: some keys for improvement

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Adequate preparedness for emergency response and recovery requires continuous improvement efforts. Conscious of that, the Spanish Society of Radiological Protection (SEPR) organized a Workshop with the collaboration of CIEMAT, UPM and ISGlobal, in which the main results and recommendations of recent research projects (PREPARE, SHAMISEN) were presented, as well as past exercises with significant stakeholder participation (within EURANOS and NERIS-TP projects) and ongoing projects (CONFIDENCE; SHAMISEN SINGS and ENGAGE). That experience, under the prism of past nuclear accidents and the recommendations issued by the ICRP, raises many questions concerning the effectiveness of radiological and nuclear emergency preparedness in Spain, including the post-accident recovery.

About 40 participants, representing a wide spectrum of organizations and stakeholders involved in EP&R, participated in the Workshop with the goal of identifying strengths and limitations in the preparation of emergency response and post-accident recovery in Spain (including health and socio-psychological follow-up), both from a theoretical and practical point of view, and to provide key elements for improvement. Several peculiarities were identified that must be duly taken into account.

A common conclusion was that radiological non-nuclear emergencies are in general more difficult to prepare for because of the difficulty to identify potentially affected areas and the heterogeneity of situations. The need to fill existing gaps and the preparation of the main actors involved was highlighted.

Another obstacle is the fragmentation of competences between central, regional and local administration levels. To avoid lack of coordination during the emergency phase, a single chain of command is necessary, while decentralization and local administration levels are important for the development and management of intermediate and recovery phases.

Efforts should be made to increase the radiological protection culture of the different actors, stakeholders and the general population, for instance by performing periodical exercises and analyses of realistic accident scenarios. Experts and stakeholders should interact and cooperate through open networks. Apart from some technical matters, the key points for improvement depend more on the participation, motivation and engagement of the stakeholders and the population. This is the big challenge.

Participation in a Conv-Ex-2c Exercise: Preparation, performance and outcomes as an Accident State

Veronica Smith, Ciara Hilliard, Kevin Kelleher, Ciara McMahon, Robert Ryan, Kilian Smith

Environmental Protection Agency (Ireland)

Ireland routinely participates in International Atomic Energy Agency (IAEA) Convention Exercises (ConvEx). In 2018, the IAEA invited Ireland to participate as 'the accident state' in a ConvEx-2c exercise, the purpose of which was to test the arrangements for a transnational radiological emergency. The exercise scenario was a malign CBRN incident involving the detonation of two radiological dispersal devices in Dublin city centre.

The items discussed from a preparation perspective are the practical arrangements both nationally and internationally and the engagement of the relevant national stakeholders in advance of the exercise. This was to ensure that Ireland had sufficient capacity to participate appropriately on the day of the exercise.

The performance on the day of the exercise is addressed. The accident scenario was useful in identifying areas that worked well in Ireland's national arrangements for such an incident as well as identifying areas for improvement, that would not have been so evident if Ireland did not participate as the accident state. This also provided a unique opportunity for Ireland to engage, on a practical level, with both national and international counterparts through this simulation.

The outcomes from the exercise are outlined. These outcomes have provided Ireland with the basis for improving practical arrangements for preparing and responding appropriately in the future if such an event were to occur. In addition, it also provided an insight into how such an event would evolve in real time and engaged the relevant national stakeholders in a manner that would not have been possible otherwise.

The use of non-radiological resources to support nuclear and radiological emergency response

Robert Ryan, Ciara Hilliard, Kevin Kelleher, Ciara McMahon, Veronica Smith

Environmental Protection Agency (Ireland)

In 2014, the Radiological Protection Institute of Ireland merged with Ireland's Environmental Protection Agency (EPA). This merger resulted in a much larger organisation with additional human and laboratory resources that had the potential to increase capacity to respond to nuclear or radiological emergencies. Therefore, the Emergency Preparedness Unit of the EPA rolled out a training programme across the EPA so other areas of the organisation can assist if such an event were to occur. This work outlines the progress made to date and the work planned in the future to ensure the EPA can make full use resources and skills available in the organisation.

The work carried out to date has primarily focussed on three areas:

- Raising awareness of the EPA's role in nuclear and radiological emergencies and incidents.
- Utilising the regional presence of the organisation to respond to radiological incidents
- Provision of training and equipment to the EPA's chemistry laboratories to expand radiation measurement capabilities within the organisation.

This work has been conducted through general communications to staff and specific training sessions to laboratory staff on the basic concepts of radioactivity and radiation protection in conjunction with practical sessions on radiation detection and measurement. A table-top exercise was also conducted in 2018 involving all radiation and environmental monitoring staff that identified additional resources and skills that can be utilised in emergency preparedness and response.

This work is ongoing but has already resulted in improving internal practical arrangements and has identified additional skill sets within the organisation that can be utilised in response to a nuclear or radiological emergency.

Session 6 – Countermeasures and countermeasure strategies in emergency & recovery, decision support & disaster informatics

Local stakeholders confronted to mid- and long-term uncertainties in a post-nuclear accident situation: outputs from the TERRITORIES Workshop

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CEPN (France)

One of the tasks of the European project TERRITORIES[1], is dedicated to stakeholder involvement in decision-making processes associated with the management of contaminated territories characterized by long-lasting exposures. In particular, it aims at anticipating stakeholder concerns and needs, by confronting them with the possible decisions – accounting for the uncertainties – that could be taken according to existing local, national, international decision-making processes doctrines and frameworks related to mid- and long-term recovery.

To exchange with local actors on this topic, several workshops have been set up in Europe. In France, the workshop was organized by CEPN and IRSN in collaboration with the Local Nuclear Information Commission (CLIN) of Blayais Nuclear power Plant.

As an introduction of this workshop, testimonies and feedback experiences were reported by Japanese and Belorussian stakeholders who are involved in the rehabilitation of living conditions after the Fukushima and Chernobyl accidents.

In a second step, the local French actors (elected officials, wine producers and vineyard syndicates, farmers, representatives of the local Chamber of Agriculture, Health Agency, and of environmental protection associations, etc.) discussed about health, social and environmental issues which could be at stake in the Medocan territory, as well as the conditions for the resumption of economic activities (e.g. agricultural recovery). More specifically, uncertainties that the local population would face following a fictitious nuclear accident at the Blayais nuclear power plant, have been described and discussed in depth by the local interested parties.

For the simulation of the event, OPAL – a specific tool for improving awareness of Local Actors toward post-accident issues, developed by IRSN - was used and the potential impacts and consequences on the territory were placed in the French context of post-accident management (e.g. using post-accident zoning criteria as proposed by CODIRPA in its "Elements of Doctrine for the Post-Accident Management of a Nuclear Accident").

The workshop was organized in several working sessions, bringing together a plurality of stakeholders. Their discussions focused on the following topics:

- The monitoring of the radiological situation of the people and the territory,
- The future of the agricultural sector in the territory,

[1] This project has received funding from the Euratom research and training programme 2014-2018 under Grant Agreement No 662287.

- The challenges of restoring the quality of life, health and welfare,
- The maintenance and revitalization of a sustainable socio-economic activity.

The presentation will develop the findings and outputs that emerged from these focus working groups.

On the basis of this work as well as those carried out in other countries, recommendations will be proposed to feed the final reports of the TERRITORIES project. These recommendations will focus on how to manage existing exposure situations to take into account the different uncertainties that local actors face in the medium and long term.

Involvement of French stakeholders in the decision-making process in the context of uncertainties - The European project CONFIDENCE - WP4

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The European Research Project CONFIDENCE Work-Package 4 (WP4), aims to identify and reduce uncertainties which could emerge in decision making processes, in order to improve the preparedness and response during the early and transition to long-term recovery phases of a nuclear accident. To that extend stakeholder panels and participatory workshops have been set up in different European countries. In France, a national panel has been created which gathered several decision makers at the national and local levels of the French post-emergency response system: ASN (Nuclear Safety Authority), IRSN, Directorate General for Food, Regional Health Agency, Departmental Directorate for the protection of population, retired Prefect and retired mayor, Interdepartmental Civil Defence and Protection Service, Chamber of agriculture, firemen, etc. In this context, this paper aims to present the main results of the work which has been conducted with the panel.

Two panel meetings have been organised by IRSN and CEPN in 2018. The first one, in June was focused on the management of emergency phase. The objective was to understand and evaluate how and on which elements decision-makers are taking decisions in a context of uncertainty. The second meeting, held in October, was focused on the transition phase. The aim was to assess the influence of prior decisions made during the emergency phase over the medium to long term decision processes: how could prior knowledge – or a more accurate evaluation – of the radiological impacts have influenced the initial decision-making? What information would have been useful to ease and comfort their decisions? Etc. During the meetings, the panel focussed on two crucial protective actions: i) the evacuation and temporary relocation of populations and, ii) the restrictions on food consumption and distribution.

The methodology used for the panel meetings was to consider inherent uncertainties about the real situation (use of the fictitious nuclear accident scenario prepared specifically for the CONFIDENCE project). For the first panel meeting, CONFIDENCE WP1 outputs (maps of probability of exceeding specific reference levels) have been presented together with other maps highlighting socio-economic aspects of the affected territory (agriculture issues, population density, etc.). For the second meeting, a synthetic map of measurement data (also from the fictitious nuclear accident scenario) provided again by WP1 has been used to show the difference between forecast data and measurements.
Discussions with the panel resulted in the following findings and outputs: i) the temporal dimension (evolution of zoning with time) is confirmed to be very useful for decision-makers; ii) beyond radiological aspects, decision-makers need various information (geographical information, socio-economic issues, etc.); iii) the transition between emergency and post-accident phases is challenging; iv) decisions will not only rely on local level, but would also be a national or international issue. Besides these elements, these meetings allowed to identify and highlight various types of uncertainties whether associated with the production of information (modeling, field measurements, etc.) or with the use of information (related to the decision itself, to their implementation and their governance, social and economic uncertainties, etc.).
Based of these lessons learned, some recommendations will be discussed in the last part of this presentation.

Decision support diagrams for public protective actions during nuclear emergencies

Jan Johansson[1], Peder Kock[1], Anna Maria Blixt Buhr[1], Jonas Lindgren[1], Jonas Boson[1], Simon Karlsson[1]

Swedish Radiation Safety Authority (Sweden)

The Swedish Radiation Safety Authority (SSM) has developed decision support diagrams that provide guidance for making decisions on public protective actions in nuclear emergencies at the Swedish NPP, taking the inherent uncertainties of such events into account. The decision support diagrams are based on emergency class and recurring evaluation of the situation and lead to a recommended course of action given the present knowledge of the situation. The decision support diagrams were developed in close collaboration between radiological experts, the authorities responsible for nuclear emergency response planning and the final decision makers. Methodologies developed by SSM from a review of the Swedish emergency planning zones and distances were used in the development.

The protective actions considered in the decision support diagrams are evacuation, relocation, sheltering, iodine thyroid blocking, prevention of inadvertent ingestion, contamination control and decontamination of people, medical actions and food restrictions. Recommended protective actions in the decision support diagrams are in some cases based only on emergency class and in other cases on additional information as well. The distances where recommended protective actions are to be implemented are generally predetermined taking the present emergency response planning around the NPPs in Sweden into account. Protective actions closer to the NPP are recommended to be implemented in all directions around the facility whereas protective actions at further distances are recommended to be implemented only in potentially affected areas as indicated by dispersion modelling. An important assumption behind the recommended protective actions in the decision support diagrams is that the threshold to terminate already decided protective actions is generally high.

A potential release is placed in one of three release magnitude intervals. For each interval, a predetermined source term representing the upper limit of the interval has been used to calculate residual doses for different combinations of protective actions in order to identify on optimised combination of protective actions to aim for. When using the decision support diagrams, key questions on starting time, duration and magnitude for the release as well as potentially affected areas are repeatedly evaluated before and during the release. Answers to those questions will guide the user to an optimised course of action given the present knowledge of the situation.
The decision support diagrams are robust in that a decision can always be made even when limited or no information is available. At the same time, the decision support diagrams make use of additional information if it is available thereby providing an instrument to optimise protective actions for the public during a nuclear emergency.

The basis for the Swedish emergency preparedness and response plan for ESS

Anna Maria Blixt Buhr[1], Jan Johansson[1], Peder Kock[1], Jonas Boson[1], Simon Karlsson[1], Jonas Lindgren[1]

[1]Swedish Radiation Safety Authority (Sweden)

The Swedish Radiation Safety Authority (SSM) has decided to place the European Spallation Source (ESS) in emergency preparedness category II in accordance with the IAEA's GSR Part 7: Facilities for which on-site events are postulated that could give rise to doses to people off the site that would warrant urgent protective action or early protective actions.

The research facility ESS is under construction in the city of Lund, in the southern part of Sweden, and is planned to be in full operation 2025 (2 GeV, 5 MW). At ESS, scientific experiments will use the high neutron flux produced by spallation when a proton beam from a linear accelerator hits tungsten bricks on a rotating target wheel. For emergency response planning around ESS, the postulated event is a loss of cooling accident and the loss of target cooling (He gas) is assumed to occur while the proton beam is in full operation and the target wheel continues to rotate.

SSM has performed analysis for the emergency preparedness categorisation and the emergency response planning. A number of choices was made within the analysis: the types of emergency planning zones and distances to be established, the reference level that serve as the basis of emergency planning, the dose criteria and intervention levels for different protective actions, the released materials associated with the postulated event, the selection of radionuclides in the corresponding representative source term, the settings for the dispersion and dose calculation and the number of weather cases to include when estimating the distances at which it is justified to take different types of protective actions. Due to uncertainties in the properties of the released materials, SSM also examined possible alternative outcomes in a sensitivity analysis. In addition, SSM analysed possible needs for decontamination and radiation monitoring brought about by the emergency.

The emergency response planning proposal includes an emergency planning zone (UPZ) surrounding the ESS facility extending approximately 700 meters. Within the UPZ, planning should be in place for sheltering. SSM also analysed the residual doses, i.e. the possible radiation doses that may occur assuming that the proposed protective actions in the UPZ can be implemented. The proposal serves as the basis for the future emergency response planning to be put in place when the facility starts to operate.

The present work is in line with the proposals for new emergency planning zones and distances surrounding the nuclear installations placed in emergency preparedness category II in Sweden, such as the fuel fabrication plant and the central interim storage facility for spent nuclear fuel.

A reflection on the way for setting intervention regions at the end of the urgent phase of a radiological accident

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Introduction

As part of the strategy for protection in emergency exposure situations [1], it is necessary to define response phases, namely an urgent phase from the alarm until the end of the principal releases, followed by an early phase when the radiological situation is sufficiently well characterized to be able to identify which additional protective actions have to be taken based on the actual situation. During the different phases of the emergency phase, portions of the territory are defined in order to facilitate the adoption of protective measures. The areas established for the urgent phase on the basis of the reference scenario and dispersion modelling are no longer relevant for taking early protective action or others response actions in the early phase. The present proposal for the distribution of the territory at the end of the urgent phase is based on the measured radioactive deposition and includes three regions that differ in the exposure pathways to which they are addressed and in the protective measures they involve.

Zones defined at the beginning of the urgent phase/beginning of the early phase

In the urgent phase, where the main protective measures against exposure to the radioactive cloud are precautionary evacuation, sheltering and stable iodine tablets intake, there is a broad international consensus on the establishment of protection zones [2]. These are, in the case of an accident in a nuclear power plant, the PAZ (Precautionary Action Zone), an area extending at a distance of about 5 km from the facility and in which exposures leading to immediate health effects can be expected, and the UPZ (Urgent Protective Action Planning Zone), an area extending at a distance of about 30 km where people can suffer exposures leading to unacceptable risks of stochastic effects. These zones are established based on a model of the course of the reference scenarios. During this phase of the response, the basis on which precautionary protective measures are taken is the status of the facility and the meteorological conditions.

New situation at the end of the urgent phase/beginning of the early phase

The situation is different at the end of the urgent phase/beginning of the early phase: Here the basis on which protective measures are taken is the actual radiological situation in the environment, specified mainly by the deposition of radioactivity on the territory. At the beginning of the early phase, the zones defined for the urgent phase are no longer relevant and new areas, referred to here as "regions" in order to distinguish them from the zones established for the urgent phase, are to be defined to facilitate the implementation of additional protective measures. It should be recalled that this new geographical distribution is based on new criteria and is largely independent of the areas defined for the urgent phase, at a time when the actual radioactive deposition is not known. The health risks at this stage of intervention are mainly external exposure of people through radioactive deposition on the territory and ingestion of contaminated food products. Three regions are proposed to facilitate the application of protection measures.

Forbidden region

To manage highly contaminated territories in which population maintenance is not feasible, a forbidden region (FORE) must be set up and the population of this region must be temporarily evacuated. The proposed criterion for setting the FORE is an effective dose due to external exposure of 100 mSv for the first year following the accident by living without particular constraints. Indeed, the organisation of social life in a territory leading to a dose to the inhabitants of more than 100 mSv per year is not considered possible or desirable. It should be recalled here that, on the one hand, decontamination and behavioural measures make it possible to significantly reduce people's exposure and, on the other hand, evacuation, even temporary, represents a major social disruption for a population. In addition, the decision to stay in a territory or to leave remains an individual choice that must be respected in all cases. The proposed operational quantity for setting the FORE is the ambient dose rate at 1 m from the ground 24 hours after

the reactor shutdown. For the reference scenario used in Switzerland [3], the value of the operational quantity leading to an effective dose of 100 mSv in the first year is estimated at 500 µSv/h.

Region of residence with constraints (RECO)
In those parts of the territory where the effective dose due to external exposure does not exceed 1 mSv during the first year, no residence restrictions are to be considered. Regions between this part of the territory and the forbidden region are likely to be inhabited, but measures to reduce the dose received by residents should be considered. This region, referred to here as the "region of residence with constraints", RECO, is thus defined as the part of the territory where the effective dose due to external exposure during the first year is between 1 mSv and 100 mSv. The operational quantity for fixing the RECO is, as in the case of the FORE, the ambient dose rate at 1 m from the ground 24 hours after the reactor shutdown. The RECO thus includes territories where ambient dose rate is between 5 and 500 µSv/h. Measures to reduce residents' exposure in the RECO include preventive personal decontamination, protection of living areas from contamination and limitation of outdoor stay. All these measures reduce exposure by an estimated factor of 10, making the population's residency acceptable.

Region of Agricultural Production Protection (RAPP)
Agricultural production in areas outside the RECO may be contaminated to a level that renders the products unfit for consumption. These regions are referred to here as the " Region of Agricultural Production Protection " (RAPP). The criterion used to define them is an effective dose during the first year, due to the consumption of locally produced foodstuffs, greater than 1 mSv. It is assumed that below this exposure no direct measures are to be considered. This criterion is relatively conservative, given that the products consumed are generally not all locally produced. For the reference scenario used in Switzerland, the deposition leading to an ingestion dose of 1 mSv for the first year is about 100 kBq/m2, corresponding to an ambient dose rate of 0.2 µSv/h at 1 m from the ground 24 hours after the reactor shutdown. This value corresponds to about twice the background radiation and is therefore relatively easy to measure. It should be noted that the presence of a high contribution (compared to the reference scenario) of strontium-90 or alpha emitters challenges the relationship indicated here and requires a change in the proposed strategy.

Conclusions
The analysis presented highlights the need to define, at the beginning of the early phase of a nuclear accident, a new distribution of the territory, fundamentally different from that defined for taking precautionary measures in the urgent phase. At this point, the radiological situation is known and the risk is no longer external exposure and inhalation of contaminated air as the cloud passes, but is also associated with external exposure and internal exposure due to consumption of contaminated foodstuffs following the deposition of radioactivity on the territory. In summary, the proposed criteria for fixing the protection regions at the end of the urgent phase and the values of the operational quantity (ambient dose rate, H*(10), at 1 m from the ground 24 hours after the reactor shutdown are given in Table 1).

Table 1. Criteria for fixing protection regions

Protection region	Exposure pathway	Effective dose criteria (E) (mSv during the first year)	H*(10) µSv/h)
Forbidden residence (FORE)	external	100 mSv	500 µSv/h
Residence with constraint (RECO)	external	1 mSv < E < 100 mSv	5 µSv/h
Agricultural Production Protection (RAPP)	ingestion	E > 1 mSv	0.2 µSv/h

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Session 7: Countermeasures and countermeasure strategies in emergency &recovery, decision support & disaster informatics (Cont.)

Simulations of decontamination scenarios using the system dynamics approach

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Using methods of system dynamics, a simulation model of selected decontamination scenarios has been proposed. A large-scale grassed area contaminated by 137Cs and 134Cs after a nuclear accident was considered. Three possible scenarios were tested in relation to a real recreation meadow ground in the Czech Republic. Collective effective doses, costs and benefits of chosen scenarios were calculated and compared. The research was supported by the project of Ministry of the Interior of the Czech Republic VH172020015 – Recovery Management Strategy for Affected Areas after Radiation Emergency.

Significant sources uncertainty in the ERMIN urban dose model

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The ERMIN model was developed to provide prognoses of residual doses in urban environments contaminated by airborne radioactivity, and the effect of clean-up and other management options on those doses. It has been embedded within the jRODOS and ARGOS decision support systems. Under the European research project CONFIDENCE, sources of uncertainty were identified, reviewed and prioritised in order to better understand the range of uncertainty on the predicted residual doses and to identify ways to reduce uncertainty and handle it more effectively in ERMIN.

ERMIN parameters were revisited and indications of parameter (judgemental and stochastic) uncertainty compiled from the available literature. These enabled a series of constrained sensitivity and uncertainty analysis exercises to be performed. The exercises focused on ^{137}Cs in a soluble aerosol form and the residual normal living annual dose endpoint, but looked at different urban environments, both wet and dry deposition and with a range of clean-up options applied. In addition, the review went further and qualitatively considered other sources of uncertainty including; epistemological, model, computation and ambiguity related uncertainty.

Initial deposition in the environment was identified as a significant source of uncertainty, particularly early in the accident when measurements are few and there is a reliance on atmospheric dispersion models. Relative deposition onto different urban surfaces is also significant, particularly if there is uncertainty about the wet and dry components of deposition, and if the ERMIN idealised environment is not a good match with the real environment. The parameters concerned with initial indoor deposition were found to have considerable uncertainty, although this was only significant for the overall residual dose in specific situations. Uncertainty in long-term retention on surfaces and uncertainty on where people spend time were generally of lesser significance but again could be important in specific circumstances. Much of the uncertainty surrounding the effectiveness of clean-up options can be attributed to uncertainty of relative deposition and the subsequent retention on urban surfaces.

The recommendations arising from this study have to balance model and parameter improvement, with ensuring that ERMIN as a tool is still usable operationally; i.e. input requirements are not onerous, the user interface is simple and run times remain short. The recommendations include for example; improving the representation of soil migration by allowing different soil types to be chosen and using element and particle group specific parameters, increasing the range of environment types and sub-types within ERMIN and by including and refining the building ingress model within ERMIN. There is much that could be done in improving the depiction/communication of ERMIN uncertainty but this cannot be done in isolation but must be consistent across all the tools within the decision support system.

Agent-based Negotiation Simulation

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Nuclear emergencies are characterized by severe disruptions in society's functionality and adverse impacts on human, environment and economy. How to find out suitable countermeasures and countermeasure strategies is always important for the nuclear emergency management. For the past decades, many works focused on the definitions, simulations and evaluation of countermeasures and countermeasure strategies. However, a key problem remaining open is how to mimic the negotiation process for the stakeholders of different backgrounds when given existed strategies. Our work aims at solving this problem by constructing agent-based negotiation models with the corresponding computational implementations. By using this computer program, various phenomena of negotiation process can be realized numerically and further uncertainty studies, for example, the influence of choices of stakeholders on the final result of negotiations, can be carried out on basis of statistical analysis of hundreds of numerical simulations.

Preparedness for a "dirty bomb" attack: Antidotes and screening capacities as complementary medical countermeasure resources

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In radiological emergencies, there is a risk of radionuclide incorporation. The radiological doses absorbed can be reduced by decorporation treatment. Antidote requirements depend on the scenario and treatment strategy ("urgent approach": immediate treatment of all patients with possible incorporation; "precautionary approach": treatment after confirmation of incorporation). We calculated the number of daily antidote doses for different scenarios and the differences in outcome for both treatment strategies.

The number of potentially contaminated victims was varied from 1,000 to 60,000 (a maximum that might seem plausible for "dirty bomb" scenarios), the proportion of patients actually needing decorporation treatment from 0.1 % to 100 %, the radioactive screening capacities from 250 to 2,500 people/day and treatment duration from 10 to 90 days. The outcomes were assessed as total statistical lifetime saved assuming an inhalation of 1 mCi cesium-137 and the achievable dose reductions by a Prussian Blue treatment.

Assuming 1 % of the potentially contaminated people actually needing treatment and applying an "urgent approach" the requirements for 1,000 victims range from 1,100 to 3,400 and for 60,000 victims from 489,000 to 4,400,000 daily doses, depending on treatment duration and screening capacities. The "urgent approach" is associated with larger stockpile requirements than the "precautionary approach", up to several hundred times in large scale scenarios. The impact of the screening capacities is particularly important in large scale scenarios, a low proportion of people needing treatment and extended treatment duration. The outcome is better for an "urgent approach" particularly in large scale scenarios and low screening capacities.

If only a small fraction of the victims actually needs treatment, their timely identification by enhancing screening capacities may be the most efficacious way to reduce antidote requirements. In large scale scenarios, it might be necessary to abandon the medically preferable "urgent approach" for an antidote-sparing "precautionary approach".

Management of contaminated goods in post-accident situation – Lessons learned from Fukushima

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Feedback analyses from post-accident situations, as Chernobyl and Fukushima, have clearly emphasized the importance of management strategies for contaminated goods during the days, months and years after the accident. Indeed, following the accident, the response generally focuses on the implementation of protection actions, radiological countermeasures and the control of radioactivity in foodstuffs, in order to ensure the quality and sales of the products. Then, issues concerning the loss of image of local products can appear, and subsequent strategies have to be taken to restore the consumer confidence.

Based on a literature review and interviews performed in 2017-2018 with Japanese stakeholders involved in the Fukushima accident recovery, this presentation proposes an analysis of the strategies for the management of contaminated goods which have been implemented in Japan.

Major lessons learned from this analysis reveal that, today, many strategies have been implemented trying to regain the food safety and the confidence of consumers. These strategies have involved various actors (producers, retailers, local and national authorities, citizen and consumers' associations, etc.). There are all committed, each in their own way, to ensure the quality of the products and their promotion to the public. Key elements of these strategies are:

- The implementation of agricultural countermeasures to minimize contamination of foodstuffs;
- The development of a comprehensive radioactivity control system to ensure the radiological quality of goods produced in the Fukushima prefecture. Associated with this control, specific reference values had to be defined;
- The establishment of a compensation system, to indemnify producers for the loss of earnings due to the accident;
- The choice to sell local products at reduced prices, to maintain sales volume, as well as preserve farming activity and processing industry;
- The implementation of circumvention strategies (e.g. renaming) or conversion strategies (e.g. toward organic farming) to ensure sales of local products;
- The constant improvement of the overall quality of products (notably their taste) to restore the confidence of consumers;
- The development of new partnerships and stakeholder networks seeking in particular to characterize as accurately as possible the radiological situation of their local products;
- The implementation of actions aiming to promote and advertise local products as well as certify the quality of the products.

Therefore, exceptional resources have been implemented in Japan since the Fukushima accident to revitalize the socio-economic activity of the affected territories, where profound social and demographic disturbances have been brought by the accident. Indeed, Fukushima accident has accelerated the decline of agricultural activities in the Fukushima prefecture. Affected areas are changing dramatically: many innovative projects, supported by the government, are emerging as part of an economic reorientation (photovoltaic farms, waste treatment industry, robotics, drones, etc.). In such a context, the sustainable recovery of agricultural activities in this territory remains a real challenge.

Also, the future of the radiological control system remains a whole question. The fact is that almost all measurement results show now concentrations below detection limits, and the people have less and less interest for measuring radioactivity in food and other goods. This raises the following question: how to maintain vigilance and sustain the radiological protection culture within these territories?

Finally, while the consumer confidence in local products appears to have improved significantly within the Fukushima prefecture, this seems not to be the case for consumers living outside. Therefore, it is necessary to further explore the evolution of the behavior of these consumers as well as how authorities, local producers and retailers will tailor the response in the forthcoming years.

Session 8 – Setting-up a transdisciplinary and inclusive framework for preparedness for emergency response and recovery (Cont.)

Identification of mental models of uncertainty management in emergency situations

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The study on mental models of uncertainties management in emergency situation was carried out in the framework of the European project CONFIDENCE (COping with uNcertainties For Improved modelling and DEcision making in Nuclear emergenCiEs). The methodology included mapping of mental models within several emergency preparedness and response experts and then performing interviews based on structured protocol with lay people in 5 countries: Germany, Greece, Slovakia, Slovenia and Spain. The aim of these investigations was to trace the concepts and understandings of emergency preparedness and responds and to identify possible gaps between experts and lay people models. The report on the mental models was developed with the summary of findings for individual countries, followed by comparison between them.

The collected results showed that participants have a general idea on what are the basic elements of the emergency plan, but only vague knowledge of each specific protective measure. The important inconsistences present about planned measures shown where the authorities can improve the information and also where better communication is needed. In particular, there are different ideas about sheltering where people understand that special underground bunkers should be used for such case. Also there is lack of information about the iodine prophylaxes and what it is used for. Interestingly, interviewees differentiate two possible situations: major or minor accident. In case of major accident, we find out a fatalistic belief that nothing would help as the accident would have very rapid and deterministic effects. They imagine a scenario of death and devastation and many times they do not see the utility of emergency plan useful. In case of minor accident, they believe it will be radiation contamination and the emergency plan would be useful. Nevertheless, there is a clear awareness that in case of an accident it would be better to comply with governmental instructions. Main uncertainties identified would be what to do, where to go, and how would they be informed.

Uncertainties that decision makers, affected population And emergency responders may face during a nuclear emergency

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In order to identify uncertainties that decision makers, affected population and emergency responders may face during a nuclear emergency, this research focuses on the behavior of people involved in emergency exercises. It provides insights into the way uncertainties are addressed and handled during emergency exercises, by looking at the information flow and communication between actors, as well as the assumptions and decisions made under emergency exercise conditions. The methodological approach relies on nonparticipant observation as a technique for the systematic study of human behavior The observers recorded actual behavior under almost completely natural conditions. In order to enhance and deepen the understanding of uncertainties in emergency management, a constructivist approach has been applied with special attention to authenticity, trustworthiness, reflexivity, particularity and subjectivity (takes into account biases), and triangulation across data sources (capturing and respecting multiple perspectives). The objective was to maintain the integrity of unique cases/findings, to crystallise rather than generalize, and contribute to theory and dialogue about nuclear emergency management under uncertainties. 11 national exercises were observed in 6 countries, as well as one international exercise, with a total of 29 observation points. The observers recorded in conventional language the various behaviors of the emergency exercise participants and the conditions under which they occurred .

Results demonstrate a gap between theory and practice as well as pinpoint specifics in decision-making process related to a nuclear emergency management. In theoretical typologies, uncertainty is usually categorized as: aleatory (ontic/ stochastic) resulting from factors which are unpredictable, random or stochastic in nature; epistemic uncertainties, caused by limited or lack of knowledge and/or information; and uncertainties due to ambiguities. However, the non-participatory observation of exercises reveals uncertainties that cannot be readily placed in the above-mentioned categories.

The following dilemmas, causing uncertainties or being caused by uncertainties have been defined: How to coordinate cross-border aspects?;Is there a gap between legislation and reality?; How will coordination among emergency response actors be achieved?; How to deal with time pressure?; How to deal with technical aspects during the early phase of the emergency (e.g. source term)?; When is the time of the beginning of the release?; Which areas will be affected?; How to decide on protective actions?; How to implement protective action?; Which protective actions to apply?; Is radiological assessment consistent?; How serious is the accident?; Are the emergency actors familiar and trained to use equipment?; Are all emergency management actors familiar with their roles, procedures and plans?; Are the available resources adequate?; How to deal with long-term consequences?; Will people follow the instructions or recommendations given?; Are social considerations taken into account concerning emergency actors?; What is the origin of the first information?; Is the information exchange sufficient?; Which tools of information exchange are reliable?; Which factors impact information exchange?; How is information understood by different stakeholders?; Is information consistent?; Are all emergency actors informed timely?; How to communicate negligible impacts?; Is

ICT reliable?; Which information is public and which should be restricted to the emergency management actors?; How will communication needs be addressed effectively?; How to interpret atmospheric dispersion and deposition maps produced by models?; etc.
Identification of uncertainties contributes to creating awareness about potential challenges and improving decision-making under uncertainty in nuclear emergencies.

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Non-radiological impact of a nuclear emergency: focus on Psychological and mental health

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WHO

Available experience from Chernobyl and Fukushima clearly demonstrate that nuclear emergencies may result in low and very low exposure levels, at which psychological and social effects among the affected population will dominate over the actual biological effects of ionizing radiation. International protection standards and guidelines request, that both radiological and non-radiological health consequences have to be considered in preparedness and response to an actual emergency and there is a need to broaden the radiation protection system's philosophy beyond the metrics of radioactivity and radiation dose. During the past decade a number of multidisciplinary projects were set up with the aim of evaluating management options according to social, economic and ethical criteria, in addition to technical feasibility to achieve this goal. WHO and partners from the Inter-Agency Standing Committee Task Force on Mental Health and Psychosocial Support in Emergency Settings have developed a comprehensive framework and guidelines, which can be applied to any type of an emergency or disaster regardless of its origin. There is a need to include the available scientific expertise and the technical, managerial and personal resources to be considered within a similar decision framework that will apply to radiation emergencies. Key areas of the required expertise needed to develop such a framework are radiation protection, medical support (especially primary care and emergency medicine, mental health support), social sciences (anthropology, psychology, ethics), and communications experts. The implementation of such a multi-disciplinary concept in the operational world requires education and training well beyond the level currently available.

Societal uncertainties in emergency preparedness and response: perception rather than fact

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Societal uncertainties are considered a significant challenge to effective decision making processes in emergency preparedness and response. Addressing this challenge implies not only a reduction of these uncertainties but also increasing the understanding in the complexity in the interaction between uncertainties, the influence of these uncertainties and their interactions on decision making, and the complexity of the interaction between uncertainties in the various phases of a nuclear or radiological emergency. In order to obtain this understanding research was conducted that in an initial phase identified uncertainties after an actual radiological incident and a hypothetical nuclear accident in Belgium. Qualitative research, i.e. structured interviews, were conducted in Fleurus, Belgium, and a stakeholder panel was conducted on a hypothetical nuclear accident at the Nuclear Power Plant of Doel, Belgium. Insights from this research showed that the existence of societal uncertainties is highly dependent on the person who experiences the uncertainties, rather than the actual existence of the uncertainty, or the extent to which the uncertainty exists. As research has shown that a gap exists between knowledge (or awareness) and behavioural change, the argumentation is made to define and address uncertainty based on perception rather than occurrence. Furthermore, when assessing uncertainty within various phases of an emergency revealed that uncertainties should be addressed not only in the phase in which they are perceived or exist, but should be additionally (and precautionary) addressed in the appropriate emergency phase, i.e. preparedness phase. Several methods to address and reduce societal uncertainty in the appropriate phase are presented.

RP Culture in the field of Emergency Preparedness and Response: First outcomes from the European Project ENGAGE

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The ENGAGE project, funded under the H2020 CONCERT, aims at ENhancinG stAkeholder participation in the GovernancE of radiological risks. This two-year project, started on November 20th 2017, seeks to identify and address key challenges and opportunities for stakeholder engagement in relation to three domains of exposure management: medical use of ionising radiation, emergency preparedness and response and indoor radon. Within this Project, a specific Work Package (WP3) is dedicated to the investigation of the processes for enhancing radiological protection (RP) culture and to the development of guidelines for building this culture. The research is based on case studies performed in each of the three domains.

In the field of Emergency Preparedness and Response, taking into account the crucial role of the stakeholder involvement process for the implementation of the radiological protection system in case of an accident, the development of a radiological protection culture is essential. Experiences developed since the Chernobyl accident emphasize the challenges for the radiological protection experts for addressing this issue. In this context, the following case studies have been analysed:

- In France: Actions undertaken in the framework of the Steering Committee for the Management of the Post-Accident Phase of a Nuclear Accident (CODIRPA) set up by the French Safety Authority (ASN);
- In Slovak Republic: Actions undertaken to improve and strengthen the emergency and post-accident preparedness and recovery management at all levels: national, regional and local;
- In Italy: Preparedness to nuclear emergencies management at the level of hospitals;
- In Belarus: Radiological protection knowledge and culture in Education (state higher, primary and secondary schools' education) and in Public Information - mass media.

The analysis was structured around the following topics:

- Characterisation of case study (context of the process, actors, target stakeholders, objectives, etc.);
- Characterisation of RP Culture in the given context and exposure situation;
- Tools, methods & processes elaborated to build, enhance and transmit RP Culture;
- Methods to evaluate the level of RP Culture;
- Role and contribution of RP Culture for the governance of radiological risk.

The synthesis of the case studies provided recommendations for the practical implementation of RP Culture dissemination processes, illustrating the specificities of the areas of exposure as well as the common aspects. These recommendations will be shared and elaborated further in a workshop to be held in February 2019, bringing together Project researchers and various stakeholders, including those involved in the case studies, and representatives of European radiation protection research platforms. The proposed paper will summarize the key elements related to the radiological protection culture Emergency Preparedness and Response and present the recommendations as formulated at the end of the Workshop.

Session 9 – Challenges in estimating the source-term and operational radiological picture (on-site versus off-site)

Update on the IAEA IEC activities in EPR

Frédéric Stephani

IAEA (Austria)

The presentation will be available after the Workshop on the NERIS website.

Identification of atmospheric contamination source in an urban area by approximate bayesian computation methodology

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NCNR (Poland)

We present the framework for the identification of the parameters of the airborne contaminant source in the urbanized area. The framework is based on the Approximate Bayesian Computations (ABC) working algorithm to the identification of atmospheric contamination source in an urban environment based on the data reported by multiple sensors. We present the dedicated modifications of the Sequential version of ABC algorithm that improve estimation of the posterior probabilistic distributions of source parameters. The proposed algorithm works in real-time. Estimates of source parameters are dynamically updated with the use of online arriving concentrations of released substance registered by sensors network. We validate the proposed methodology on real data coming from a full-scale field experiment DAPPLE conducted in London. We demonstrate successful estimation of six parameters characterizing the contamination source, i.e., contamination source position (x,y,z) in a city environment, the mass of release (q), the release start time (t) and its duration (l).

As the forward model to predict the concentrations at the sensors locations, we utilize the advanced Quick Urban & Industrial Complex Dispersion Modeling system (QUIC), developed by Los Alamos National Laboratory. The obtained results prove the utility of the proposed approach for event reconstruction problem in any complex urban environment with the use of any suitable dispersion model.

RASTEP – a versatile tool for decision support in nuclear emergency situations

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RASTEP (Rapid Source TErm Prediction) is a software tool developed by LR with support from the Swedish Radiation Safety Authority (SSM) for providing independent decision support to emergency response organizations in case of an accident at a nuclear installation.

The tool is built upon Bayesian Belief Networks and pre-calculated source terms that can be taken from the output of any severe accident code of choice. The decision support will be both based on best available knowledge from PSA L1 & L2 as well as expert judgements that will be pre-loaded into the model. Thereby, the capability to make a relevant prediction within a short timeframe with limited information and personnel available during a real scenario will increase. Results from RASTEP can be easily exported in various formats, including the IAEA information exchange standard IRIX.

As of today, LR has developed both plant specific RASTEP models for operating nuclear power plants in Sweden and plant generic models for the European commission FASTNET project. Recently a new project has also been launched together with the Norwegian Radiation Protection Authority (NRPA) to develop a RASTEP model for spent fuel facilities.

Ideas for future development of the tool include improved capabilities for fine tuning of source terms, functionality for import of plant process parameters as well as improved GUI and uncertainty handling.

Comparison of ensembles of atmospheric dispersion simulations: lessons learnt from the CONFIDENCE project about uncertainty quantification.

Irène Korsakissok, Spyros Andronopoulos, Poul Astrup, Peter Bedwell, Karine Chevalier-Jabet, Hans De Vries, Gertie Geertsema, Florian Gering, Thomas Hamburger, Heiko Klein, Susan Leadbetter, Anne Mathieu, Tamas Pazmandi, Raphaël Périllat, Csilla Rudas, Andrey Sogachev, Peter Szanto, Jasper Tomas, Chris Twenhöfel, Joseph Wellings

IRSN (France)

Work Package one (WP1) of the EU-funded project CONFIDENCE (COping with uNcertainties For Improved modelling and DEcision making in Nuclear emergenCiEs) is dedicated to uncertainties during the early phase of a radiological accident. More specifically, it consisted in propagating input uncertainties through atmospheric dispersion models and analysing the ensemble results, including radiological endpoints such as threshold exceedance of dose reference levels.

The first step of any uncertainty propagation study consists in identifying and quantifying input uncertainties. Meteorological data (e.g. wind, rain fields) and source term (i.e. released rate of radionuclides as a function of time) are the key uncertainties during a nuclear crisis. The former was dealt with by using meteorological ensembles. For the latter, several scenarios were designed, from the most simple (a short release with crude perturbations on quantities, height and beginning time) to an ensemble of source terms, designed with the severe accident code ASTEC, including uncertainties. Finally, a significant literature review was undertaken to identify and characterise uncertainties linked to atmospheric dispersion models. Guidelines for ranking uncertainties in atmospheric dispersion were produced (Mathieu et al. 2017).

The second step was an uncertainty propagation exercise through atmospheric dispersion and radiological models, for both historical events and hypothetical scenarios. During this stage, participants from eight countries (Denmark, France, Germany, Greece, Hungary, the Netherlands, Norway and the UK) used the meteorological ensembles and release scenarios to propagate the uncertainties through their operational tools. The level of uncertainties taken into account depends on the participant; some only propagated the meteorological ensemble, others used Monte Carlo methods to take into account all the identified uncertainties.

This exercise lead to a tremendous amount of data: fields of atmospheric concentrations and deposition as a function of time, and associated doses, for a large number of simulations. Some lessons learnt relate to dealing with high-dimensional inputs (meteorological ensembles, source terms) and outputs, from very practical issues to more theoretical ones. This presentation aims at presenting a synthesis of the exercise, with a focus on issues related to the analysis and visualization of uncertainties, including statistical and graphical indicators to compare ensemble results.

Session 10 – Challenges in estimating the source-term and operational radiological picture (on-site versus off-site) (Cont.)

Source term estimation with a model implemented in the JRODOS DSS

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In the frame of the European project PREPARE (Innovative integrated tools and platforms for radiological emergency preparedness and post-accident response in Europe), two source term estimation modules were developed. Both are using gamma dose rate monitor information outside the plant boundary and gamma dose rate data calculated by an atmospheric transport and dispersion model. By comparing both, the measured and the calculated value, mathematical methods are used to estimate the unknown source term.

The simple source term estimation module, developed by VUJE, Slovak Republic, is implemented in JRODOS. It uses a simple Gaussian type algorithm to estimate the gamma dose rate information. The locations for these estimations have to be close to the site boundary. To estimate the source term, the monitored and estimated gamma dose rate information is compared to pre-calculated gamma dose rate data stored in a database for 10 representative radionuclides.

This paper presents a first detailed application of this tool for source terms of different complexities as well as for different meteorological conditions. Applicability and constraints of the method for decision making in the early phase of a nuclear accident will be discussed.

The advanced source inversion module of JRODOS

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Substantial scientific research efforts have been devoted in the recent years in developing algorithms for calculating the amounts of radionuclides released in the atmosphere (the so-called "source term") as result of a nuclear-power-plant (NPP) accident, such as Chernobyl or Fukushima. In the framework of the EC FP7 "PREPARE" project a source inversion algorithm has been developed with the following specifications: (a) it would be suitable for integration and automatic operation in the Java-based, real-time, on-line decision-support (JRODOS) system, (b) it would be a "top-down" or "measurement-based" algorithm, i.e., it would calculate nuclide release rates by adjusting the solution of an atmospheric transport model to measured values, (c) it would use total gamma-dose-rate (GDR) measurements—from cloud and deposition—as these are currently the most widely available measurements, (d) it would be able to calculate release rates of multiple nuclides (according of course to a "first-guess" source term) which would also be variable in time, (e) it would be able to calculate the release height or the vertical distribution of a release (the horizontal coordinates of the release are assumed to be known and are those of the NPP). The algorithm that has been developed is based on variational principles and minimizes a cost function that is constituted of two terms containing respectively the differences between measured and model-calculated GDRs and the differences between analysed and first-guess emission rates. To formulate the derivative of the cost function, the source-receptor matrix (SRM) is employed which expresses the sensitivity of model-calculated values (air concentrations, deposition, gamma dose rates) at points of measurements to values of nuclides emission rates. The SRM is calculated through forward-in-time run of the Lagrangian-puff atmospheric dispersion model DIPCOT. To estimate a multiple-nuclides source term, an approximate knowledge of the ratios between nuclides release rates is assumed. These ratios enter as additional linear equations. The root mean squared errors of measurements, model-calculated values, first-guess emission rates and ratios between different nuclides emission rates enter as regularisation parameters in the source inversion algorithm. For the automatic operation of the module in JRODOS parametrizations of the above errors have been developed. The module has been integrated in JRODOS and is accessible through the user interface from where the regularisation parameters can be controlled. The estimated source term is given in xml format, ready to be used by the dispersion modelling suite of the system.

The method has been tested for two cases. The first case concerned a release of radionuclides under the conditions of the widely used European Tracer Experiment (ETEX). The second case concerned a hypothetical accident at the RIVNE NPP in Ukraine. Artificial GDR measurements in both cases were generated through running the dispersion model DIPCOT using "true" source terms. The performance of the method in estimating the true source term, in relation to the values of and methods of calculating the regularisation parameters has been examined. The method has also been tested with different first guesses of the source term in relation to the true value. The performance of the method varied between test cases, however in all simulations the estimated time-dependent source term was closer to the true one than the first guess. The outcome of the first tests has showed aspects of the source inversion methodology where research is still needed but they are very encouraging and demonstrate the correct functioning of the module in the framework of JRODOS.

Real-time use of inverse modeling techniques to assess the atmospheric accidental release of a nuclear power plant

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IRSN (France)

In case of an accidental situation involving radioactive material, government agencies, such as the IRSN, have to provide, in support of the public authorities, a scientific estimation of the emission and of its consequences for human health and environment. To produce a fast and reliable expertise, the Technical Emergency Centre (TEC) of the IRSN relies on an organisation supposed to apply expertise methods with specific tools. The C3X platform is used to calculate the atmospheric transport of the released radionuclides at local and regional scales and to assess the consequences on the population and the environment. In the context of emergency, decision making relies on comprehensive information about the situation and its possible evolution. In particular, source term has to be estimated. Inverse modeling methods, which combine environmental measurements and atmospheric dispersion models, have proven to be efficient in assessing source term due to an accidental situation. IRSN developed its own tool which has been applied to the Fukushima accident by using dose rate measurement (Saunier et al., 2013) and air concentration measurements (Saunier et al 2016). The challenge is now to make this research tool operational to ensure that it can be encapsulate in the C3X platform and usable in an emergency context.

The operationalization challenge is to define a methodology to guide the user in applying the good practices depending on the situation. The previous applications were done after the end of the releases when a lot of measurements were available. Henceforth, one of the issues of the operationalization is to use the inverse modeling tool in real-time when the first significant radioactive levels of measurements are reported. National exercises test the capability of the crisis organization to respond to a crisis situation, they represent an ideal and a realistic application case. Therefore, the inversion method has been implemented during national exercises this year. In this presentation, the ability of the method to reconstruct a release in real time will be assessed. The relevance of the reconstructed source term will be evaluated using statistical indicators coupled with Monte-Carlo simulations. We will demonstrate that these indicators are very helpful to discriminate efficiently release periods among which we have confident and those remaining unreliable.

Collaborative Web Application to Support Source Term Assessment

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Since 2008 there has been in use a collaborative Web application in STUK - Radiation and Nuclear Safety Authority, Finland. Currently system is called TIUKU, formerly it was known as KETALE. The system covers a wide range of functionalities needed during nuclear or radiological accident management including dispersion calculations, radiation measurements handling, setting of protective actions, reporting etc.

In the system there is a source term input form. The form can be filled by hand or predefined source terms can be used as a template. Nuclides can be grouped in several ways and nuclide activities are defined as Becquerel (per second) units or as a fraction of reactor inventory. Source terms are then saved into database including version history. Further source terms are used as an input for dispersion calculations either by making a Web service request via TIUKU system or by exporting the source term to other software. It is significantly better to exchange information electronically between different software due to complex input and to minimize typing errors.

TIUKU source term handling fully supports IAEA's radiological information exchange format IRIX. Both importing and exporting of the source term is possible in the system. This makes it possible to import source terms to TIUKU generated by third-party software and also to use exported source terms in JRODOS decision support system for example.

Reliable data of the status of the nuclear power plant's safety systems is needed in order to estimate the source term. There is an automatic data transfer and display system from the power plant's process computer to STUK. Situational information is also gathered from other available sources. For maintaining situational awareness during an emergency TIUKU has a form for reactor safety assessment. In the form users define the current status of safety functions and other relevant information. The assessment can be exported as a report including a layout of the nuclear plant with status of safety functions (color coding).

The main challenge of estimating the source term are the uncertainties related to the plant parameters, inconsistency of data and hidden or unknown failures in important safety systems. In STUK a spectrum of pre-calculated accident scenarios derived from PRA level 2 are used to provide a base source term. The accident timing is adjusted by using expert judgement. When a source term is estimated before the release, it is not known if the operators will succeed with all the critical operator actions. There is also always a risk that the containment fails in an unexpected way. Therefore the estimation of the source term boils down to confidence levels: how much confidence is needed to estimate a small source term when severe accident systems work and are operated as designed.

Source term estimation of xenon releases from medical isotope production: a test case for near-range atmospheric dispersion modelling

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In this study, the capability of estimating the source term of releases to the atmosphere based on off-site monitoring and atmospheric dispersion modelling was explored. To gather the required data, a measurement campaign was set-up around the Institute of Radioelements (IRE) in which dose rate data and gamma ray spectra were collected at different locations in the near range (130 m – 680 m) downwind from the release point. During the production of medical isotopes at the IRE facility, limited amounts of noble gases (especially xenon isotopes) are released via a stack with a height of 25 m. These releases are well below any public health-related norms but can be picked-up in real-time by detectors in the close proximity of the site.

The data set was further complemented with detailed stack release values (released concentrations of individual radionuclides), which are measured routinely at IRE, and with local meteorological data collected with instrumentation mounted on a 30 m high meteorological mast that is operated by FANC on the site of IRE.

Very good agreement was found between the calculated ambient dose rates based on forward atmospheric dispersion modelling in the different locations and the measured ambient dose rates. A Gaussian plume model, developed at SCK•CEN for relatively high surface roughness and for use in the local range in nuclear emergency response was adapted for this purpose and coupled to a dose model that takes into account the finite (3D) dimensions of the plume.

The inverse problem, however, in which the source term of individual xenon isotopes is estimated, proved more challenging. It requires as input net peak count rates from gamma spectra, detector calibrations and a fluency model coupled to the atmospheric dispersion model and had to be developed from scratch. The results of attempted source reconstruction will be presented and the potential use of the assembled dataset in future NERIS ADM experiments will be discussed.

Analysis of the Fukushima source term: implications for source term estimation from radiological observations during emergencies

Martin Sogalla, Sebastian Band, Cornelia Richter, Martin Sonnenkalb

Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH

Our contribution presents a set of conclusions drawn from the analysis of the Fukushima source term (ST) which could be useful for the future development and application of ST backward calculation methods based on radiological measurements. Such a reconstruction has been carried out within the OECD/NEA project "Benchmark Study of the Accident at the Fukushima Daiichi Nuclear Power Plant" (BSAF).
Our analysis is based on measured local dose rate (LDR) on-site and nearby and activity measured in soil samples. In contrast to other ST reconstruction methodologies, we employ a deliberately "blind" approach which basically omits the use of plant information on accident progression. Particularly, no first guess on release phases or release strength is used by our method.

Our analysis provides expected and even unexpected results regarding comparison with observations. A basis nuclide composition of surface contamination has been reconstructed from soil samples. Unexpectedly, during the first few days of the accident, the observed LDR distinctly differs from calculation results based on this composition while the agreement improves later. An in-depth analysis reveals that only contributions by short-lived nuclides which have already decayed in the soil samples can explain observed LDR. The consideration of such short-lived iodine isotopes turns out to be a prerequisite for inclusion of on-site LDR measurements in our reconstruction approach. This inclusion leads to a striking agreement with ST reconstruction results obtained from the Japanese WSPEEDI decision support system and enables at the same time a higher temporal resolution and accuracy. The results provided by both methods have been used for an independent verification/validation of the ST predicted by severe accident (SA) analyses within the OECD/BSAF project and allow for a better/deeper understanding of the accident progression.

The results and methodology of our analysis are currently being incorporated into a source term estimation tool based on radiological data which is especially designed for the use of on-site and nearby radiological measurements and intended to cope with incomplete or even contradictory information input. It is planned to provide an interface for coupling this tool with fast running ST prediction tools based on plant data. The status of this development will be summarized and discussed.

List of Posters

Topic A – Radiological impact assessment during all phases of nuclear and radiological events

Use of different meteorological data for near-range assessments during a nuclear emergency

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Good meteorological data are of utmost importance in the assessment of the radiological impact of atmospheric releases using atmospheric transport and dispersion modelling. Most nuclear facilities have on-site measured meteorological data available. On the other hand, numerical weather data (prognoses and diagnoses) become available at very high spatial resolution allowing to extract local wind fields and other meteorological parameters of interest. In this study, meteorological data from 3 sources are compared for the Belgian Nuclear Research Centre (SCK•CEN), located in Mol, Belgium. The first set of data originates from measurements along a 114 m high met-mast located on the premises of SCK•CEN. The standard time resolution of these data is 10 minutes. The second dataset consists of meteorological parameters extracted from ECMWF diagnostic numerical weather data for the site of SCK•CEN, a tool developed for the different nuclear sites in Belgium by the Royal Meteorological Institute. These data are available on an hourly basis. The third dataset was collected using a ground LIDAR, installed at the premises of SCK•CEN in the close proximity of the met-mast, delivering high frequency data. Wind field data and atmospheric stability obtained from the three data sources are used for an intercomparison study, including an evaluation of differences in near-range atmospheric dispersion results.

In addition, and as a final "judge", the direction of the plume of releases from a 60 m high stack during normal operation of one of the research reactors is evaluated using detections in a ring of stations around this facility.

Large-scale measurements of internal contamination in case of a nuclear accident

Martin Hjellström, Nikola Marković, Mats Isaksson

University of Gothenburg (Sweden)

Through two different projects, funded by Swedish Radiation Safety Authority (SSM) and Swedish Civil Contingencies Agency (MSB), University of Gothenburg takes part in investigation of instruments for activity measurements and methodologies for estimation of internal dose from radioactive contamination. The experience from Japan after the Fukushima accident shows a need for extensive whole body measurements of the affected population. In radiological and nuclear emergency situations, action levels set on internal contamination are quite high so the sensitivity of the instrument and measurement precision are less important than the instrument throughput. Multiple studies have shown the feasibility of using gamma cameras as an alternative to whole body counters. Access to whole body counters in Sweden is limited (around 10 units), thus the use of medical gamma cameras (more than 70 units in Sweden) as a screening device provides better geographical spread and higher throughput. Since the gamma cameras are used on a daily basis by medical staff there is also trained personnel ready in the case of accident. Aim of the project is to develop guidelines for the use of gamma cameras as screening instruments. The most common gamma camera types in Swedish hospitals are identified and adaptation of a specific gamma camera system for whole body measurements is studied. This includes setting up acquisition parameters and development of computer models for Monte Carlo efficiency calculations.

Performance of gamma cameras in internal contamination measurements is compared to low-level whole body counters at Sahlgrenska university hospital.

Study on optimization for the continuous surveillance network of environmental radioactivity in Portugal

Filipa Jerónimo[1], Catarina Inácio[1], David Ferreira[1], Mário Reis[1], Luis Portugal[2], Francisco Cardoso[2], Márcia Farto[2], Paulo Marques Nunes[2], João Oliveira Martins[2]

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With the Chernobyl accident, it was important to establish a national network, that was able to detect and provide online data relative to environmental radioactivity. Due to that, in the upcoming years, Portugal installed their network stations which are based on qualitative criteria. This work intends to analyze the Portuguese network and, using the DETECT software, optimize the positioning of the stations based on simulated radioactive plums, in case of radiological and nuclear accidents.

Efficiency of a drone measuring radioactivity for a point source and a homogenous surface contamination

Stef Geelen[1,2], Johan Camps[1], Tim Vidmar[1] and Wouter Schroeyers[2]

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Unmanned Aerial Vehicles (UAVs) or drones, equipped with radiation sensors, are currently introduced by many institutes as part of their nuclear and radiological emergency monitoring strategy. The sensitivity to detect any increased levels of radiation depends on many factors such as source characteristics, detector properties and flight parameters. In this study we focussed on Vertical Take Off and Landing (VTOL), multi-copter drones of limited size in combination with dose rate sensors. Such systems are readily commercially available today and easy to operate at the scene by first responders.

The goal of the study was to find the minimum detectable activity in function of a number of factors: gamma-ray energy, detector efficiency, speed, flight height and path. Results are further linked to 2 important additional factors: the limited flight time and payload of small drones. There is a correlation between the speed of a drone and the flight time and between the detection efficiency and the detector size (payload). This makes monitoring with drones an optimization problem in which the detector size and flight parameters are adapted accordingly to have enough time for a full and qualitative scan of an area. On the other hand, when a certain minimum detectable activity is required, this will determine the flight time to fully map a certain area.

In many cases there is no or limited information available about the source when first responders arrive at the scene. Therefore, a distinction has been made between point sources and surface contaminations. Hence, the minimum detectable activity was calculated for a single point source and an infinite homogenous surface contamination. Because we need to distinguish any artificial source from background radiation a detection threshold had to be defined.

TRITIUM - a low level real-time monitor system for water quality surveillance

José Díaz, Ana Bueno, Marcos Martínez-Roig, Nadia Yahlali

University of Valencia (Spain)

In this work we present the objectives and development results of the TRITIUM project. The main objective of the project is to construct a *in situ* tritium level monitor with near real time capability that can be used for surveillance and radiologic protection of river water in the vicinity of nuclear power plants. In addition, anomalous tritium production is a precursor of nuclear accidents and an indication of reactor malfunctioning. The Council Directive 2013/51 / Euratom requires the maximum level of tritium in water for human consumption lower than 100 Bq/L. These levels are much higher than those caused by the natural or cosmogenic component of tritium, however they are easily surmountable in the cooling waters of nuclear plants in normal operation. The currently low-level liquid scintillation measuring systems in environmental radioactivity laboratories can detect such levels but the required process of collecting water samples and determine its tritium radioactive content can easily take 4 to 5 days. Moreover, there are no currently available devices that can measure in real time such low levels as those required by the Directive. In the future, when commercial fusion nuclear reactors are available, such monitors will be more useful considering that, in practice, the main radioactive contaminant produce will be tritium.

A detector based on scintillating fibers readout by PMTs or SiPM is under development.
An overview of the project development will be given and results of a first prototype which will be installed in Arrocampo dam of Almaraz Nuclear Power Plant during May 2019 will be presented.

This work was supported by the INTERREG-SUDOE program through the project TRITIUM - SOE1/P4/E0214 and is carried out by a collaboration of University of Extremadura, Junta de Extremadura, University of Aveiro, University of Bordeaux, CNRS (Delegation Limousin -Aquitaine) and University of Valencia.

Topic B – Countermeasures and countermeasure strategies in emergency & recovery, decision support & disaster informatics

Linking Advanced Monitoring and Modeling in Nuclear Emergency Decision Support Systems

Luke Lebel, Vlad Korolevych, Lucian Ivan

CNL (Canada)

In a nuclear emergency, response personnel have to determine what protective actions have to be made given the constraints of time, availability of resources, and knowledge of the current situation. Canadian Nuclear Laboratories (CNL) is currently undertaking an R&D program aimed at addressing the current challenges in monitoring an emergency and directing the response. The focus is on higher resolution monitoring data, ground-truth corrections of predictive simulations, and presenting the information on time scales that give a real-time view of the status of the incident. This presentation will provide an overview of CNL's efforts under this program, discussing its major themes:

- Improving decision support systems, the predictive dispersion and dose models that feed into them, and feedback between these models and field measurements for plume and source term reconstruction
- Improving radiological measurements, including systems to rapidly assess the composition of releases, identification of chemical signatures on the state of the accident, and the expanded use of mobile sensors on unmanned aerial vehicles
- Incorporating data from advanced meteorological measurements (e.g., from SODAR and eddy covariance systems) into transport, dispersion and deposition models
- Logically visualizing dose consequence predictions, including the development of metrics that will be used to help inform what protective actions to take

A highlight of the presentation will be the work done on advanced dispersion modelling and reconstruction of an Ar-41 plume with airborne-based (i.e., unmanned aerial vehicle) measurements, with a focus on how the methodologies being developed will be integrated into a larger system. In all cases, the research priorities of this program focus on the fact that nuclear emergencies evolve quickly, and response personnel must make prompt decisions on what protective actions to take, especially in the face of uncertainties and incomplete information. The goal of this program is to provide tools that provide a rapid assessment of the current situation, reduce uncertainties, and ultimately help better manage the response to a nuclear emergency.

Application of the rodos system to determination of the restricted use area and emergency planning zones for the planned nuclear power plant in poland

S. Potempski or A. Wawrzynczak, P.Kopka, H. Wojciechowicz

NCNR (Poland)

According to the Polish Programme of Atomic Energy, the first nuclear power plant should be constructed approximately in the next fifteen years. Two possible localizations are considered in the Pomerania region, and five technologies are taken into account in the process of the selection of the vendor. Following national regulations, one of the elements that should be verified before the final decision concerning the choice of technology will be undertaken, is the estimation of the possible area of the restricted use and emergency planning zones. In accordance with national atomic law, some criteria concerning estimation of various doses have to be checked assuming both different types of the scenarios of nuclear accidents and releases during the normal operation period. For this purpose, the RODOS decision support system has been applied as the main tool for the calculations of possible doses to public taking into account a variety of meteorological conditions. The results of the performed simulations will be presented with the emphasis on the problems and difficulties encountered in using the RODOS system. Possible solutions to these problems and alternative approaches will be discussed. Some general comments concerning the needs of further research in the field will be also given.

Optimization of the food chain and dose module for terrestrial pathways (FDMT) applied to Portugal

Catarina Inácio[1], David Ferreira[1], Filipa Jerónimo[1], Mário Reis[1], Paulo Marques Nunes[2], Luis Portugal[2], Márcia Farto[2], Francisco Cardoso[2] , João Oliveira Martins[2]

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The decision support system for off-site nuclear emergency management present in Portugal (RODOS), uses default data only suited to Central Europe. With this work, is intended to optimize and adjust one of the models contained in RODOS, namely the Food Chain and Dose Module for Terrestrial Pathways (FDMT), for the Portuguese reality. This will be achieved through the data collected from Portugal's agricultural statistics and data implementation in the module.

Topic C – Setting-up a trans-disciplinary and inclusive framework for preparedness for emergency response ad recovery

Stakeholder engagement in emergency preparedness and response: state of the art

Abelshausen Bieke, Van Oudheusden Michiel, Tanja Perko ,Zeleznik Nadja, Turcanu Catrinel

SCK.CEN (Belgium)

Following the aftermath of past nuclear and radiological events, notably the Chernobyl and Fukushima accidents, as well as the increasing demands for citizens involvement on environmental issues, as shift towards the engagement of stakeholders has been made in nuclear emergency, preparedness, response and recovery, including the general public. Lessons learned from international experiences suggest this shift is not without its challenges: it brings forth conceptual, methodological and discourse challenges for the radiation protection community, researchers and practitioners. Tackling these challenges requires a (re-) examination of previously accepted conceptualisations of stakeholders and stakeholder engagement. Therefore, systematic research is conducted to clarify the concepts, rationales and venues for stakeholder and stakeholder engagement mobilised by researchers and practioners in the field of nuclear emergency management. For this a systematic literature review is conducted. The systematic literature review is conducted on academic literature published in the period 2007-2017 from the database Web of Science. For this search key words include stakehold* AND nuclear* OR radiologic* AND emergency OR accident. A synthesis analysis is conducted to explore the interpretation given to the term stakeholder and stakeholder engagement. Additionally, this research provides insights in stakeholder rationales for participation (i.e; instrumental, normative and/or substantive), the level of participation and/or model for participation, and the identification of trends, contradictions or divergences to standard practices. The research shows that stakeholders in emergency preparedness and response are defined and categorised according to on the one hand their level of power and on the other hand heterogeneity of the stakeholder group. Concerning stakeholder engagement five different types of stakeholder engagement can be identified: reaction engagement, responsibility engagement, natural engagement, deliberate engagement, disingenuous engagement. Furthermore, research shows that the phase of an emergency in which stakeholder engagement is implemented and defined influences the type of engagement. In general, in can be concluded, that stakeholder engagement is mostly instrumental in nature and only rarely implemented from a substantive or normative motivation.

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RAMESIS – support to Citizen Radiation Monitoring Network in the Czech Republic

Petr KUČA, Jan Helebrant, Marek Helebrant

SURO (Czech Republic)

The research programme RAMESIS "Radiation Monitoring network for institutions and schools to assure early awareness and enhancing safety of citizens" is aimed to increasing of the public knowledge and understanding of matters concerning radioactivity and radiation protections through introducing a radiation monitoring system operated by institutions, schools and citizen on voluntarily basis.

This paper presents equipment for fixed-station based monitoring of radiation situation through dose-rate measurements developed in the frame of the RAMESIS project.
This publication was supported by the Ministry of Interior of the Czech Republic under the project VI20152019028.

Modification of the regulatory framework for radiological protection and nuclear safety in Portugal

Márcia Farto[1], Luis Portugal[1], Paulo Marques Nunes[1], Francisco Cardoso[1], João Oliveira Martins[1]

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In Portugal a new legislation was approved that establishes a new legal framework for radiological protection, as well as the competencies of the regulatory authority and of the inspection authority for radiological protection and nuclear safety, transposing Directive 2013/59/Euratom of the Council of 5 December 2013 into the national legal framework, laying down the basic safety standards for protection against the dangers arising from exposure to ionizing radiation.

The Portuguese Environment Agency will be the new regulatory authority ensuring an independency from operators and promoters of the using of ionizing radiation, and we will receive the regulatory competences that until now were dispersed by several institution from several ministries. The General Inspection for the Environment will be responsible for the inspections and enforcement.

This change of the framework will also bring a new paradigm for Portugal on dealing with nuclear and radiological Emergency Preparedness and Response.

How the EU strengthens CBRN response capacities outside the European Union: 2 examples from the Western Balkans and the Black Sea Region

Katrijn Vandersteen, Klaas van der Meer

SCK.CEN (Belgium)

The European Union Chemical Biological Radiological and Nuclear Risk Mitigation Centres of Excellence Initiative (or EU CBRN CoE) was launched in order to strengthen the capacity of countries outside the European Union to mitigate CBRN risks. These risks may be created intentionally, accidentally or naturally. The countries that join the initiative work together in eight regions, headed up by a secretariat at regional level.

The two projects that are presented here have been implemented in the Western Balkans and the Black Sea Region, consisting of 9 countries in total: Albania, Armenia, Bosnia and Herzegovina, Georgia, Macedonia, Moldova, Montenegro, Serbia and Ukraine.

Training of respectively first responders and forensic science institutes' staff as well as enhancing cooperation and networking are the main objectives of two closely related Projects within the CoE Initiative, i.e. Project 44 and Project 57. P44, which ran from 2015 until mid-2018, was created with the intention to address the inadequate readiness of the first responders to responding to a CBRN incident, while P57, which started in 2017 and is still ongoing, aims to strengthen the forensics expertise for the crime scene investigations in the environment of a CBRN incident.

In the course of both projects, the status and challenges were thoroughly assessed and a list of equipment, mainly for detection and personal protection, was developed that the first responder teams and forensic institutes' staff would need to have available in order to cope with (realistic) threats in their country. The equipment was purchased within 2 separate projects. Additionally, a standard operating procedure (SOPs) set of guidelines for respectively first responders and forensic institutes' staff was developed enabling them to make their own SOPs to either respond to CBRN events or to conduct CBRN crime scene investigation. Local experts were hired to develop these SOPs. First responders and forensic institutes' staff were trained through a train-the-trainer system. In P44, the level of preparedness, cooperation but also acting in a case of eminent CBRN threats or their aftermath was assured by establishing table top and field exercises on the national and sub-regional level. For P57, similar exercises, with a focus on CBRN crime scene investigation, are foreseen for 2019. The activities in both projects are conceived with a focus on increasing local ownership and long-term sustainability.

EURDEP system as exercise bed for European nuclear exercises

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The European Commission (EC), Directorate General for Energy organises international exercises to test its radiological and nuclear emergency procedures in collaboration with European national competent authorities and international organisations. During these exercises, the European Commission takes the opportunity to test the European Community Urgent Radiological Information Exchange (ECURIE) and the European Radiological Data Exchange Platform (EURDEP) systems and to carry out a comprehensive analysis of the performance of these emergency support systems.
The exercises are usually based on a hypothetical release scenario, in which fictitious monitoring datasets, following a nuclear power plant event, are produced beforehand and injected at regular intervals into the EURDEP database. Then, these fictitious values are shown through regular EURDEP stations as if they were measured in almost real-time by national monitoring networks.

In this framework, the Radioactivity Environmental Monitoring group of the EC-Joint Research Centre has developed a method to create ad-hoc European nuclear dispersion scenarios based on:

- the use of atmospheric dispersion models, such as RIMPUFF and MATCH, to simulate the dispersion of radionuclides and to fully support the production of fictitious monitoring datasets (e.g. total gamma dose rates, air concentration) which would be seen by regular EURDEP stations;
- to automatically inject at regular times these fictitious measurements in the set of EURDEP stations which would be affected by the plume (synchronised with the on-going of the exercise).

This methodology is fully in agreement with the need to expand the functionalities of the EURDEP system in order to use it as exercise bed for European, national or bilateral nuclear and radiological exercises. Among others, the benefits of this method are:

- the use of a large amount of EURDEP monitoring stations increases the quality of the EURDEP/ECURIE exercise as it makes the exercise more realistic;
- to provide valid insights about the time and spatial evolution of the plume.

We describe the methodology and the work carried out during the ECURIE exercise of 19 November 2018 (ECUREX 2018), in which the recent Ru-106 dispersion event (October 2017) was simulated and taken as reference to exercise the urgent information exchange arrangements foreseen under the Council Decision 87/600/EURATOM.


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