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Session 1 – Radiological Monitoring and Citizen Monitoring

Organisation of the Environmental monitoring: lessons learnt from Fukushima

Mélanie Maître, Pascal Croüail and Thierry Schneider

CEPN, France

In post-accident situations, the implementation of the environmental monitoring is essential for characterising the radiological situation of the affected territories, as well as, allowing people living in such territories to understand what is at stake in their own environment and so helping them to become actors of their own radiological protection. In this context, roles playing by institutional and non-institutional actors are determining factors to set up a sustainable monitoring, reach a consensus and so encourage the citizen vigilance.

This paper proposes an analysis of the Japanese situation 6 years after the Fukushima accident, in order to provide feedback experiences of the environmental monitoring implemented to cope with the post-accident situation. This analysis consists in (i) identifying the environmental schemes implemented following the Fukushima accident (ii) mapping the different actors who come into play in such situations and (iii) highlighting some local experiences developed by local associations or municipalities within the affected territories.
These overall goals have been achieved by interviewing different Japanese actors involved in the practical setting up of the environmental monitoring within the Fukushima prefecture. In this way, feedback experiences, points of view and comments have been collected from both institutional actors (e.g. Japan Nuclear Safety authority, Health and Labour Ministry, Fukushima prefecture, etc.) and local actors (e.g. local associations, municipalities, citizens, etc.) in November 2016.

Results of this study clearly show that the environmental monitoring implemented in Japan after the Fukushima accident gathers multiple actors on both national and local levels. The *'Comprehensive Radiation Monitoring Plan' (CRMP)*, set up by the Japanese government since August 2011 proposes a national monitoring system concerted, coherent and embracing all environmental compartments. However, all the results obtained under this plan are put online without harmonization. This leads to confusion on the published results, which besides are not largely consulted by the local population.
Indeed, at the local level, the mistrust towards government leads people living in the affected territory to implement their own environmental monitoring. However, these local data are heterogeneous and often redundant with the CRMP but have all the trust of their initiators.
In this context, the remaining issue consists in knowing how to go towards a better sharing between results produced by institutional and non-institutional actors. It appears that scientific experts, often involved in both sides, could play a key role in sharing these results, which represents a strong lesson learnt for the preparedness phase.

Science *for* citizens or *by* citizens? Exploring grassroots radiation monitoring after Fukushima

Joke Kenens, Ine Van Hoyweghen, Michiel Van Oudheusden

SCK•CEN (Belgium)

Citizen science transforms the relationship between science and citizens. While it implies science for citizens, it also draws upon the understanding of science as science by citizens (Irwin, 1995). In the field of nuclear incidents and accidents two events are paramount to the rise of citizen science networks. The Chernobyl and the Fukushima Daiichi nuclear accidents triggered a sudden rise of grassroots measuring networks (Abe, 2015) across the globe. While they create additional platforms for information and data concerning radiation monitoring, they also provide new ways to deal with an invisible problem: "We cannot see, smell, touch nor taste it. Radioactivity, whose existence can only be confirmed by numbers measured by a machine, has poured and slipped into our food, water and lives." (Translated from Japanese, みんなの 放射線測定室「てとてと」, http://sokuteimiyagi.blog.fc2.com/)

As citizen scientists gain expertise on radiation monitoring, they not only collect and share information, but may also provide a means to live within and adapt to a new reality. Grassroots measuring networks thus unveil and address uncertainties and concerns that citizens are confronted with during and after a nuclear incident or accident. At the same time these networks create an opportunity to complement the governance of nuclear incidents and accidents throughout the preparedness, response and recovery phases. This presentation explores the opportunities and challenges of grassroots measuring networks by learning from the Japanese experience after the Fukushima Daiichi disaster. Drawing on research on citizen science (Irwin, 1995, Morris-Suzuki, 2014, Fujigaki, 2015) and preliminary results from fieldwork in the Fukushima prefecture and Tokyo, it aims to reflect upon the concept of citizen science and to analyse the growth and evolution of grassroots networks and their activities. By doing so it aspires to gain more insight into existing citizen science initiatives, their potential role in supporting emergency management and recovery efforts and the uncertainties encountered by citizens in the event of a nuclear incident or accident.

Keywords: Fukushima Daiichi nuclear accident, grassroots measuring networks, crisis management and recovery, uncertainties References: Abe, Yasuhito. (2015) Measuring for what: Networked Citizen Science Movements after the Fukushima Nuclear Accident [dissertation]. University of California
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みんなの放射線測定室「てとてと」 (Minna no hōshasen sokutei shitsu, Everyone's Radiation Measurement Laboratory 'Hand in Hand'). http://sokuteimiyagi.blog.fc2.com/.

Science by, with, or for citizens? Reframing "citizen science" through radiation monitoring in post-Fukushima Japan

Michiel van Oudheusden

SCK•CEN (Belgium)

In the aftermath of the 2011 Fukushima Daiichi nuclear disaster, citizen scientists (e.g. Safecast; Citizens' Radioactivity Monitoring Project) began monitoring radioactivity in affected areas and openly sharing information on environmental radiation and risks. In these processes, they generated their own participatory, open-source data, do-it-yourself measurement devices, and radiation maps, with the aim of empowering publics with trustworthy, actionable data about their environments. This paper takes these observations as its entry point to explore how radiation monitoring by citizen scientists has emerged as a public issue in and beyond Japan, and how citizen-initiated monitoring reframes the relationship between science and society. Drawing on a conceptual distinction made in Japan between *science by citizens* and *science for citizens*, it argues that these citizen-science initiatives are best understood as expressions of *scientific citizenship* rather than as forms of *public participation in scientific research*. Whereas the latter form employs citizens as "sensors" or information providers, the former engages citizens in the definition of problems, data collection, and analysis; thereby foregrounding the necessity of opening up science and science policy processes to the public (Irwin 1995). The paper argues the need for policy makers and scientists of meeting this demand for a more participatory, open science, as this can strengthen institutional disaster response capacity by broadening the types of knowledge (e.g. scientific, lay), issues (e.g. data reliability) and views (e.g. local Fukushima residents' perspectives) that inform radiation protection research and decision making.

Keywords: Citizen Science, Citizenship, Fukushima, Monitoring, Radiation Protection.
References: Irwin, A. (1995). Citizen Science: A Study of People, Expertise and Sustainable Development. Routledge.

Citizen Monitoring in the Czech republic – progress achieved during the last year

Petr Kuča[1], *Jan Helebrant*[1], *Irena Češpírová*[1], *Jiří Hůlka*[1], *Martin Landa*[2]

[1] *National Radiation Protection Institute, Prague, Czech Republic*

[2] *GeoForAll Labs, Department of Geomatics , Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic*

The presentation describes progress in spreading of citizen monitoring in the Czech Republic achieved during the last year and future plans for years 2018 and 2019, it follows up to the presentation provided during the last NERIS Workshop 2017 in Lisbon, Portugal.

The first part describes involvement of the public into the citizen monitoring, showing significant increase especially after the nation-wide presentation, in media (especially TV, newspapers, etc.) of the possibility of providing by SURO both the measurement devices and support to volunteers from public, schools and selected institution. The cooperation is based on mutual profitable manner: SURO provides the equipment and necessary scientific support (manuals, guides, information and tools, etc.), the public perform the measurements and provides the results to the central database operated by SURO.

The second part describes software tools for the field of radiation protection developed under SURO guidance by students of the Faculty of Civil Engineering of the Czech Technical University, mostly within the context of their bachelor´s and master´s thesis. These tools are aimed at presentation and processing of data gained during field measurements in the form of map outputs including the citizen monitoring results (but not only them). All these tools are developed in the form of specialised extensions (plugins) for the Open-source Geographic Information System QGIS, and - including the full documentation and source code – released under the GNU General Public Licence, so that all these plugins are freely available for public.

The paper shows selected results of research project RAMESIS (ID: VI20152019028) supported by the Czech Ministry of Interior in the frame of security research.

Citizen-science involvement after nuclear accidents: SHAMISEN SINGS project

Liudmila Liutsko[1-3], Adelaida Sarukhan[1-3], Koichi Tanigawa[4], Takashi Ohba[4], Joan Francesc Barquinero[5], Paola Fattibene[6], Pascal Croüail[7], Thierry Schneider[7], Wataru Naito[8], An Van Nieuwenhuyse[9], Deborah Oughton[10], Dominique Laurier[11], and Elisabeth Cardis[1-3]

1) *ISGlobal, Barcelona, Spain;*
2) *UPF, Barcelona, Spain*
3) *CIBERESP, Madrid, Spain*
4) *FMU, Fukushima, Japan*
5) *UAB, Barcelona, Spain*
6) *ISS, Italia*
7) *CEPN, Fontenay-aux-Roses, France*
8) *AIST (National Institute of Advanced Industrial Science and Technology) – Japan*
9) *Scientific Institute of Public Health WIV-ISP, Brussels, Belgium*
10) *NMBU, Oslo, Norway*
11) *IRSN, Fontenay-aux-Roses, France*

Historically, citizen-science participation was widely used in biological and ecological sciences for supporting projects related to biodiversity and environmental monitoring. The first attempts of using citizen-science for dosimetry measurements after nuclear accidents were performed by Safecast and D-shuttle projects. One key purpose of the latter, conducted after the Fukushima accident, was to promote well-being among individuals returning to evacuation areas through voluntary participation in personal exposure measurements and interaction with facilitators that provided adequate counseling and basic knowledge on radiation protection and dosimetry.

The SHAMISEN SINGS EC-funded project aims to analyze the existing tools applicable for citizen use with the purpose of promoting health and well-being of affected populations in the recovery phase of a nuclear accident. The bottom-up strategy could be useful for collecting data on exposure doses, complementing environmental monitoring, and providing real-time information covering more areas. On one hand, this information could be analyzed and used by relevant stakeholders: ministries of environment, agricultural and urban planning sectors, for the effective land-use and decision making processes, etc. On the other hand, some of the personal information could be used by specialists for individual dose assessment for medical and epidemiological surveillance studies. In addition to dosimetry data, SHAMISEN SINGS will analyse existing tools that could be used by affected citizens for the assessment of health and well-being indicators as well as for providing practical information and professional support.

Thus, in addition to contributing to data collection, citizens can benefit from these tools by acquiring basic knowledge on dosimetry and radiation protection issues that will help to increase their awareness toward the prudent behavior and creation of radiation protection culture.

SHAMISEN SINGS will suggest how to improve existing tools (mobile applications, for example) or, if necessary, design new ones that enclose environmental and health monitoring for the affected populations after nuclear accidents, while assessing the ethical challenges and implications.

Assessment of Safecast bGeigie Nano Monitor

Walsh Joshua, Kelleher K., Currivan L.

Environmental Protection Agency, Dublin Campus, Richview, Dublin 14

The bGeigie Nano Monitor is a radiation sensor developed by the team at Safecast as an affordable and easy to use mobile radiation monitoring device for public use as part of its citizen science project. The bGeigie Nano Monitor is said to measure alpha, beta and gamma radiation accurately to within a 15% uncertainty, as well as the ability for this measured data to be uploaded to a Safecast API website. The objective of this study was to evaluate the bGeigie Nano Monitor's accuracy and reliability in both measuring and recording radiation from alpha, beta and gamma sources.

It was found that the bGeigie Nano Monitor is very accurate in the range of 5-500µSv/hr. Above this dose rate the accuracy of the measurements were not as reliable as the monitor was brought closer to the 1000µSv/hr limit of detection. The monitor was capable of detecting alpha, beta and gamma radiation from the tested sources of Am-241, Sr-90/Y-90 and Cs-137. During the assessment of the monitor it was found that it could take up to a minute for the measured dose rate exposed to a source to stabilise, it was also found that after being exposed to a high dose rate it took up to a minute to return to background dose levels after the removal of the radiation source.

In conclusion, the bGeigie Monitor is capable of being an easily assembled radiation sensor for the public to accurately measure the levels of radioactive dose in their area and to share this monitoring data through the Safecast API website.

The development of a dual-use low-cost CsI(Tl)-SiPM detector for radiation monitoring by authorities and members of the public

Steven James Bell[1], *Craig Duff*[2], *Sotiris Ioannidis*[1], *Toby Izod2*, *Martin Kelly*[1], *Louise McNamara*[2] *Peter Rhodes*[2], *Adam Tuff*[2]

[1]*National Physical Laboratory (Teddington, United Kingdom)*
[2]*Kromek (Sedgefield, UK)*

The accident at the Fukushima Daiichi NPP has increased interest amongst members of the public in the measurement and monitoring of radiation. Many simple radiation detectors have been developed and made available for public purchase and use; however these devices often lack a metrological underpinning and so their results are difficult to interpret. A collaboration between Kromek and the National Physical Laboratory has been established to develop and metrologically validate a CsI(Tl)-SiPM gamma radiation detector for on-line, geo-tagged radiation monitoring by both authorities and members of the public. The device under development is based on the hybrid gamma/neutron detector; D3S, which was developed by Kromek for homeland security as a "wearable" networked detector carried by government agencies. The new device; the D3M, contains a re-designed CsI(Tl)-SiPM gamma spectrometer and Bluetooth for communication with the user's smartphone. A website will be developed to allow public sharing of radiation measurements. Presented is an overview of the project aims, details of the device design and results of early testing at NPL's dosimetry irradiation facilities. This work is part of the EMPIR Preparedness project funded by EURAMET, BEIS and Kromek.

Preparedness European Project: Metrology for mobile detection of ionising radiation following a nuclear or radiological accident – WP1 unmanned aerial systems

Arturo Vargas[1], *S. Neumaier*[2]

[1]*Universitat Politècncia de Catalunya, Avda. Diagonal 647, 0808 Barcelona (Spain)*
[2]*Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig (Germany)*

In the framework of the European Metrology Programme for Innovation and Research (EMPIR, https://msu.euramet.org/calls.html), the European project Preparedness (http://www.preparedness-empir.eu/) started on 1 August 2017, lasting 3-years. The project is coordinated by the National Metrology Institute of Germany (PTB) and the consortium is formed by a total of 17 research centers for 12 European countries and other collaborating institutions. The overall objective of this project is the establishment of a metrological basis to support adequate protective measures in the aftermath of nuclear and radiological emergencies using mobile systems for the detection of radioactivity and ionising radiation. To achieve this, the specific objectives of this project are to: i) Develop unmanned aerial detection systems installed on aerial vehicles, ii) Develop transportable air-sampling systems for immediate information on radioactive contamination levels in air, iii) Investigate the metrological relevance of 'crowd sourced monitoring' data on dose rates and iv) Establish stable and reproducible procedures to measure ambient dose equivalent rates using passive dosimetry and v) Facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (instrument manufacturers, accredited laboratories), standards developing organisations (ISO, IEC) and end users (national nuclear regulatory bodies, decision/policy makers e.g. IAEA, European Community Urgent Radiological Information Exchange (ECURIE), OECD/NEA, EURADOS, NERIS, UNEP, WHO, WMO).

The presentation will be focused on the activities regarding the development of unmanned aerial vehicles, i.e.,WP1 of the project. The aim of this WP1 is to develop, test and validate metrologically-traceable systems and methods for remote measurements of ambient dose equivalent rates and radionuclide ground concentrations using rotary-wing unmanned aircraft systems (RWUAS), commonly named 'drones', with spectrometry systems mounted on them. The tasks are divided in 5 groups: i) Current Status of unmanned aerial vehicles (UAVs), measurement system and communication; ii) Development of unmanned aerial monitoring systems (UAMS), iii) Developments and optimization of software for data acquisition, processing and analysis of UAMS, iv) Development of test and calibration procedures, and v) Measurement campaigns.

Metrology for mobile detection of ionising radiation following a nuclear or radiological accident – Overview of the European joint research project EMPIR - 16ENV04 "Preparedness"

S. Neumaier[1,6], A. Vargas[2], S. Bell[3], K. Bogucarskis[4], H. Dombrowski[1], P. Kovar[5]

[1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig (Germany)
[2]Universitat Politècncia de Catalunya, Avda. Diagonal 647, 0808 Barcelona (Spain)
[3]National Physical Laboratory, Hampton Rd, Teddington TW11 0LW (United Kingdom)
[4]JRC-Joint Research Centre – European Commission, Ispra (Italy)
[5]Cesky Metrologicky Institut, Prague (Czech Republic)
[6]Coordinator of the Preparedness consortium

The protection of the public against ionising radiation and radioactive contaminations caused by nuclear accidents or other radiologically relevant events, including terrorist attacks, is of major importance and may affect thousands of people. Following such a radiological event, radiation protection authorities and other decision makers need quick and credible information on affected areas. Therefore, the joint research project "Preparedness", funded within the framework of the European Metrology Programme for Innovation and Research (EMPIR, https://msu.euramet.org/calls.html) by EURAMET and the European Commission, will develop reliable instrumentation and methods needed, so that correct decisions on countermeasures of legal authorities, responsible for preparedness in nuclear and radiological emergency response will be possible. In addition, new measuring devices and methods will be developed to quickly gather quantitative data on contaminated areas and dose rate levels by aerial measurements, and to analyse contamination of the air by flexible transportable systems. This project will further work on improved methods for long-term monitoring of contaminated areas using passive dosimetry and will investigate whether non-governmental networks could support official data or undermine it. The results of this project will enable an adequate response for the protection of the public and the environment against dangers arising from ionising radiation during and in the aftermath of a nuclear or radiological event.

The presentation will give a general overview of the main objectives of the Preparedness project, its work package (WP) structure and of some of the challenges concerning (WP1): the mobile detection of ionising radiation, (WP2): transportable air-sampling systems, (WP3): dose rate and radioactivity monitoring by the public, (WP4): long-term passive monitoring of affected areas, and (WP5): the generation of impact and the dissemination of results to the stakeholder community.

Awareness of local stakeholders to the post-accident issues
The example of the CLIn of Blayais using the cartographic tool OPAL

Xavier Paulmaz[1], Yves Lheureux[2], Véronique Leroyer[3]

[1]CLIn of Blayais,
[2]ANCCLI
[3]IRSN

The French Association of the Committees and Commissions of Local Information (ANCCLI) and the Institute of Radiation Protection and Nuclear Safety (IRSN) have decided in 2010 to engage together in an action to raise the awareness of local stakeholders to the post-accident issues. The objective of this approach is to foster the commitment of local actors around nuclear facilities for better understanding and preparedness to the consequences of a potential accident in their territory.

In order to interest local actors to these issues and help them to find what is at stake, IRSN and ANCCLI have chosen to develop a cartographic tool to provide, in a given region, map information on the medium-term consequences of generic accidents: OPAL (tool to post-accidental issues for local actors) is a tool that can be used to educate and train local people about the post-accidental consequences of an event affecting a French nuclear facility but also to prepare them for an accidental situation by identifying post-accidental issues of their territory.

This tool is made available to Commissions of Local Information (CLI) so that they can engage local actors to reflect together on the stakes of a post-accident situation in their territory and develop with these actors a culture of risk dealing with long term issues. Several CLI have already been interested by such an approach (Marcoule-Gard, Saclay, Gravelines, Paluel-Penly, Blayais…).

The CLIn of Blayais started in 2017 a process of raising the awareness of local actors on emergency and post-accidental preparedness, with the Mayors of 23 municipalities around the nuclear power plant.
During six months a trainee accompanied this project which includes two parts:

- The first one is to collect data in order to draw a representation of the stakes of the territory and of major risks, which can be combined with the zoning provided by the tool OPAL, using a Geographic Information System (GIS),
- The second one is to prepare and to carry out interviews with the Mayors of 23 municipalities around the nuclear power plant. The purpose of these interviews is to gather their perception of the nuclear risk, to exchange with them and to keep them informed on the preparation for the management of the crisis, for the emergency phase but also for the long-term phase.

The presentation will provide the first results of this work, in particular regarding the variability of perception and knowledge of elected representatives, as well as a feeling of helplessness facing the potential magnitude of the affected areas. It will also present perspectives to continue this work considering the diversity of questions raised by these elected representatives.

Session 2 – Novel approaches to communication & stakeholder engagement

Dialogue as therapy? An ethnographer's analysis of the Fukushima Dialogues

Makoto Takahashi

University of Cambridge, UK

It seems that the jury is still out on participatory forums. For many decades, ideas of "co-expertise" enjoyed the support of social scientists and policy makers alike. But recent years have seen deliberative forums come under increasing scrutiny, not least from the people involved in them. The *Fukushima Dialogues*, which facilitate discussion between local residents and experts in radiological protection, are no exception to this trend. At the fifth seminar, held in July 2017, discussion turned to the Dialogues themselves. What do they do? Could they do more? And at what point do they end? This paper addresses the first of these questions. It has "no utopia to propose" (Latour in De Vries, 2016:147). I do not seek, nor do I expect, to sell the ICRP on a new vision of its mission in Fukushima. Nor do I aim to make an organisational intervention by arguing that a new outreach strategy, new rules of dialogue, or a new spatial configuration would allow the Dialogues to be more effective. My aim is more modest: I seek only to document what the Dialogues have *been doing all along*. That is to say, I aim to provide a richer description of *what* the Dialogues are doing, so that we might better appreciate *why* they are important. To this end, I offer an ethnographic account of two Fukushima Dialogues, held in Date City (8-9 July 2017) and Yamakiya village (25-26 November 2017) respectively. In an analysis informed by the empirical philosophy of Bruno Latour (2004, 2005) and Gerard de Vries (2016), I argue that the Dialogues are best understood as a form of therapy. I conclude that the principal value of the Dialogues is not instrumental but lies in the *process itself* and suggest that this case may offer insight into the role of deliberation in confronting trauma more generally.

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Knowledge base for stakeholder engagement in radiation protection

T. Duranova, J. Bohunova[1], C. Turcanu, B. Abelshausen[2], N. Zeleznik[3], C. Pölzl-Viol[4], C. Schieber[5]

[1]VUJE, Slovakia

[2]SCK•CEN, Belgium

[3]EIMV, Slovenia

[4]BfS, Germany

[5]CEPN, France

Over two decades of experience in the use of different forms of stakeholder engagement in emergency preparedness, response and recovery led to the development of a proposal for building a knowledge base reporting on stakeholder workshops and public participation under the NERIS Platform and other projects. Other organisations, for instance OECD, have also made efforts to document exemplary cases of stakeholder engagement practices around the world. Experience from practices that have previously been undocumented because they were not 'officially' part of radiation protection will also be considered in this process.

Building on these experiences, the ENGAGE project (ENhancinG stAkeholder participation in the GovernancE of radiological risks for improved radiation protection and informed decision-making) aims at supporting the development of a joint knowledge base for stakeholder engagement in Radiation Protection. This will cover three exposure situations: medical exposures to ionizing radiation, post-accident exposures and exposure to indoor radon. Specific focus will be given to the conceptualisation of stakeholders and stakeholder engagement, the rationales for and expectations from participatory processes, the level of engagement (e.g. with respect to the impact on policy-making), the instruments used (e.g. workshops, focus groups, surveys, panels,...). Designing and building the knowledge base can contribute to learning from past experience, highlighting challenges and opportunities for stakeholder engagement and identifying good and bad practices, thus helping to shape and improve future processes. The knowledge base will allow comparing and contrasting stakeholder engagement processes in the three aforementioned exposure situations.

This presentation summarises the work undertaken under the NERIS-TP (Towards a self-sustaining European Technology Platform (NERIS-TP) on Preparedness for Nuclear and Radiological Emergency Response and Recovery) and PREPARE (Innovative integrated tools and platforms for radiological emergency preparedness and post-accident response in Europe projects, as well as relevant projects in non-nuclear areas as a basis for further development and discussions. The approach developed for documenting the experience in stakeholder engagement in helping to plan for emergency response and recovery will be reviewed.

The foreseen report on the knowledge base will propose a structured reporting of participatory activities carried out within the radiation protection platforms NERIS, MELODI, ALLIANCE, EURADOS and EURAMED as well as with Social Sciences and Humanities community and members of the CONCERT stakeholder group. The presentation will open the floor for discussions and co-operation in the area of building a joint knowledge base for stakeholder engagement in Radiation Protection.

Engaging stakeholders in the governance of radiological risk: Developing theory, practice, and guidelines

C. Turcanu, M. Van Oudheusden, Bieke Abelshausen[1], Nadja Zeleznik[2], Christiane Pölzl-Viol[3], Caroline Schieber[4], Tatiana Duranova[5]

[1]SCK•CEN, Belgium

[2]EIMV, Slovenia

[3]BfS, Germany

[4]CEPN, France

[5]VUJE, Slovakia

Stakeholder engagement and informed decision-making are nowadays recognised as central elements in the governance of radiological risks. However, the practical implementation of stakeholder engagement in radiation protection is confronted with multiple challenges and a continuously evolving landscape of actors producing radiation protection knowledge, and the communication means and tools they utilise.

The recently commenced European project ENGAGE aims at "ENhancinG stAkeholder participation in the GovernancE of radiological risks for improved radiation protection and informed decision-making". The project will identify and address key challenges and opportunities for stakeholder engagement in relation to three situations of exposure to ionising radiation: medical use of ionising radiation, post-accident exposures, and exposures to indoor radon.

To this end, ENGAGE will:

a) answer the questions why, when and how are stakeholders engaged in radiation protection issues;

b) develop novel approaches to analysing stakeholder interaction and engagement and, provide guidance for meeting challenges and opportunities identified in response to (a);

c) investigate the processes for enhancing radiation protection culture and their role in facilitating stakeholder engagement, and develop guidelines for building radiation protection culture;

d) provide recommendations and build a joint knowledge base for stakeholder engagement in radiation protection.

This contribution summarises the work programme and methodology mobilised by ENGAGE researchers to address the aforementioned research questions, with a focus on stakeholder engagement in relation to emergency and recovery preparedness and response.

Through its research and innovation activities, the project will inform stakeholder engagement approaches to radiation protection in ways that relevant stakeholders find meaningful and legitimate. It will thus contribute to improving the governance of radiological risk and, as a result, radiation protection itself. The project's beneficiaries are the radiation protection platforms, policy makers, civil society stakeholders and publics.

Keywords: Stakeholder engagement; radiation protection; informed decision-making; participation frameworks; impact of participation; radiation protection culture.

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

Communication and Transparency related to radiological emergencies according to New Basic Safety Standards and amended Nuclear Safety Directive: Are we prepared?

Tanja Perko[1] *and Meritxell Martell Lamolla*[2]
[1]*SCK•CEN, Belgium*
[2]*MERIENCE, Spain*

The implementation of new Basic Safety Standards Directive and amended Nuclear Safety Directive provide opportunity amongst the EU Member States to review existing procedures and improve implementation measures in the area of public information and transparency requirements in the event of an emergency. Furthermore, Council Decision 87/600/Euratom on Community arrangements for the early exchange of information in the event of a radiological emergency stipulates the arrangements that apply regarding the notification and provision of information whenever a Member State decides to take measures of comprehensive nature in order to protect the general public in case of a radiological emergency.

This study assesses the current practices in public information and transparency related to radiological emergencies in 28 EU Member States under the existing legal requirements, and highlights best practices. Furthermore, the study analyses the way and the extent to which the arrangements are implemented at a practical level, taking into account the points of view of various governmental and local authorities, licensees and other stakeholders. In addition, the planned changes and potential improvements for implementation of the recently adopted Directives to be transposed by the Member States are considered.

This study involves document analysis of applicable EU legislation, as well as the on-going and planned implementation in national legislation of the 28 EU Member States. In addition, it conducts an on-line survey with regulatory bodies (nuclear safety authorities or other responsible authorities) to collect and assess the national legal frameworks for applying the public information requirements in all the EU Member States. Through this on-line questionnaire (with open and closed questions) an assessment of the scope and practicability of these national provisions and international and European standards and guidance is carried out and gaps are identified. Moreover, a number of national case studies are analysed in greater detail to highlight, e.g. which national or regional authorities are responsible for public information in the event of an emergency, framework for stakeholder involvement, timing of issue for the holding statement (first public information about an emergency), etc. Specific emergency cases are studied (e.g. ^{137}Cesium event in a laboratory in Finland (2016)) from the communication and public information point of view. The way public information needs were managed, the lessons learned and their relevance in the EU context are investigated.

Acknowledgement: The research has been conducted in the context of the *BSS radiological emergency, public information and transparency* project, which has received funding from European Commission DG Energy, under grant agreement ENER/2017/NUCL/SI2.756526.

Session 3 – Inverse modelling & data assimilation

Inverse modelling method to analyze detections of radionuclides within Europe –illustration on an actual case

Olivier Saunier, Anne Mathieu, Damien Didier and Olivier Masson

IRSN, France

In case of an accidental situation involving radioactive material, the Institute for Radiological Protection and Nuclear Safety (IRSN) uses atmospheric dispersion models to assess radiological consequences for human health and environment. The accuracy of the models results is highly dependent on the source term assessment, including the location, the duration, the magnitude and the isotopic composition of the release.

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 a tool based on a variationnal approach. It has been applied to the Fukushima accident by using dose rate measurements (Saunier et al., 2013) and air concentration measurements (Winiarek et al. 2012, Winiarek et al. 2014 and Saunier et al. 2016). The approach is suitable when the source location is known as usually would be the case for severe nuclear accidents.

In the past few years, several radionuclides detections events have been reported in Europe (^{131}I in 2011, 2012, 2015 and 2017, ^{137}Cs in 2015 and ^{106}Ru in 2017). These accidental situations involved small amounts of radionuclides released in the environment. Although the concentrations levels measured were too low to have an impact on human health and environment, the knowledge on the location and the magnitude of the release are required to accurately assess the potential consequences close to the source. However, all these events were characterized by the fact that the source location was not known at the time when the first detections were reported.
Therefore, the inverse modelling method of IRSN has been extended to identify the most reliable source location in addition to its magnitude. The method has been applied to several radionuclides event detections in Europe. The results of the source term obtained by inverse modelling are presented. The relevance of the source term is investigated using several statistic indicators coupled with Monte-Carlo simulations.

Assessment of source regions and source terms based on the Ru-106 measurements in air in Europe in September and October 2017

Thomas Hamburger, Florian Gering, Andreas Bollhöfer

Bundesamt für Strahlenschutz (BfS), Germany

On the evening of October 2nd, 2017 first reports about the detection of traces of Ru-106 in the air in several European countries became available to the BfS. Since then, several assessments of the source region and source term for the release of Ru-106 to the atmosphere were performed.

To allow for a first rough estimation of possible sources of the Ru-106 in air, several thousand backward trajectories were calculated with the HYSPLIT model (NOAA) based on archived GFS numerical weather data. For this purpose backward trajectories were started from several measurement locations that reported observations of Ru-106. This assessment allows to define a first rough guess of a possible area where the Ru-106 release may have occurred.

An improved assessment of the source region has been made on the basis of several hundred forward atmospheric dispersion calculations from different potential release sites within the "first guess" source region identified with backward trajectories. Atmospheric dispersion calculations were performed with the HYSPLIT model (NOAA) based on archived GFS numerical weather data. The dispersion calculations were started for 120 potential release sites within the first guess source region, covering an area between 30°E – 72°E and 45°N – 66°N. The dispersion calculations were started for 9 different release periods between 22.09.2017 00h (UTC) and 01.10.2017 00h (UTC), each release period covering 24h.

To date, 470 observations of Ru-106 from Europe, Russia, and Asia are available for the inverse modelling to assess the source region and possible source term. For each of the potential release sites and each of the release days the correlation between the measured air concentration and the model results (with the atmospheric dispersion model = ADM) has been investigated using the Pearson Correlation Coefficient R. With this approach those release sites and days can be identified which give the highest correlation of ADM results with the measurements.

An assessment of the source term has been carried out also based on forward atmospheric dispersion modelling. The ADM results were scaled with various factors to simulate various amount of releases. The scaled ADM results were compared against the full set of measurements by using the FAC2 criteria and the optimal amount of release was identified.

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.

Source localisation of the Ru-106 detected in autumn 2017

P De Meutter, J Camps, A Delcloo, P Termonia

SCK-CEN, Belgium

Atmospheric transport and dispersion models are important tools for crisis management and decision support in case of nuclear accidents, such as the Fukushima nuclear accident in 2011. These models can also be used to locate nuclear weapon tests, such as the announced nuclear tests by the Democratic People's Republic of Korea. For these cases, it is often of interest to know the source parameters (for instance, the release amount and the release timing), based on a set of observations. This is called inverse atmospheric transport and dispersion modelling. Inverse modelling is often complicated by (i) its ill-posedness, (ii) the presence of errors in the atmospheric transport and dispersion modelling, (iii) the presence of errors in the observations and in some cases also (iv) the presence of a background of radionuclides, interfering with the observational signature of the event of interest.

In autumn 2017, Ru-106 has been measured at several stations in the northern hemisphere by several detection systems. One of these detection systems is the International Monitoring System that is being setup to verify compliance with the Comprehensive Nuclear-Test-Ban Treaty. These measurements provide an interesting case for long-range inverse modelling given the amount of observations, the spatial scales at which detections took place, and the fact that there is no background of Ru-106.

We will present and compare inverse atmospheric transport and dispersion modelling methods to locate the source and to determine the source strength and release period. The Lagrangian particle dispersion model Flexpart will be used, driven by meteorological data from the Integrated Forecast System of the European Centre for Medium-Range Weather Forecasts (ECMWF). The influence of the chosen cost function used for the optimisation will be discussed. Furthermore, the uncertainties will be assessed via sensitivity experiments and/or an ensemble approach using the Ensemble Data Assimilation product of ECMWF.

Position optimization techniques for stationary and mobile radioactive incident monitoring

R. Dewarrat[1], P. Mandrin[1], M. Bleher[2], U. Stöhlker[2]

[1] IMSD, Switzerland
[2] Bundesamt für Strahlenschutz (Federal Office for Radiation Protection), Germany

Even a dense radioactive incident monitoring network can only be effective if the spatial distribution of the monitoring sites is carefully chosen, and an efficient mobile monitoring system is unavoidable in order to reduce the dose rate uncertainties further and take the appropriate decisions for the protection of the population. As an example, Germany currently operates 2000 stationary sites representing an area of 175 m^2 per station. Despite such a high network density, detecting every tiny atmospheric propagation of released radioactive material and reconstructing the contamination chart within 24 hours appears to be a challenge. Though subsequent mobile monitoring allows to improve the spatial resolution of the measured dose rates, it may be an even greater challenge to identify safe high priority zones for mobile monitoring. Data from stationary monitoring are important for source term reconstruction methods. For this reason, a two-fold optimization tool has been developed recently on behalf of the German radiation protection service. On one hand, the tool performs a spatial optimization for further stationary monitoring probes, using a linear combination of eight spatially dependent optimization criteria, for example the population density, the distance to the next probe or the time between first alarm and exposure. On the other hand, the tool provides a post-incident contamination chart and a chart of the dose rate uncertainty, both based on already available dose rate measurements and on a collection of propagation simulations (RODOS simulations for the most recent weather forecast models and for several scenarios of radioactive material release). The contamination chart is reconstructed by inverse modelling, resulting in a weighted combination of the simulation models. The weights are computed from the matching probability between the models and the measurements. As a new feature, in order to improve unsatisfactory matchings, the model plumes are subject to tiny spatial deformations compatible with general physical requirements. The resulting overall dose rate uncertainty of the contamination chart is used to obtain the priority chart for mobile monitoring. Realizing so a first step in the complex field of data assimilation, the tool allows to rapidly gain accurate information about the post-incident situation of radioactive contamination and to identify the zones for most urgent mobile monitoring missions. In the early phase after an accidental release, this will help to reduce uncertainties for dose assessment tools.

Session 4 – Data reproducibility & model validation

Severe Accident Diagnosis and Prognosis in European Nuclear Power Plants

Juan Carlos de la Rosa Blul, Miodrag Strucic, Patricia Pla, Luca Ammirabile

EC, The Netherlands

The European Commission Joint Research Centre is embarked in a project aimed at diagnosing and predicting the progression and consequences of a severe accident in Nuclear Power Plants (NPPs) located in European countries.

This tool is based on performing plant-specific sequence simulations for the most risk-significant severe accidents integrating probabilistic and deterministic safety analysis methods.

By building up a plant-specific surrogate model of the plant based on up-to-date available information specific for each of the European NPPs as collected in a EC-JRC database, the most relevant events are predicted, including a thorough prognosis of released source term characterization in magnitude and timing and at a radionuclide level, and further meteorological dispersion by coupling the results with a suitable radiological assessment code.

In order to validate the feasibility and accuracy of such innovative approach, the results of a pilot surrogate model of the plant have been compared with those generated by an as-built, complete model of one real plant and the deviation has been statistically treated and afterwards incorporated into the following surrogate models corresponding to one specific NPP design. It is worth noting that deviations are found within a very reasonable band, narrow enough to be confident on the accuracy of the method.

Within the following steps to be carried out before applying the methodology to all European NPPs (except for the AGR design), a blind benchmarking exercise is to be performed in the near future.

This presentation gives an overview of the methodology together with the very first comparison of the results between the surrogate model and an as-built, fully comprehensive model for a 1000 MWe, Westinghouse Large Dry Containment, 3-Loop Pressurized Water Reactor type of design.

The NERIS near-range atmospheric dispersion modelling experiment

Johan Camps[1], *François Menneson*[2], *Wolfgang Raskob*[3], *Tuomas Peltonen*[4], *Hartmut Walter*[5], *Margit Pattantyús-Ábrahám*[5], *Spyros Andronopoulos*[6], *Milagros Montero Prieto*[7], *Christina Trueba Alonso*[7]

[1]*Belgian Nuclear Research Centre (SCK•CEN), Belgium*
[2]*Federal Agency for Nuclear Control (FANC-AFCN), Belgium*
[3]*Karlsruhe Institute of Technology (KIT), Germany*
[4]*Radiation and Nuclear Safety Authority (STUK), Finland*
[5]*Federal Office for Radiation Protection (BfS), Germany*
[6]*National Centre for Scientific Research "Demokritos", Greece*
[7]*Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Spain*

Near-range atmospheric dispersion modelling, i.e. calculating the air-concentrations, doses and dose rates in the first kilometres around the release point, is important in the context of incidents and accidents at nuclear installations to assess the potential impact. In the first place because maximal impact can be expected, at least in general, in the vicinity of the release location. Secondly, a release will also be first pick-up by radiation detectors near the installations, for instance by the ring early warning stations installed at the fence of many nuclear installations. These detections allow to gain the first information on the impact and on the source term if source term reconstruction techniques can be applied. However, near-range modelling is challenging, due to local effects not always very well represented by, for instance, numerical weather data. To evaluate near-range atmospheric dispersion modelling, an experiment was set-up, in which NERIS members were invited to perform atmospheric dispersion and gamma dose rate calculations for routine releases picked-up by the ring stations of the TELERAD early warning network.

The experiment consists of simulating the dose rate at 7 locations, corresponding to the positions of early warning detectors, around the Belgian Reactor BR1. BR1 is an air-cooled, graphite moderated research reactor. During operation, Ar-41 is released via a stack of 60 m height at levels far below any health standard but regularly detected by the early warning stations. 16 days of the first half of 2017 were selected, during which the BR1 reactor operated at constant power (constant release rate) for several hours. This provides a rather unique dataset because it allows a statistical analyses of combined atmospheric dispersion and gamma dose rate modelling over different meteorological conditions. On-site meteorological data, collected along a meteorological mast, was made available to the participants.

The results of all participants are anonymised and compared with the measured dose rate data after correcting for background. Results are presented and interpreted in context of overall agreement between model results and measurements, agreement as function of location and as a function of meteorological conditions. Based on the results, potential further work in this domain is discussed.

Uncertainty assessment of DIPCOT based on the NERIS ADM experiment

S. Andronopoulos[1], *G. Efthimiou*[1], *J.G. Bartzis*[2]

[1]*National Centre for Scientific Research "Demokritos", Greece*
[2]*University of West Macedonia, Greece*

A study assessing the uncertainties in calculated gamma radiation dose rates by the atmospheric dispersion model (ADM) DIPCOT is presented in this paper. DIPCOT (DIsPersion over COmplex Terrain) is a Lagrangian ADM that operates either in puff or particle mode, upon user's option, and is contained in the JRODOS system. The uncertainties assessment presented here is based on the data provided by the Belgian Nuclear Research Centre (SCK•CEN) in the framework of the NERIS near-range ADM experiment described elsewhere in this Workshop (by J. Camps et al.). The sources of uncertainties in DIPCOT results that have been examined in this study are: (a) input meteorological and land cover data, (b) dispersion modelling options, (c) atmospheric turbulence. In particular uncertainties in input meteorology concerned atmospheric stability assessed by the measured vertical gradient of temperature or by the measured standard deviation of wind direction. Uncertainties in land cover referred to assumed aerodynamic roughness length of the ground surface around the emission point (stack of the BR1 reactor) and the in the area including the gamma dose rate monitors. In addition, different dispersion modelling options have been examined, specifically puff and particle mode. Each of these modes is connected to a different algorithm for computation of concentrations in air and of gamma radiation dose rates from cloudshine. Diffusion by atmospheric turbulence in Lagrangian models as DIPCOT is modelled through the random motion of puffs or particles that is superimposed on the motion by the mean wind velocity. So assessment of uncertainties due to atmospheric turbulence has been carried out by running the model repeatedly, each time with a different "seed" in the random number generator procedure that produces different trajectories of puffs or particles.

The conclusions of the study concern estimation of the relative influence of the different sources of uncertainty. The uncertainties assessment is performed through statistical analysis of the time histories of gamma radiation dose rates calculated at the monitoring locations around the reactor.

Individual dose reconstruction after nuclear accidents based on environmental monitoring data

K. Folger, F. Gering, S. Schantz, E. Huber, Y. Yevdin, M. Bleher, M. Lechner, M. Stanko

Bundesamt für Strahlenschutz (BfS), Germany

Assessing doses of individual persons affected by nuclear accidents is an important issue in emergency response. It enables the individual comparison of doses with e.g. reference levels, and thus provides the adequate basis for proper treatment of affected persons. In addition, large-scale individual dose assessment can provide the basis for epidemiological studies.

A software tool for dose reconstruction was recently developed by the German Federal Office for Radiation Protection. It makes use of available environmental measurement data, including gamma dose rate, air concentration and ground contamination. Missing data at measurement sites is calculated taking into account all available radiological information from neighboring sites, preceding and subsequent time steps and source term estimations. Individual doses are computed based on the time and duration of stay of the respective person within areas defined by Voronoi polygons around each measurement site. The output of the tool comprises individual values for the effective dose and for the equivalent doses of the thyroid and red bone marrow.

This dose reconstruction tool is designated to be used in emergency care centers where potentially contaminated people arrive after an emergency exposure situation, and was successfully tested during an emergency response exercise in Berlin in autumn 2017.

Session 5 – Operationnal challenges

Challenges in a changing world to be prepared for nuclear emergency response

Marie Claire Cantone[1], *Ivan Veronese*[2]

[1] University of Milan, Department of Biomedical, Surgical and Dental Sciences, Milan, Italy
[2] University of Milan, Department of Physics, Milan, Italy

When considering natural hazards that encounter mankind and turn into disasters, or disasters resulting directly from human actions such as terrorism or war, it is fundamental to be able to deal effectively and specifically with a proper response to emergencies, depending on the type of risk (medical, chemical, biological, radiological and nuclear).

The world is changing in rapid timescales, with technologies improving exponentially and with an increased level of population, even in areas of higher risk and in large, populated cities or regions. An increasing interconnectedness is used by a large number of people, and the crowd-sourced web ratings are used significantly to inform many of the decisions people make in their daily lives. Within the robotic technologies which are widely used in many civil and military applications, studies have been addressing the subject of 'disaster robotics' to implement response actions in specific harsh environments, and to evaluate the related safety benefits. In this changing world, a range of evolving challenges can be underlined and discussed in nuclear and radiological emergency response, either as new ones or as evolutions of our already present challenges.

I- A number of emergency exercises and lessons learned are available in relation to past emergencies, and it is important to avoid a gap in the application of those lessons to possible new cases of emergency response, and to consider new emerging lessons. The emergency exercises provide the basis for a review of the arrangements in a nuclear emergency response, at national and international levels, and one challenge is to highlight whether positive changes, identified through these exercises, are followed up with proper implementation, and to trace whether these changes really persist over the time.

II-When managing emergency situations, it is useful to concentrate on how to work in partnership with other countries, and to create coordination at national and international levels, with attention to concerted actions in the relevant aspects of risk. It is a continuous challenge to integrate the decision-making process with stakeholders, and to create and count on public trust and confidence. By responding to an idea of shifting from 'need to know' to 'need to share', social media is recognised as bringing beneficial changes in the communication of risk directly with the public and, at the same time, opening up challenges in a situation of information overload, by considering mainly public-led or government-led media towards creating an effective and continuously resilient community.

III- The response to emergency situations may benefit from the development of robotic systems based on the interaction between human-robot-environment, to be used in lieu of human operators. An emerging challenge is the evaluation of risk connected with their use in a nuclear emergency response. Indeed, different scenarios may have extreme terrain and operating conditions which affect the size and performance of the sensors and, more generally, the correct operation and survival of the robot. A system-oriented approach, such as the one based on failure mode and effects analysis, represents another challenge to identifying the components that may most contribute to a failure, to evaluating the reliability of the robot equipment and to emphasizing the conditions for it to possibly function successfully.

ANURE project: Towards the implementation of a nuclear risk assessment methodology

García Puerta, B.[1], Hernández-Ceballos, M.A.[2], Trueba Alonso, C.[1], De Felice, L.[2], Sangiorgi, M.[2], Montero Prieto, M.[1]

[1]Department of Environment, Radiation Protection of Public and Environment Unit, Research Centre for Energy, Environment and Technology (CIEMAT)
[2] Radioactivity Environmental Monitoring and Emergency Preparedness and Response (REM-EP&R); Knowledge for Nuclear Security and Safety Unit, Joint Research Centre (JRC)

The CIEMAT (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas) and the JRC (Joint Research Centre) of the European Commission have expressed their mutual desire to co-operate in various areas of nuclear research with emphasis on nuclear safety. One of the areas identified for cooperation between these two organizations is the Emergency Preparedness and Radioprotection. Considering the crucial point of understanding the interactions between nuclear facilities and their environment, the objective in this specific area of collaboration is to develop and/or improve guidelines to help determine what actions are necessary to protect people from unhealthy levels of radiation. Under this framework, the ANURE project "Assessment of the Nuclear Risk in Europe - A case Study in the Almaraz Nuclear Power Plant, Spain" aims at developing a methodology to elaborate nuclear risk maps, considering local factors, to be used by the decision-makers in the preparedness and management of a nuclear post-accident exposure situation. The Almaraz Nuclear Power Plant in Spain has been taken as reference in this feasibility study. The risk assessment methodology is expected to be reproducible in any technological risks and scalable for different territorial levels around the potential release point. The technique to address this kind of analysis is to run many hypothetical events covering a wide range of possible outcomes. With this premise in mind, the methodology and the ANURE's results are based on 1825 numerical dispersion calculations from 5 consecutive years (2012-2016) using the Lagrangian mesoscale atmospheric dispersion model RIMPUFF, which is implemented in the JRODOS Decision Support System. For this period, the dispersion of two different source terms has been simulated, 1) severe accident with relative large release and 2) severe accident with small release. The outputs of each dispersion calculation, among others, consist of ground contamination on an irregular geographical grid. This information is useful to establish the affected area and the probability of exceedance of thresholds of contamination. This deposit probability combined with detailed information of soil vulnerability and the food chain impact provides an estimation of the risk distribution associated with both kinds of nuclear releases. These maps can be used in the preparedness phase to determine the potential foodstuff and feedstuff restriction areas, or to establish where remediation and recovery measures could be applied. The objective of this contribution is to present the ANURE project and the first results obtained.

Summary of the European joint research project "Metrology for radiological early warning networks in Europe" (MetroERM)

S. Neumaier[1,2], on behalf of the MetroERM consortium

[1]*Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig (Germany)*
[2]*Coordinator of the MetroERM consortium*

After an airborne spread of nuclear contamination, especially in case of transboundary implications, there is an urgent need for authorities to advise the population on the necessary precautions to be taken against dangers arising from ionising radiation. In the aftermath of a nuclear or radiological emergency, recommendations given by the European authorities could affect millions of people and may have severe economic and sociological consequences. Therefore, metrologically sound monitoring data of ambient dose rate and airborne radionuclide activity concentrations are a prerequisite for sound governmental decisions. As an important contribution to nuclear emergency preparedness, all European countries operate radiological early warning networks. Presently, there are approximately 5000 dosimetry monitoring stations and a few hundred air-sampling stations active across Europe. Each dosimetric monitoring station has a detector that is designed to detect ionising radiation, and is linked to other stations, giving a live picture of the radioactivity levels across large areas. The air-sampling stations are designed to measure airborne radioactivity, but only a few have a real-time capability. These national networks of monitoring stations provide important radiological information to enable European authorities to take appropriate actions and counter measures in the event of a nuclear accident. However, many of these stations, especially the majority of the dosimetry network stations, are based on simple detector designs, like Geiger-Muller counters which do not give the required level of accuracy nor any details on the nuclide vector involved, and thus further time-consuming data analysis is needed before any decisive action can be taken.

In the framework of the European Metrology Research Programme (EMRP), jointly funded by EURAMET and the European Commission, the project ENV57 MetroERM "Metrology for radiological early warning networks in Europe" aimed at the development of metrologically sound measurements of fundamental radiological quantities such as ambient dose equivalent rate, radioactivity concentrations in air and ground contamination levels in real-time. This required novel joint multidisciplinary approaches to be taken by a European collaboration of metrology and research institutes, 15 in total, including the JRC at Ispra which is responsible for the EURDEP database (collecting radiological data for the European Commission), accompanied by stakeholders and manufacturers of radiological monitoring systems.

The presentation will introduce the various objectives of this project which ended in June 2017, after a duration of three years, and will summarize its main results. Especially the development of novel scintillator based spectrometry systems capable for both, the measurement of dose rate values in real time, as well as for the provision of nuclide specific information like ground contamination levels will be described. The long-term impact of the developments and findings of this project, published in detail in about twenty mainly peer-reviewed journals, will be discussed.

National Monitoring Strategy to Promote Efficient Response and Preparedness in Radiological Emergency in Finland – progress report

TK. Ikäheimonen, M. Muikku, P. Vesterbacka

STUK, Finland

In a radiological emergency, decision-makers need reliable and timely information on forecasts of the radiation situation and its development. Radiation measurements must be generally planned beforehand and prioritized to obtain a better knowledge of the radiation situation and its development. This is important for ensuring the radiation safety of people and environment in different situations. Decision-makers need monitoring strategy, which helps them to promote efficient response to avoid extra doses to people or at least minimize them to as small as reasonable achievable. Strategy must give guidance for response and actions for various types of radiation emergencies. It must take into account monitoring needs and available resources since in the different phases of a radiological emergency, the measurement needs and their prioritizations may vary.

This paper describes the progress in development of national monitoring strategy, which also takes into account resources and needs of the society and focuses to secure safety and vital functions of the society. The work is based on guidelines given in the previous STUK ground report. The strategy is developed together with other authorities and relevant decision makers (ministries, rescue service, police, defence forces, hospitals etc.).

A software platform for environmental measurement preparation and data control of nuclear emergency exercises

M. Tombette, E. Quentric, D. Didier, T. Doursout, N. Scheiblin, J. Groell and O. Isnard

IRSN, France

In case of a nuclear accident that may imply a release of radioactivity into the environment, measurements of radioactivity are made in situ by a large variety of different means.
Exercises are essential to train the entire response organization to collect, gather, analyse and share the measurement values in a comprehensive way for experts and decision makers. To make it more realistic, the values collected on field have to be replaced with the fictitious measurement values corresponding to the scenario and computed by a numerical model. To avoid a bias in the response delay, the best way is to deliver the simulated measurements to the measurement teams as soon as they are provided. This is the job of the scenario data controller.
In France, there have been 12 to 15 nuclear emergency exercises annually at a national level for decades. IRSN is responsible for, or participates in, the technical scenario of all these exercises. With this experience in data control, IRSN has developed the C3X-Exercise software platform for that purpose. C3X is also the software platform for emergency response (C3X-Response).
Knowing the meteorological and the release scenarii, C3X calculates all kinds of measurement quantities such as air and soil activity concentrations, ambient dose rates, activities on smears and in other environmental samples (grass, leaf vegetables, water…). C3X also calculates the expected values delivered by most common transportable contamination probes.
As the years go by, measurement means have evolved to be more and more automatic (monitoring network, carborne, airborne…) and deliver their values in near real-time to informatics systems. Moreover, exercises specifications impose to use real meteorological fields and a large release more often. These constraints together imply doing the environmental scenario in real time. That is why a web dimension has been added to the C3X platform. The whole data control platform relies on an original client-server architecture which consists of a calculation server, data controller clients (PCs) and on-field measurement teams clients (tablet PC). The technical scenario, computed from a C3X client, is sent to the web app which presents the results to the whole scenario data controllers and to tablet PCs given to the players. Web services are also available to be interrogated by any other program through http requests, for example to transform data in any adequate format. Tablets are provided to mobile teams so that they can directly make the readings by themselves and can react just as if the accident was a real one. Measurement missions can then be visualized on maps through the web server which can be useful for debriefing of the responding teams.
The presentation will describe the platform and illustrate its operation by examples of exercises in France, but also the data control furnished by IRSN during the last AIEA exercise in Fukushima or during the national exercise in Hong Kong which took place last December.

Needs in making european recovery prepardness operational

Kasper Andersson & Yvonne Hinrichsen

UT, Denmark

Countermeasures for management of different types of contaminated areas have been investigated extensively since the Chernobyl accident took place more than 3 decades ago. The experience with respect to recovery options has been summarised in a number of generations of standardised 'datasheet' template compendia, including more and more information, also on indirect costs, problems and advantages, incorporating social, ethical and environmental perspectives.

The countermeasure descriptions should be used well in advance of any contaminating incident to identify those countermeasure methods that are locally acceptable and for a number of other reasons make sense to focus on and keep operational so they could be implemented with as little delay as possible, if needed. Even though many recovery countermeasures may be implemented quite efficiently several months after the contamination took place, and prior potentially highly time-consuming stakeholder consultation is required in some cases, it should also be made clear that countermeasure efficiency will generally decline with time, some types of surface need to be treated before other, and some very simple and inexpensive recovery countermeasures may be very advantageous (e.g. early mowing and removal of contaminated grass), but need rapid implementation. For instance this was not possible in the Fukushima case, where this type of planning had not been done. European guidelines and examples could start the process.

After the Fukushima recovery processes, both the Japan Atomic Energy Agency and the Japanese Ministry of Environment have issued series of countermeasure 'datasheets' for a number of countermeasures tested in different environment types. A number of new techniques were tried successfully, and may have potential for inclusion in the European compilations (e.g., dry ice blasting, use of road stripping equipment for turf removal). Both positive and negative experiences are interesting to learn from. Also a number of techniques have been combined in new ways at Fukushima. A method like shotblasting seems to have been reinvented in spite of earlier failure. It should be stressed that a number of parameters in the Japanese reports do not match European findings (e.g., wrt. time consumption), and some figures from some Japanese trials give no meaning (e.g., stating a countermeasure removal effectiveness of 10-90% without mentioning what gives the difference). There is clearly a need to revisit the European handbooks, also to look at data for a new range of surface materials and new Western methods (examples of these will also be given in the presentation), and uncertainty/variation concepts deserve more focus and elaboration. Clarification of the needs will be given on the basis of decades of specific countermeasure experience.
Very importantly, guidelines are needed for simple investigations of how to optimise the effect in the field of countermeasure implementation. Such methods can make all the difference between success or failure in practice. Examples will be given

OPERRA-HARMONE, Knowledge Database and FDMT regionalization

Shan Bai, Christian Saudt, Wolfgang Raskob

KIT, Germany

The OPERRA project HARMONE, Harmonising modelling strategies of European decision support system for nuclear emergencies, aimed to provide a system that is able to deal with a wide range of possible release scenarios, environmental characteristics and shortcomings on information in all phases of an emergency. As part of HARMONE, the decision support system JRODOS was updated. This paper deals with two aspects of the project

In one sub- project, a knowledge database which comprises of baseline scenarios and the corresponding generic strategies, together with a general guidance tool box in the form of an easy-to-read handbook, has been developed. This allows to define a first management strategy to reduce doses and contamination in inhabited areas and food production systems, respectively. The baseline scenarios depict different situations arising from a hypothetical atmospheric release. In each scenario, the source term FKA was used such that the release of about 10% of the total reactor inventory starts few hours after reactor shutdown and continues for around 50 hours. From this, three main contamination levels were defined as low, medium and high categories and the corresponding generic strategies for remediation options in inhabited areas and food production systems have been defined and stored in the knowledge database with respect to different surface/food types, radionuclides, seasons, times for implementation and so on. Further information about the strategies such as cost, waste and number of workers was provided by the two JRODOS models ERMIN and AgriCP and stored in the database. All this can be now used in ,a web-based decision support system that has also been developed to support the decision making process online by using that comprehensive knowledge database.

A second sub-project aimed at improving the customisation process of foodchain models to allow a better dose assessment of the population following a potential release of radionuclides into the environment. To improve the In this respect five radioecological regions were defined, parameter sets collected and implemented into the decision support system JRODOS covering Europe. These regions cross country borders and divide Europe in Boreal, Continental, Atlantic, Mediterranean and Alpine regions. For each of these regions, data sets of region dependent model parameters, such as agricultural yields, food consumption rates or feeding habits of livestock, were collated as input for the terrestrial food chain and dose module (FDMT) of JRODOS. This expanded the previous default data set for JRODOS, which was optimized for southern Germany. The comparison of model results for activities of key radionuclides in different food types shows pronounced differences between the radioecological regions for several release scenarios. This clearly demonstrates the need for proper customisation of these models which is now easier having baseline parameters for the dominating climatic conditions in Europe.

Using dose for prediction of early health effects after ionizing radiation : a challenging task

Port Matthias, Abend Michael

Bundeswehr Institute of Radiobiology, Munich, Germany

The relation of dose to different severity degrees of the hematologic acute radiation syndrome (HARS) which represents an early health effect after irradiation may differ over the dose range. We sought to understand the relation of absorbed dose and risk of clinically relevant HARS in humans. In the first part of the presentation we provide an overview on exposure and biological parameter interfering with the dose-to-effect relationship. In the second part of the presentation we show an analysis based on the database SEARCH (System for Evaluation and Archiving of Radiation Accidents based on Case Histories) containing the history of radiation accident victims. From 153 individuals we extracted data on dose estimates which were correlated with haematological response categories of clinical significance (H1-4) based on the medical treatment protocols for radiation accident victims (METREPOL) Most of the Caucasian (82.4%) male (92.8%) victims originated either from the Chernobyl (69.3%) or Goiânia accident (10.5%). All cases received a whole body exposure (mean 3.8 Gy, stdev +/- 3.1) and the reported single exposures (79%) predominated. Our analysis indicates that single whole body doses below 1 Gy and doses > 5 Gy roughly corresponded with Ho (healthy individuals) and H3-4 HARS and this was consistent with medical expectation. This underlines the usefulness of dose estimates for HARS prediction. However, whole body doses between 1-5 Gy poorly corresponded to H1- H3 HARS. The dose range of 1-5 Gy was of limited value for medical decision making regarding e.g. hospitalization for H2-3 but not H1 and treatment decisions that differ between H1-3. Also, some instances of Ho were observed at high doses and outcomes H2-4 were seen at low doses, thus, challenging an individual recommendation based only on dose. In the last part of the presentation we will provide an alternative approach which allows an individual and early prediction of the later developing health effects which integrates important exposure details and biological parameters such as individual radiosensitivity.

The IAEA arrangements for international assistance in the framework of the Assistance Convention

K. Smith, F.Baciu, E.Buglova

IAEA, Austria

The IAEA Response and Assistance Network (RANET) was established by the IAEA as the operational tool for implementing the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Assistance Convention). RANET is a network comprised of Member States capable and willing to consider providing, upon request, specialized assistance by appropriately trained, equipped and qualified personnel with the ability to respond in a timely and effective manner to nuclear or radiological emergencies.

RANET provides a compatible and integrated system for the provision of international assistance to minimize the actual or potential radiological consequences of a nuclear or radiological incident or emergency on human health, the environment and property. It also facilitates the provision of advice and assistance to the requesting State for on-scene response activities to mitigate the impact of emergencies.

State Parties can fulfil their obligation under the Assistance Convention by identifying the National Assistance Capabilities (NAC) that could be made available to assist another State, and then registering these capabilities in RANET. The NAC consist of qualified experts, equipment, materials and other resources that can be activated to provide assistance either by deployment of assistance to the event scene, or by providing assistance from an external base, such as State offices, hospitals, laboratories or other locations. States Parties may register their NAC as Field Assistance Teams (FAT) and/or as External Based Support (EBS). RANET FATs are deployable capabilities consisting of experts with appropriate equipment, materials and other resources, while EBS is home-based support that provides assistance from within the State. An Assistance Mission is performed by a group of qualified experts and can be a FAT, an EBS or a Joint Assistance Team (JAT) comprising of a combination of FATs and/or EBSs to provide advice, assessment, medical support, monitoring or other specialized assistance following nuclear or radiological incidents or emergencies.

Since 2000, RANET has been effectively used in the provision of assistance through deployment as either a single FAT or through assistance provided by an EBS capability. To date, no Assistance Missions have been performed by a Joint Assistance Team comprising of a number of FATs and EBSs from different State Parties. However, large scale nuclear or radiological emergencies could necessitate complex Assistance Missions involving the deployment of a JAT.

In October 2017, the first emergency exercise involving the deployment of a JAT comprising FATs supported by EBSs took place. The overall objective of the exercise was to identify operational and compatibility issues that may arise through the deployment of an Assistance Mission as a JAT.

This paper will summarise the IAEA arrangements for international assistance and will report on the JAT exercise

Session 6 – Coping with uncertainties

The Various Meanings of Uncertainty

S. French[1], *S. Haywood*[2],
D. Oughton[3], *C. Turcanu*[4]
[1]*Warwick Univ, UK*
[2]*PHE, UK*
[3]*NMBU, Norway*
[4]*SCK•CEN, Belguim*

Emergency planning, response and recovery inevitably bring much uncertainty; and the radiation protection community is now not only acknowledging this in relation to nuclear accidents, but also seriously addressing how procedures, processes and decision support tools can be modified to help manage the uncertainties. In many respects, there is still a tendency to treat uncertainty as a homologous topic, a single concept.

However, 'uncertainty' is a portmanteau word covering many different meanings. It is interpreted differently by different people and disciplines and can include:

- *stochastic* uncertainties (i.e. physical randomness);
- *epistemological* uncertainties (lack of scientific knowledge);
- *endpoint* uncertainties (when the required endpoint is ill-defined);
- *judgemental* uncertainties (e.g. setting of parameter values in codes);
- *computational* uncertainties (i.e. inaccurate calculations);
- *modelling* uncertainties (i.e. however good the model is, it will not fit the real world perfectly).

Moreover, there are further uncertainties not relating to knowledge and prediction as those above, but relating to lack of clarity, values and ethics:

- *ambiguities* (ill-defined meaning);
- *partially formed value judgements* (what are the precise objectives in a set of circumstances);
- *social and ethical* uncertainties (i.e. how expert recommendations are formulated and implemented in society, and what their ethical implications are).

Some uncertainties may be quantifiable, but others maybe *deep*; i.e. within the time and data available to support the emergency management process, there is little chance of getting agreement on their evaluation or quantification. Some may in principle be resolved by analysis, were there enough data, but others may only yield to reflection and discussion.

This paper explores the meanings of these different types of uncertainty and their potential for confusion, before discussing how each should be addressed and the research needed to achieve this.

Operational use of dispersion calculation with quantified uncertainties

Steen Hoe and Jens Havskov Sørensen

DEMA, Denmark

In the early phase of a nuclear accident with long-lasting consequences, e.g. a core-melt scenario, two large sources of uncertainty exist: one related to the source term and one associated with the meteorological data. In addition, a smaller source of uncertainty is related with the dispersion models used.

In the recent NKS-B projects MUD (Meteorological Uncertainty of atmospheric Dispersion model results, Sørensen *et al.*, 2014), FAUNA (Fukushima Accident: UNcertainty of Atmospheric dispersion modelling, Sørensen *et al.*, 2016), and MESO (MEteorological uncertainty of ShOrt-range dispersion, Sørensen *et al.*, 2017), the implications of meteorological uncertainties for nuclear emergency preparedness and management have been studied, and means for operational real-time assessment of the uncertainties in a decision-support system (DSS) have been developed and demonstrated. In the ongoing project AVESOME (Added Value of uncertainty Estimates of SOurce term and Meteorology), the influence of the source-term uncertainties on atmospheric dispersion is being investigated. The methodology developed in AVESOME is well suited, and prepared, for the RASTEP formalism and the coming results of the FASTNET project.

In the ARGOS DSS v. 9.6, the effects of meteorological uncertainties on dispersion prediction are now in operation for long-range modelling. This has proven to be an excellent tool for the TSO, but implies also a challenge regarding communication to the decision makers. In ARGOS, the concept of risk areas is suggested as a solution to this problem. A risk area is a geographical area presented directly to the decision makers. In the future, this area may be in accordance with the meteorological uncertainties of dispersion prediction; and uncertainties on other parameters, such as the source term, can be included as well.

The statistical methods and the display used for predicting dispersion has also proven useful in the recent ruthenium case where we have adapted this methodology to inverse modelling aiming at localizing the unknown source of ruthenium geographically as well as in time. Thereby, candidates for the release have been identified. By forward modelling from each of these potential source locations, the absolute magnitude of the release has been estimated by fitting to the measured concentrations at the European filter stations.

An operational implementation of the latest results in Nordic research on uncertainty of atmospheric dispersion prediction

Jens Havskov Sørensen[1], Bjarne Amstrup[1], Thomas Bøvith[1], Henrik Feddersen[1], Rashpal Gill[1], Ulrik Smith Korsholm[1], Martin Sørensen[1], Flemming Vejen[1], Jerzy Bartnicki[2], Inger-Lise Frogner[2], Heiko Klein[2], Magne Simonsen[2], Alvaro Valdebenito[2], Peter Wind[2], Viel Ødegaard[2], Poul Astrup[3], Neil Davis[3], Bent Lauritzen[3], Steen Cordt Hoe[4], Carsten Israelson[4], Patric Lindahl[5], Jonas Lindgren[5], Niklas Brännström[6], Jan Erik Dyve[7], Jan Pehrsson[8]

[1]Danish Meteorological Institute (DMI), Copenhagen, Denmark
[2]Norwegian Meteorological Institute (MET Norway), Oslo, Norway
[3]Technical University of Denmark (DTU), Roskilde, Denmark
[4]Danish Emergency Management Agency (DEMA), Birkerød, Denmark
[5]Swedish Radiation Safety Authority (SSM), Stockholm, Sweden
[6]Swedish Defence Research Agency (FOI), Umeå, Sweden
[7]Norwegian Radiation Protection Authority (NRPA), Østerås, Norway
[8]PDC-ARGOS, Brøndby, Denmark

Atmospheric dispersion model calculations for radionuclides released from a nuclear accident provide information on possible contamination levels and radiation hazards thereby facilitating decisions on protective actions. This is implemented for emergency management through the use of Decision Support Systems (DSSs).
Recent developments in numerical weather prediction modelling include probabilistic forecasting techniques addressing the inherent uncertainties. This approach may be taken over by atmospheric dispersion modelling. Today, however, most nuclear DSSs do not take uncertainties into account, but merely allow for presentation of a single deterministic plume hoping, or expecting, that the prediction is 'realistic'.

In the NKS research project 'Meteorological Uncertainty of atmospheric Dispersion model results' (MUD), the uncertainties of atmospheric dispersion model calculations were investigated as well as means for incorporating the uncertainties into DSSs, allowing for the presentation of uncertainties to decision makers in a comprehensible manner. The MUD methodology has been implemented operationally in the Danish setup providing long-range atmospheric dispersion modelling for the Danish Emergency Management Agency (DEMA).

In a following project 'Fukushima Accident: UNcertainty of Atmospheric dispersion modelling' (FAUNA), the MUD methodology was applied to the Fukushima Daiichi nuclear accident. A third project 'MEteorological uncertainty of ShOrt-range dispersion' (MESO) addressed two items: (i) to study uncertainties of short-range atmospheric dispersion forecasting involving the use of NWP model data only, and (ii) to study hindcasting including the combined use of NWP model data and weather radar data. A fourth project 'Added Value of uncertainty Estimates of SOurce term and Meteorology' (AVESOME) is still in progress, in

AVESOME source term uncertainty and its interaction with the meteorological uncertainty is studied. A second goal of AVESOME is to provide an operational implementation of the results from MUD, FAUNA, MESO and AVESOME (so far).

In the presentation an overview of how the methodology has been implemented in the ARGOS DSS will be given. As well considerations towards how to present the concept of uncertainty to experts and decision makers will be discussed, including the pros and cons of different types of communicating the uncertainty.

In an outlook the implications of requiring information on source term uncertainty provided from the DSS to the ADM-model is discussed, including various options for how to make this operational in a reasonable manner for the DSS operator.

The impact of different Atmospheric Dispersion Models in the results of the European Model for Inhabited Areas after a Radiological Scenario

Paulo Marques Nunes [1], *Francisco Mariano* [2], *Luis Portugal* [1], *Márcia Farto* [1], *Francisco Cardoso* [1], *João Oliveira Martins* [1],

[1] *Agência Portuguesa do Ambiente (Portuguese Environment Agency)*
[2] *Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa*

The European Model for Inhabited Areas, ERMIN, included in the JRODOS Decision Support System, has been used to evaluate the effectiveness of several recovery strategies and to assist in the development of appropriate response strategies for an urban area affected by a hypothetical radiological emergency scenario.

Several dispersion maps were produced using different Atmospheric Dispersion Models (ADM). ERMIN was run with each of these possible deposition cases and the corresponding results for several response strategies were obtained. A comparison of these different strategies was carried out in order to assess the uncertainty of the impacts on an urban area created by different ADM results.

Experiences from operational actions and recent research with respect to atmospheric disaster events

Hieden Alexander, Paul Skomorowski, Kathrin Baumann-Stanzer

ZAGMA, Austria

The Central Institute for Meteorology and Geodynamics (ZAMG) is designated by the World Meteorological Organization (WMO) as Regional Specialized Meteorological Centre (RSMC) and supports the CTBTO verification system with inverse atmospheric modelling activities on global scale. Beside of supporting the Austrian Federal Crisis and Disaster Management (SKKM) with meteorological expertise, ZAMG holds leadership of the EU project "European Natural Disaster Coordination and Information System for Aviation" (EUNADICS-AV), provides input data for various dispersion models and performs preliminary assessments in cases of radiological, biological or toxic disaster events from local to large scale.

Whenever contaminated material is or might be dispersed in the atmosphere in the case of a nuclear or chemical release, a quick and accurate prediction of the concentrations is crucial for crisis management and emergency response. In such a case, different approaches are available, ranging from simple parametric models and Gaussian methods to Lagrangian dispersion models and advanced computational fluid dynamics (CFD) based modelling suites. The variety of the models implemented in today's emergency response systems, used in crisis management and emergency response planning, therefore ranges from very simple, robust and fast approaches to highly sophisticated model systems taking into account changes in the meteorological conditions in time and space, terrain as well as buildings. These various methodologies have different advantages and disadvantages with respect to their accuracy, computational efficiency and reliability of the results so that for any release scenario, authorities may come to different decisions and a variety of instructions may be given to emergency responders, depending on the simulation tools applied. Regional to large scale atmospheric dispersion calculations from different emergency response tools, e.g. TAMOS, RODOS and ESTE for radiological hazards, suffer from the fact that representative meteorological data may not (or at least not in time) be available as input but may also render significant differences in the simulated affected areas even in case of identical meteorological input and source term due to uncertainties arising from available forecast data but also from the applied model physics. Due to scientific and especially computational limitations these uncertainties can not be avoided completely nor can they be neglected. However, within various studies and experiments, different methods have been introduced helping to assess the quality of the model results and increasing the validity of predications provided by emergency response tools.

The Austrian emergency response system for nuclear releases will be introduced. Results from model comparison studies and preliminary results of the EU project EUNADICS-AV will be presented.

Uncertainty propagation in an atmospheric dispersion modelling of the Fukushima nuclear accident

Raphaël Périllat[1,2,5], *Irène Korsakissok*[1], *Vivien Mallet*[3], *Anne Mathieu*[1], *Damien Didier*[1], *Thomas Sekiyama*[4]

[1] *IRSN - Institute of Radiation Protection and Nuclear Safety, Fontenay-aux-roses (France).*
[2] *BERTIN Technologie, Saint-Aubin (France).*
[3] *INRIA, Paris (France).*
[4] *Japan Meteorological Agency, Meteorological Research Institute, Tsukuba (Japan).*
[5] *now at Phimeca Engineering, Paris (France).*

When a radionuclides' accidental release occurs, atmospheric dispersion simulations are used to estimate the consequences of the event. However, these calculations have a lot of uncertainties. A sensitivity study on the Fukushima disaster with the short distance model pX from the C^{3}X operational platform (Korsakissok, I. et al. 2013, Tombette M. et al. NERIS 2018) has shown that the meteorological data and source terms are the most influent inputs on the simulation results. The use of meteorological data ensemble is a realistic way to propagate this uncertainty through the model.

In this study, two meteorological sets were used. One, designed by the Meteorological Research Institute of Japan (MRI) (Sekiyama et al. 2013), has been built to be representative of the a posteriori analysis error, i.e. the uncertainty of the meteorological fields after assimilating observations from the period of interest. The other, a forecast ensemble from the European Centre for Medium-Range Weather Forecasts (ECMWF), is more representative of the uncertainty of the meteorological data that can be available in case of an accidental situation for emergency situations management.

After assessing the quality of the ensembles, namely to ensure that their spread is representative of the uncertainty of meteorological fields. The uncertainty was propagated through atmospheric dispersion models with Monte Carlo simulations in order to obtain the best assessment of the output uncertainty. The resulting statistical model of uncertainty was compared with gamma dose rate and airborne deposition observations using rank histograms.

The Monte Carlo sample issued from both ensembles are spread wider than the radiological observations, despite the ensembles themselves being under-dispersed compared to the meteorological observations. Both samples are biased relatively to the observations. Additionally, they both contain, especially the ECMWF one, simulations with values below all the observations. Adjustments of the input perturbations could compensate for these discrepancies.

For these simulations, seven source terms from the literature were used. Additional perturbations were applied to the release times, the source altitude and the amplitude of the release. A next step to this study would be to use source term ensembles obtained by simulations of the accident's events to obtain a more realistic uncertainty as an input of our dispersion model. This approach will be use in the CONFIDENCE European project.

Scenarios and issues to address with stakeholders in the transition phase. Towards the reduction of uncertainties in the management of long-term recovery

Cristina Trueba, Milagros Montero, Roser Sala, Blanca García-Puerta

CIEMAT, Spain

In a post-nuclear accident situation, in what is known as transition phase just after the end of the emergency phase, the establishment and implementation of strategies that guarantee the adequate management of existing exposure situations, as set out in the European Directive 2013/59/Euratom, requires a decision-making process, in which the knowledge of the radiological situation or its potential evolution plays an important role. During this phase, a new management structure needs to be established and the necessary actions are planned to begin the recovery of the environment and the rehabilitation of the affected areas, with the aim of returning, as far as possible, to the previous living conditions.

The experience gained in the management of the Fukushima accident highlights that these plans must be developed through a process of national dialogue with the participation of stakeholders, point that is also set in the above mentioned Directive, taking into account the inherent uncertainties about the knowledge of the real consequences of an accident, the strategies that should be applied and their possible social and economic impact on the affected population.

In the framework of WP4 of the CONFIDENCE Project on, Transition to long term recovery involving stakeholders in decision-making process, discussion panels are foreseen to establish and assay the process of national dialogue with stakeholders during the transition to recovery based in generic contamination scenarios. The target of the discussions will deal on what to do and how to proceed in such contaminated scenario and evaluate the potential impacts of their decisions on the course of actions to recover acceptable living conditions. The inputs, concerns and viewpoints of such stakeholders, will take into account the uncertainties that stem from the different decision criteria and actions taken in the transition phase. A complementary Delphi survey will be carried out among the stakeholders of each to obtain a prioritization of their preferences in order to be used in the Multi-criteria Decision Analysis (MCDA).

The methodology follows the improvement of the preparation and response during the transition phase, identifying and trying to reduce uncertainties in the subsequent management of the long term.

This paper summarises the work done to establish the generic contaminated scenarios and the preliminary items of interest identified by stakeholders and experts to be considered in the discussion panels.

Decision-making processes in post-accidental situations: manifestation of uncertainty

Jérôme Guillevic[1], *Pascal Croüail*[2], *Mélanie Maître*[2], *Thierry Schneider*[2] *et al*

[1]*IRSN, France*
[2]*CEPN, France*

In the framework of the European project TERRITORIES*, a dedicated work package (WP3) aims to analyse the decision-making processes in long-lasting radiological exposure situations, taking into account all components of risk assessment, with two key points: management of uncertainties and stakeholder engagement. Among existing exposure situations is the aftermath of nuclear accidents. Criteria have to be defined as a basis for decision making and risk assessment, notably for the level of exposure of populations over time and for addressing the effectiveness and control of protective measures. The establishment of criteria is complex and involves many assumptions and analytical processes. There are also many associated uncertainties of scientific, economic, political and societal dimensions, leading to considerable difficulties in managing existing exposure situations in the past.

The first step of the TERRITORIES WP3 aimed to identify in which decision areas, and for which potential decision factors and criteria, uncertainties are the highest and the most questionable by the public could impact the life of affected people.
This paper proposes to present this first analysis which has been published in a dedicated deliverable last December 2017 (D.9.65), focusing on the main uncertainties of concern as well as the necessity to explore the difficulties that have arisen to date with their management.

Based on insights from past experiences of post-accident situations (post-Chernobyl and post-Fukushima), the presentation will propose an analysis of the different manifestations of uncertainties which come out in these contexts, as for example: radiological characterization and impact assessment, zoning of affected areas, feasibility and effectiveness of the remediation options, health consequences, socio-economic and financial aspects, quality of future life in the territory, social distrust. Then, the presentation will present the general approach adopted in WP3 to further address how uncertainty management comes into play in decision making processes for such situations and influence stakeholder's decisions and choices, with a view to developing improved mechanisms of governance to facilitate good decision making under uncertainty.

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Coping with uncertainty for individual decision-making in nuclear emergency situations

Catrinel Turcanu, Tanja Perko[1]

Roser Sala[2]*; Yevgeniya Tomkiv, Deborah Oughton*[3]*,*

Astrid Liland[4]

[1]*SCK•CEN, Belgium*

[2]*CIEMAT- CISOT, Spain*

[3]*NMBU, Norway*

[4]*NRPA, Norway*

Understanding people's concerns, motivations, beliefs and value judgments underlying individual decision-making in an emergency situation, is crucial for improving the governance of nuclear or radiological accidents and incidents.

This contribution provides results from an empirical study on expected behaviour in nuclear emergencies and related information needs. It first highlights main concerns linked to potential emergency situations. Next, drawing on social psychology theories, the study aims at clarifying how people expect to react in an emergency; what is their perception of the official advice concerning protective actions, willingness to follow these actions and which factors influence expected behaviour. Potential explanatory factors investigated include socio-demographic variables, descriptive norms, hazard and resource related attributes, self-efficacy aspects and trust in nuclear actors.

Data underlying the study originate from large scale opinion surveys in Belgium, Spain and Norway, among different categories of lay publics: general public and people living in the vicinity of nuclear installations.

The study is carried out in the framework of the European project CONFIDENCE (COping with uNcertainties For Improved modelling and DEcision making in Nuclear emergenCiEs), specifically the work package addressing social, ethical and communication aspects of uncertainty management.

Keywords: nuclear emergency; protective actions; expected behaviour; social psychology; CONFIDENCE

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Returning or not in areas affected by the Fukushima accident?

Crouail P. [1], *Schneider T.* [1], *Gariel J.-C.* [2], *Rollinger F.* [2]

[1] *CEPN,*
[2] *IRSN, France*

In the aftermath of both the Chernobyl and the Fukushima accidents, the post-accident management of the situations highlighted the crucial role of involving the population with the support of national and local authorities and experts, in order to ensure the effectiveness and sustainability of protective actions implemented in the contaminated territories. In Japan in particular, the process of lifting the evacuation orders shows that it is of utmost importance to take into account concerns and worries of the inhabitants of the affected territories and to involve them in the rehabilitation processes, to increase their efficiency.

Since 2013, CEPN and IRSN have met and gathered viewpoints from numerous Japanese stakeholders who face the consequences of the Fukushima accident at the national and local levels. In particular, the modalities and conditions governing the decision of evacuees to return home - or not to return - after the lifting of evacuation orders, have been examined. This has raised a number of new issues in the context of post-accident management. The feedback analysis revealed the complexity of the situation in a context of high uncertainty, and also emphasized the need for decision-makers and decision-helpers (e.g. radiological protection and medical experts) to take into account and respect the different choices made or envisaged by the affected people and communities for whom radiological issues are only one aspect of the problem they are facing to.

The lessons to be presented firstly deal with the dynamics of the emergency evacuation which has strongly influenced the issue of managing the return of populations. Social and especially family dimensions will also be emphasized, particularly related to the organization of temporary housing. Then, lessons will discuss the organization and the evolution of the characterization and zoning of the affected areas, the radiological criteria that have been used and how they have been perceived by people as well as the effects on health and welfare, by analysing in particular the temporal dynamics during the six years since the accident of March 11, 2011. The difficulties encountered by evacuees and returnees and the specific situations of the various communities will be highlighted. The question of the development of a radiological protection culture through self- monitoring and protective actions and its long-term role will also be discussed. Another key element concerns the effects of the compensation system: without going into detail on the mechanisms put in place, the social and ethical questions raised by this system will be presented. Another highlight will concern the involvement of a multitude of actors in the rehabilitation processes by supporting evacuees and returnees, with a focus on the difficulties for coordinating all these different stakeholders. Finally, the question of 'the future' will be evoked by stressing the concerns of several municipalities for restoring the attractiveness of the territory for new inhabitants.

New emergency planning zones and distances in Sweden

Jan Johansso[1], Peder Kock, Jonas Boson, Simon Karlsson, Patrick Isaksson, Jonas Lindgren, Elisabeth Tengborn, Anna Maria Blixt Buhr, Ulf Bäverstam

[1]Swedish Radiation Safety Authority

The Swedish Radiation Safety Authority (SSM) has developed a proposal for new emergency planning zones and emergency planning distances surrounding the nuclear power plants, the fuel fabrication plant and the central interim storage facility for spent nuclear fuel in Sweden. First, SSM decided on the standpoints serving as the basis for the proposal. These encompass overall objectives, the types of emergency planning zones and distances to be established, reference levels that serve as the basis of emergency planning, and dose criteria and intervention levels for different protective actions. Second, SSM determined postulated events for the relevant facilities. For these events, representative source terms that illustrate the releases assumed to follow the respective type of event were defined. Third, dispersion and dose calculations were used to produce a statistical basis for estimating the distances at which it is justified to take different types of protective actions. Based on these distances, the final proposal for new emergency planning zones and distances surrounding the nuclear facilities under consideration were produced by the County Administrative Boards in Sweden in collaboration with SSM and other relevant stakeholders. SSM also analysed residual doses for different combinations of protective actions that are possible given the proposal. In addition, SSM analysed needed measures in food production and the possible need for decontamination brought about by emergencies at the relevant facilities.

A number of key challenges were identified by SSM when working on developing the proposal for new emergency planning zones and distances. One key challenge was separating between tasks that are largely based on value judgements and tasks that are mainly based on current knowledge. SSM's ambition has been to clearly identify tasks that are largely based on value judgements, recognizing that these need to be discussed in depth with stakeholders. Another key challenge that was identified is dealing with great uncertainties. An inherent part of rare events is their being characterised by many uncertainty factors, and that in many cases, there is a lack of empirical data as a starting point. This has been addressed using sensitivity analyses in order to identify the parameters of key significance for the proposed emergency planning zones and distances. SSM also examined possible alternative outcomes given the existing uncertainties, as well as the suitability of the proposed emergency planning zones and distances for other potential highly unlikely events.

SSM has also developed decision support diagrams based on the proposed emergency planning zones and distances that can be used to make decisions on protective actions in nuclear emergencies, 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.

LIST OF POSTERS

Session 1 – Radiological Monitoring and Citizen Monitoring

Testing of commercial dose rate meters used in non-governmental networks

Patrick Kessler

Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig (Germany)

In the framework of the European Metrology Programme for Innovation and Research (EMPIR), the project Preparedness which focusses on the mobile detection of ionising radiation is investigating the performance of crowd based monitoring of ionising radiation. The possible use of information collected by these non-governmental networks is one of the main topics of this project.

Many of these networks have developed rapidly after the accident at the Fukushima Daiichi nuclear power plant. However, only few scientific studies have been performed to investigate the monitoring results. To be able to assess the value of the data given, the used dose rate meters of these networks are tested and metrologically characterised.

Most of these dose rate meters are small hand held devices based on a Geiger-Mueller tube. Some are even distributed as kits where the user has to solder and assemble it. 16 of these types have been selected and from each 4 will be investigated to gain also information about the production spread. The response of these systems to secondary cosmic radiation, their inherent background and the response to different radiation fields will be measured. First results of these investigations will be shown.

Enhancing Citizen Participation in preparedness for and recovery from a radiation accident: review of existing APPs for citizen based dose measurements

Paola Fattibene[1], *Joan Francesc Barquinero, Leonardo Barrios, Jean Francois Bottolier, Cecile Challeton-de Vathaire, Vadim Chumak, Cinzia De Angelis, Sara Della Monaca, Didier Franck, Liudmila Liutsko, Cristina Nuccetelli, Takashi Ohba, Koichi Tanigawa, Francois Trompier, Elisabeth Cardis*

[1] *IST, Italy*

The EU project SHAMISEN SINGS, funded under the European CONCERT call 2017 and started on October 2017, has the aim of enhancing Citizen Participation in preparedness for and recovery from a radiation accident through novel tools and APPs suitable to support data collection on radiation measurements, health and well-being indicators.

Within the project, the role of WP2, in which ISS, FMU, IRSN, UAB and ISGlobal as well as international experts are involved, is to review existing apps, plug-ins, and technologies for citizen based dose measurements. As a first step the WP will critically review the existing plug-ins, apps and technologies through literature and internet review; a selection of some software and devices will be experimentally tested and some criteria for the definition of the performance criteria for the evaluation of the quality of the tool, like accuracy, reproducibility, friendly use as well as its limitations will be defined.

After the experimental tests with stakeholders, the platforms and tools will be tested in real life, in particular focusing on how they are perceived, used and understood by public and how they may be integrated in the decision support systems. Finally, interactive platforms or tools on radiation measurements to provide information on exposure at the same time rigorous and understandable by all segments of society (based on needs learnt from SH consultation in WP1) will be developed or improved from existing ones.

In the present work, the work design and preliminary results of the literature and internet review about the existing plug-ins, apps and devices will be shown.

Monitoring of ionising radiation by non-governmental networks in the framework of the empir - 16env04 "preparedness" project

Giorgia Iurlaro[1], Konstantins Bogucarskis[2], Steven Bell[3], Lorenzo Campani[1], Marc De Cort[2], Harald Dombrowski[4], Patric Kessler[4], Alexandra Helbig[5], Sotiris Ioannidis[3], Djordje Lazarevic[6], Francesca Mariotti[1], Gordana Pantelic[6], Annette Röttger[4], Luciano Sperandio[1], Ulrich Stöhlker[5], Milos Zivanovic[6], Craig Duff[7]

[1] AgenziaNazionale per le nuovetecnologie, l'energia e lo sviluppo economico sostenibile (ENEA), [2] Joint Research Centre - European Commission (JRC), [3]NPL Managment Limited, [4] Physikalisch-Technische Bundesanstalt (PTB), [5]BundesamtfuerStrahlenschutz(BfS), [6] Vinca Institute of Nuclear Sciences, University of Belgrade, [7]Kromek

The analysis of possible nuclear or radiological consequences caused by relevant incidents or accidents, including terrorist attacks, is crucial to the protection of the public against dangers arising from ionising radiation. In these kinds of scenarios, the levels of ambient dose equivalent rate and activity concentrations provide essential information about the progression of the radioactive cloud. This information is important to decision makers in order to be able to take timely and appropriate counter measures to protect the members of the public and also to reduce the risk of improper actions and increasable follow up costs.
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 3 "Monitoring of ionising radiation by non-governmental networks ".
For several decades, the monitoring information is provided by national monitoring networks. Since a couple of years, non-governmental monitoring networks disseminating crowd sourced data have developed rapidly after the disaster at Fukushima. This trend may continue in line with the expansion of personal networked electronics. Metrological non-reliable data of simple and private electronic devices provided by non-officials to the general public and to the media is likely to result in unnecessary concern and may raise questions about the validity of the regular monitoring networks. Although the active involvement of the public should be encouraged, one should be also aware that the results measured in this way will not provide conflicts with the official measured national dose rate values. Hence, non-governmental monitoring requires a first and detailed investigation on its metrological relevance. In line with that, the congruity of dose rate data provided by non-governmental networks and the feasibility of using such data for European Data Exchange Platform (EURDEP) will be investigated for the first time.
One of the important achievements of the project is the dissemination of the results to the stakeholders to manage the new information provided by non-governmental networks to the general public and to the media, to avoid unsubstantiated fear and to prevent the undermining of credibility of governmental information with potentially severe psychological and harmful side-effects as a consequence

The development of transportable radioactivity-in-air monitoring systems in the framework of EMPIR project "Preparedness"

Steven James Bell[1], Vojtech Bednar[2], Craig Duff[3], Denis Glavič-Cindro[4], Petr Kovář[5], Stefan Neumaier6, Toni Petrovič[4]

[1]National Physical Laboratory (Teddington, United Kingdom), [2]Nuvia (Trebic, Czech Republic), [3]Kromek (Sedgefield, UK), [4]Jožef Stefan Institute (Ljubljana, Slovenia),

[5]Cesky Metrologicky Institut (Prague, Czech Republic), [6]Physikalisch-Technische Bundesanstalt-PTB (Braunschweig, Germany)

Following a nuclear or radiological event, fast and appropriate radiation protection measures, based on reliable radiological data, are of high priority for decision makers worldwide. The nuclear accidents in Chernobyl (1986) and Fukushima (2011) are major examples where such protection measures were crucial. During events where a large radioactive plume is released to the atmosphere, it is essential to measure the radioactivity-in-air concentration to monitor the progression of the radioactive cloud. It is also vital, in the immediate and medium term, to monitor the air to ensure the safety of first responders, recovery workers and the local population as re-suspension of locally deposited contamination may occur. Transportable air samplers equipped with high-resolution gamma spectrometers offer a flexible and economic solution to this dynamic monitoring requirement. Presented is an overview of three such systems that are being developed through the EMPIR "Preparedness" project. The first system, which utilises a modern co-planar grid CdZnTe detector, is a compact, light-weight system suited for use by first responders. The second system is a rapidly deployable, rugged air sampler with high sensitivity $CeBr_3$ scintillator detector. This instrument is built into a flight case, is easily re-deployed by one person with a car, and is suited for use by recovery workers. The final system is a semi-permeant, high-volume air sampler with electro-mechanically cooled HPGe gamma-spectrometer. The modular design provides benefits through optimised utilisation of expensive components (e.g. HPGe) and rapid commissioning. The system also utilises novel, low-background bricks that can be built around the instrument to provide shielding from ground contamination.

Large scale individual thyroid monitoring following nuclear accidents by means of non-spectrometric devices

Ignazio Vilardi, Giuseppe Antonacci, Paolo Battisti, Carlo-Maria Castellani, Nadia Di Marco, Isabella Giardina, Giorgia Iurlaro, Giovanna La Notte, Luciano Sperandio

ENEA, Italy

In order to properly respond to an emergency caused by an accident or a deliberate terrorist attack in a nuclear power plant with spread of radionuclides in atmosphere, we propose a procedure to perform on field a large scale individual thyroid monitoring of internal contamination due to inhalation of ^{131}I by means of non-spectrometric equipment. Specific attention is paid on individual monitoring of five and ten years old children, being the sensitive population group with an increased risk of developing thyroid cancer.

After an acute inhalation, ^{131}I typically concentrates one day later almost exclusively in the thyroid glands. Since only iodine isotopes retain in the glands, for thyroid measurements the use of simple portable non-spectrometric equipment, such as rate meters calibrated in ambient dose rate equivalent H*(10) (reading values in μSv/h), offers a suitable alternative to spectrometric technique, being cheaper, readily portable and simple to operate.

Rate meter thyroid calibration was carried out by means of an age-dependent neck phantom, proposed in a recent project called Child and Adult Thyroid Monitoring After Reactor Accident (CAThyMARA). It consists of a plexiglass cylinder representing the neck, with three pairs of holes with different dimensions for inserting the vials containing a ^{131}I liquid source, representing the thyroid glands of different ages (2 x 1.6 ml vials simulating a 5 y/o thyroid, 2 x 3.75 ml vials simulating a 10 y/o thyroid and 2 x 9.5 ml vials simulating an adult thyroid). Concerning the positioning of the measurement configuration, the sensitive area surface of the rate meter was positioned close to the phantom surface.

Device performances were evaluated by measuring mock-iodine sources provided in the CAThyMARA intercomparison and by means of acquisitions of 60 s counts each of different volunteers; in particular 51 acquisitions of adult thyroids and 21 acquisitions of 10 y/o thyroids were performed. Detection Limit (DL) values were evaluated using the ISO 11929 methodology, whereas DL intakes (i.e. the intake corresponding to an *in vivo* amount equal to a DL value) and related committed equivalent doses to thyroid were evaluated for members of the public with particle AMAD equal to 1 μm by using the MONDAL3 software, assuming an acute inhalation intake occurred three days before the measurement and type F absorption behavior.

The employed device showed a remarkable accuracy in quantification of equivalent ^{131}I in thyroids of all ages and DL values resulting in a maximum committed equivalent dose to thyroid equal to 8 mSv (related to 5 y/o children). Considering the reference level equal to 50 mSv (in terms of projected equivalent thyroid dose), for the first seven days since the onset

of exposure, recommended in the recent guidelines by World Health Organization for implementing iodine thyroid blocking, the observed performance level makes the rate meter a very useful tool to be used for fast thyroid monitoring in nuclear emergencies. Needless to say, priority has to be given to children monitoring, being the individuals at higher risk of developing radiation-induced thyroid cancer compared to adults, due to a range of physiological and behavioral factors.

The procedure here proposed cannot be exhaustive; this kind of measurements has to be carried out in conjunction with whole-body measurements to fully assess a committed effective dose due to all the gamma emitters involved in a nuclear accident.

Monitoring of contaminated area in a late phase of radiation accident

Cespirova, Irena; Lubomir Gryc; Helebrant, Jan

SURO, Czech Republic

The nuclear power plant accidents associated with the release of radionuclides into the environment have demonstrated the need for preparedness to handle such situations. In the Czech Republic the plans for solutions of the impacts of radiation accident are developed, putting emphasis on activities in an early phase of accident. The detailed procedures are developed for adoption of the protective measures for this period.

As the Chernobyl and Fukushima accidents have shown, a rehabilitation of affected area should begin immediately after an early phase so that the evacuated population could return to their homes as soon as possible and start living again according to their habits. An essential part of this is a rapid monitoring of affected area in order to identify areas where remedial actions are needed.

Within testing of procedures for monitoring contaminated areas and searching for hot spots, a number of measurements have been carried out over the past few years. The measurement took place in the areas with higher fallout after Chernobyl accident or in the areas with inhomogeneous distribution of natural radionuclides. The poster presents the measurement results. There are also documented and evaluated the procedures of individual measurements (aerial measurements, in situ spectrometry, sampling and subsequent measurements in the field and the laboratory). During measuring the new devices and their usability for radiation emergencies were also tested.

The poster was elaborated on the basis of the results of the Projects of the Ministry of the Interior ID: VI20172020015.

Session 3 – Inverse Modelling & data assimilation

Variational Data Assimilation for Short Range Atmospheric Dispersion of Radionuclides Based on Measurements Provided by an Unmanned Aerial Vehicle

L. Ivan, D. Hummel, S. Yue, M. King, I. Donohue, S. Cudmore and V. Korolevych

Canadian Nuclear Laboratories, Canada

Airborne radiological three-dimensional data can enhance the prediction accuracy of atmospheric transport and dispersion models used in tracking atmospheric release of radioactive pollution. The airborne mobile sensors can complement the stationary networks and improve the real-time dose prediction. Development and testing of the data assimilation methodology is the objective of the current work.

Canadian Nuclear Laboratories (CNL) has recently developed a light and compact radiation sensor package that is carried onboard an unmanned aerial vehicle (UAV). The gamma radiation detector has an energy range of 30-2000 keV with an energy resolution of 8.5 keV. The detector can operate in either spectrometric or dose-rate measurement mode. The range of dose measurements is 0.001 – 10 □Sv/hr with a measurement error of 20%. GPS coordinates of this airborne sensor are monitored with an accuracy of 5-10 m. The radio transmitter-receiver system communicates the measurements to the ground station. Measurements in this study were performed with the UAV in three successive 10-minute flights in the vicinity of the stack of the National Research Universal (NRU) reactor at CNL on October 3, 2017. Three-dimensional data for the radioactive plume was collected at 1 Hz frequency on a clear day between 5 and 7 pm right before and during the sunset, i.e., during the late afternoon transition of atmospheric boundary layer. During flights meteorological data at 0.1 Hz was taken from 30 and 60 m about ground levels at the tower at Perch Lake located 1800 m approximately upwind from the stack. Routine gamma-emissions from the NRU stack were dominated by Ar-41 released at the rate of 2.1E+14 Bq/week and apart from UAV also recorded by a CNL network of monitoring stations.

The application of variational data assimilation based on a simple Gaussian plume model for radionuclides is considered in this work. The model parameters are computed so as to minimize discrepancies between stationary monitoring observations and model outputs. Atmospheric release and meteorological conditions can be considered quasistationary. Under this assumption the Gaussian-model parameters were determined with data from certain flights and the rest of the data is used to validate the predictions.
The final presentation will provide details about the detection equipment, the process of data acquisition and the collected measurements. Additionally, the devised algorithm to perform variational data assimilation will be presented. Results to illustrate how the data-enhanced dispersion model performs in the short range will be shown.

Session 5 – Operational Challenges

Operational Challenges in Nuclear Emergency Response in Ireland Identified during the ConvEx-3 (2017) Exercise

Kevin Kelleher, Veronica Smith, Robert Ryan, Caroline Donnellan & Ciara McMahon

EPA, Ireland

The International Atomic Energy Agency organised a level 3 Convention Exercise (ConvEx-3) which took place in June 2017. The exercise scenario involved a nuclear emergency at the Paks nuclear power plant in Hungary resulting in a release of radioactivity to the atmosphere. Ireland participated in this exercise with the overall objective of testing key elements of the National Emergency Plan for Nuclear Accidents which is currently under revision. These elements included the provision of information to the public, decision making regarding agricultural protective actions and the provision of advice to Irish citizens both in and travelling to the accident country.

Following the exercise, the Environmental Protection Agency evaluated Ireland's performance in terms of the objectives set for the exercise. A number of areas of good performance were identified but there were also areas where work is required to improve performance. Specific challenges which need to be overcome include emergency communications and the use of social media, building capacity to respond to an emergency over a prolonged period and managing the surge in requests for radioactivity measurements in food and feedstuffs in the aftermath of an accident. This paper sets out these challenges in more detail and ways in which they can be addressed.

Building capability in Research Reactor Emergency Plans

MORAIS, Gustavo Ferrari; CALÁBRIA, Jaqueline Alves de Almeida; SILVA, Maurício Santarosa Pereira

CNEN, Brazil

Brazilian legislation requires that all nuclear facilities establish and maintain arrangements for on-site preparedness and response for a nuclear or radiological emergency [1]. Those arrangements must obey IAEA guidelines [2] and the Brazilian Nuclear Program Protection System (SIPRON) procedures.

Currently, the Brazilian regulatory authority is dealing with 6 licensing processes of research and test reactors, with power from few hundred watts to close to 50 MW. Although CNEN normative states generic requirements which these plans must comply, there is not a well-defined national guideline regarding the details that an emergency plans should contain.

This lack of pattern became a challenge during the assessment of the new licensing documents. Furthermore, while elaborating the emergency plans the operators are not following the same guidelines, thus applying documents that not necessarily are cohesive with CNEN's emergence response plans. Which poses as a problem for the assessment of the documents and the implementation of the plans.

This work intends to perform a review of the available international documentation related with emergency planning for test and research reactors, in order to subsidize the development of the Brazilian regulation specific to research and test reactors. It will be taken into account the IAEA standards and guides [2, 3], the U.S. N.R.C. [4, 5, 6] documentation, and the European Union directives [7], making a parallel between them, mainly pointing the differences in definitions and approaches.

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[2] IAEA; GSR Part 7 – Preparedness and Response for a Nuclear or Radiological Emergency; Vienna, 2015
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[6] US NRC; NUREG 0849 - Standard Review Plan for the Review and Evaluation of Emergency Plans for Research and Test Reactors; Washington; 1983
[7] COUNCIL DIRECTIVE 2013/59/EURATOM; available at: http://eur-lex.europa.eu/eli/dir/2013/59/oj;

Probabilistic assessment of the effect of sheltering and evacuation on the radiological dose for the population – a generic approach

Thomas Hamburger, Florian Gering

Bundesamt für Strahlenschutz (BfS), Germany

As part of an international collaboration BfS (Germany) and PHE (UK) investigated the effectiveness of the countermeasures sheltering versus evacuation during a hypothetical accident in a nuclear power plant. The method used by BfS and respective outcomes are discussed here.

The RODOS (Real time On-line DecisiOn Support) system was used to calculate the effective dose in the first days after an accident in a nuclear power plant based on several pre-defined source terms and real weather data. Six different source terms - based on two main source terms - were used for the simulations to investigate the impact of varying source strengths and release durations. 365 model runs were performed per release scenario to cover most possible meteorological conditions and transport patterns throughout one year.

All scenarios have in common, that an immediate release is assumed and the potential of an evacuation under the cloud is given.

The total effective dose for the emergency measures sheltering and evacuation were assessed at each point within a 20 km radius from the release site. Generic evacuation routes lead to four reception centers located North, South, East, and West of the release site at a distance of 30 km. The population was evenly distributed within the 20 km zone. The total effective dose was either evaluated for the population located at one point or the whole population located within one of the 13 emergency sectors. Only points or sectors were considered where the estimated effective dose for 7 days for children exceeded 100 mSv in at least one location, i.e. where evacuation would be recommended in Germany.
The results and the effectiveness of sheltering versus evacuation were analyzed for the collective and for each individual sample. The comparison of sheltering versus evacuation, and the question which one of the two countermeasures is preferable, largely depends on the selected source term, duration of the release, distance to the release site, and if individual samples are considered for a countermeasure or a whole collective within an affected section. For example, the probabilistic analysis showed that evacuation has a larger benefit for long releases and samples close to the release site and vice versa for sheltering.

However, the pure radiological benefit of one countermeasure over the other has to be set into the context of other factors that have to be considered by decision-makers, such as disruption, societal impact, economic cost and other hazards.

Further work on investigating the impact of different meteorological scenarios, evacuation settings and plume location during evacuation is planned.

Training of monitoring teams

Cermakova, Eva; Cespirova, Irena; Lubomir Gryc

SURO, Czech Republic

Training of monitoring teams involved in monitoring during a radiation emergency is a part of every radiation response plan worldwide. It is clear that all workers should be properly trained and experienced to fulfil successfully the challenging tasks in a contaminated area. In case of their deployment in a contaminated area, they should be able not only to measure required quantities (dose, dose rates, and specific activity of contaminants) and to sample required environmental components, but also to protect themselves, instrumentation and collected samples from cross-contamination.

Within the Radiation Monitoring Network of the Czech Republic 25 mobile groups operate in the following departments now: the State Office for Nuclear Safety (SÚJB), the Ministries of the Interior, Defense and Finance. The training of these groups (theoretical part and practical exercises of individual activities) takes place within individual ministries separately or on the basis of bilateral agreements among them. The ministries are responsible for the training of their mobile groups.

Every two years the emergency exercise of the crisis management "Zone" in the emergency planning zone of NPP Dukovany or Temelín organized by the General Directorate of the Fire Rescue Service in cooperation with SÚJB takes place. The exercise also includes a monitoring of radiation situation by mobile groups.

The poster shows the activities of mobile groups during the "Zone 2017" exercise and the training of individual activities of the SÚJB mobile teams and the Czech Army "Tisa 2017".
The poster was elaborated on the basis of the results of the Projects of the Ministry of the Interior ID: VH20172020006.

Session 6 – Coping with uncertainties

Using Meteorological Ensembles to Provide Meteorological Uncertainty when Modelling the Spread of Radioactive Material

Susan J. Leadbetter, Benjamin Evans, Andrew R. Jones, Sarah C. Millington

Met Office, United Kingdom

Atmospheric dispersion models are used to estimate the dispersion and deposition of radioactive material following its release to the atmosphere. These models rely on inputs of meteorological information as well as information about the material released. There are three sources of uncertainty in this modelling process: information about the material released (called the source term); the meteorological inputs; and the parameterisations within the dispersion model.

An awareness of the uncertainties in dispersion modelling has been growing over recent years. The current operational response in the UK involves considering a 'best estimate' and 'reasonable worst case' for an event. Currently, the 'best estimate' and the 'reasonable worse case' only differ in their source term, while meteorological and dispersion model uncertainties are not taken into account. Here we explore how meteorological uncertainties may be included in the operational response.

In meteorology, scientists use an ensemble approach, creating many realisations of the weather forecast in order to provide an estimate of the uncertainty in the forecast. This information can be used to drive dispersion models providing an estimate of the impact of meteorological uncertainty on the uncertainty of the dispersion predictions. However, the response to dispersion emergencies requires a rapid response and computing power has only recently increased sufficiently to enable the running of ensemble dispersion models in real-time.

The UK Met Office is currently working on a project that will make ensemble dispersion model predictions available to specialist forecasters trained to model dispersion and deposition in the event of an accidental release. The work presented here demonstrates some early results achieved by coupling the Met Office dispersion model, NAME, with the Met Office meteorological ensemble system, MOGREPS.

One of the challenges of producing an ensemble dispersion forecast, given the time constraints for decision making, is the presentation of the information in a succinct format. Here we explore some of the methods for presenting information from an ensemble dispersion system.

Uncertainty quantification of Lagrangian dispersion modelling using ECMWF's ERA5 ensemble data within the framework of the ATM Challenge

A Delcloo and P De Meutter

Royal Meteorological Institute of Belgium, Belgium

FLEXPART is a Lagrangian particle dispersion transport model which is originally designed for calculating the long-range and mesoscale dispersion of air pollutants from point sources. Through the years, these type of models have proven their usefulness in an operational context in the framework of protecting the population in case of accidents in a nuclear power plant, but it can also be used for other purposes. In the meantime, FLEXPART has evolved into a more comprehensive tool for atmospheric transport modelling and analysis. The model can also be used in a forward or backward mode, making it possible to trace back the source pollution contribution of a certain pollutant.

To perform the FLEXPART dispersion simulations under consideration, we will use meteorological reanalysis data from the European Centre for Medium Range Forecasts (ECMWF), more specifically the new ERA5 10-member ensemble which is publically available at a 63 km resolution.

Radioxenon concentrations at six locations, located in the southern hemisphere, will be calculated during a one-month time period. Therefore, stack emission data from the medical isotope production facility ANSTO, Australia, will be used for these calculations. State-of-the-art observations of radioxenon which are made available by the International Monitoring System, that has been setup to verify compliance with the Comprehensive Nuclear-Test-Ban Treaty, will be employed.

We will explore how well we can access the model uncertainty in an objective way by taking advantage of the meteorological ensemble.

Web-based decision support system for emergency management – System architecture and enhancement possibilities

Stella Moehrle, Shan Bai, Tim Mueller, Elvira Munz, Dmytro Trybushnyi, Wolfgang Raskob

KIT, Germany

Decision support systems for different crisis events in general follow similar structures: given a scenario defined by outlining attributes, a decision support system should provide help in a comprehensible and easily understandable way. Particularly the beginning of such events are characterized by high uncertainty that should be taken into account in the decision supporting method in a transparent way. Furthermore, each user of such a system may have different perspectives on the event and preferences concerning decision making. Therefore, high flexibility in the usage and possibilities to easily extend the decision supporting backend is of added value as well.

Regarding crisis management, a decision support system is operated in the context of an emergency management group whose members are frequently located in different places. Therefore, such a system has to be accessible from different locations and the input as well as the results should be synchronized and shared with all the members of the group.

This work presents a generic web-based decision support system for emergency management using case-based reasoning as decision supporting backend. The generic system design can be facilitated individually or extended in an easy way. Furthermore, the web-based access would overcome the problem of distributed locations and provides a comfortable way to also exchange already calculated data, greatly simplifying the requirements of software and hardware as only a mobile device with a web browser is needed. Case-based reasoning constitutes the problem-solving paradigm assuming that similar problems have similar solutions and where knowledge from already experienced problem situations is utilized. Given uncertain and highly dynamic situations that require decisions in a limited time frame, case-based reasoning pose a complementary approach to the familiar decision support systems in the nuclear field by using pre-defined scenarios and rough event classifications to identify possible strategies in the first instance for further discussion. The core is a knowledge database that stores historical events, scenarios and further information on management options.

Societal uncertainties during a radiological emergency: A case study of an accidental release of radioactive iodine

Tanja Perko[1], *Pieternelle Lehaen*[2] , *Bieke Abelshausen*[1] *and Catrinel Turcanu*[1]

[1] *Belgian Nuclear Research Centre SCK•CEN, Belgium*

[2] *University Leuven, Belgium*

On August 22nd 2008, radioactive iodine (^{131}I) was accidentally released from Institut des Radioelements (IRE), a facility producing radioisotopes for medical use, located in Fleurus, Belgium. Due to the particularities of the source term , the release went unnoticed for several days. People living in neighbouring areas were informed no sooner than 6 days after the onset of the incident. It was only then that the Belgian authorities activated a nuclear emergency plan, taking protective actions for the population; including restrictions on the use of local farming produce within 5 km of the release point for a period of two weeks. 1320 people have been tested for possible contamination in thyroid. While technical aspects such as thyroid measurements, environmental monitoring or radiological assessments received a great deal of attention ((Carlé, Perko, Turcanu, & Schröder, 2010; Van der Meer et al., 2010) (FANC, 2008)), the concerns, uncertainties and behaviour of the affected population have thus far not been empirically investigated. Furthermore, a social scientific analysis of this incident provides a valuable basis to draw lessons to be learnt in terms of how to address societal issues in the event of such emergencies.

In order to identify societal uncertainties associated with a radiological emergency, this study reviews personal experiences from the radiological accident in Fleurus by examining how communication and public information were managed. The (mixed) methodological approach for this study includes media analysis, document analysis, and a qualitative study based on semi-structured interviews with the population living in the affected area, spokespersons at the time of the emergency, key experts and first responders.(Perko and Abelshausen, 2017).

Preliminary results reveal the complex causal relationships wherein an event or aspect of the radiological incident are both an element of societal uncertainty and the cause for subsequent societal uncertainties. A preliminary framework is developed, which identifies and classifies common denominators as either (or both) a cause of societal uncertainty or an uncertainty as such. Sources of societal uncertainties include, among others, contradictions in communication (e.g. although citizens where advised not to consume self-harvested fruits and vegetables, local farmers were allowed to sell their produce on the market), the delays in prescription of protective actions, or the inappropriate inclusion of stakeholders in communication. Examples of factors that were both intrinsic uncertainties and triggers for additional uncertainties are the thyroid measurements (intrinsic: purpose of monitoring and meaning of results; cause: concern about a potential raise in thyroid cancer), the lack of transparency in the communication about the incident, or the lack of trust in authorities. Other intrinsic uncertainties were for example the ambiguity concerning the causes and

consequences of the incident (impact of human health and environment, financial aspects, consequences resulting from insufficient isotopes for medical and industrial applications), as well as its management, disagreements between political parties, lack of transparency in the communication about the incident, lack of trust in authorities. The analysis of societal uncertainties and the (preliminary) development of an analysis framework allowed for the identification of lessons to be learned and possible improvements in addressing societal uncertainties during a radiological emergency.

Acknowledgement: The study has been conducted in the context of the CONFIDENCE project, which receives funding from the H2020 CONCERT (http://www.concert-h2020.eu/).

Session 2: Novel Approaches to communication & stakeholder engagement

The development of an Emergency Response Management Information System by the Environmental Protection Agency

Robert Ryan, Veronica Smith, Kevin Kelleher, Caroline Donnellan & Ciara McMahon

EPA, Ireland

Ireland has a National Emergency Plan for Nuclear Accidents (NEPNA) that provides a framework for co-ordinating, through a National Emergency Coordination Group (NECG), the national response to a nuclear/radiological emergency. The Environmental Protection Agency (EPA) has been assigned a major role under NEPNA to provide advice on the potential radiological consequences of such an emergency and the protective measures that may be required.

Effective communication between response agencies and the public during a radiation emergency contributes towards the efficient implementation of these protective measures and a reduction in stress/anxiety among the population. Effective communication within the EPA is also important so that the status of the emergency is clearly understood by all staff. Thus, the EPA has developed a web-based Emergency Response Management Information System (ERMIS) to facilitate the efficient sharing of critical information within the EPA during a radiation emergency.

ERMIS has been configured to display the outputs from radiation monitoring in Ireland and Europe, radar maps of rainfall over Ireland, forecasted atmospheric dispersion of radioactive plumes from selected UK nuclear power plants, Duty Officer reports, operation procedures, situation reports, emergency contacts and links to associated websites. While most of this information is automatically generated, the EPA's emergency response stakeholders are responsible for manually uploading situation reports to ERMIS. The information may then be used, as required, to provide communication updates to EPA staff, the NECG, the Government Information Service and/or the public.

Tools and approaches for improved communication in emergency situations

Ludger Benighaus, Christina Benighaus, Ortwin Renn

DIALOGIK, Germany

The authors will present an overview of communication methods to effectively communicate uncertainties in the event of a nuclear accident in the release and post-release phases of an emergency. Specifically, communication should address social concerns that arise in the course of a crisis such as: what exactly is going on? Will I or my close ones be affected? What has to be done now? Is evacuation better than sheltering? How can I report on an unclear situation?

We will distinguish methods that communicate uncertainty:

a) through visualizations (such as traffic light model, uncertainty maps, animation, etc.)
B) through special design of the message construction (certain information in the front, uncertain at the end of a message, framing of uncertainty so that not to confuse)
C) through IT (disaster apps, individually tailored crisis information (for example with GPS system connected)
D) better organization (training of volunteers, inclusion of opinion leaders, fast distribution of crisis messages by various means such as sirens, mobile phones, radio, TV)
E) by role models in crisis communication, emphasis on recruiting ambassadors with high trust potential.

The results are based on a literature analysis and a short questionnaire sent to selected stakeholders and CONFIDENCE partners concerning suitable communication tools.

Mental models of EP&R for improvement of plans

Nadja Zeleznik, EIMV, Slovenia

EIMV, Slovenia

Emergency Preparedness and Response (EP&R) plans are prepared for many radiological threats at different levels: national, regional, local, off-site, on site, for individual organisation, for facilities etc. All these plans are usually prepared by responsible authorities and very rarely developed based on public involvement. As a consequences, they are therefore lacking the appropriate information, not addressing relevant uncertainties and public concerns. As part of the CONFIDENCE project also an investigation on the mental models of understanding, processing & management of uncertainties in EP&R will be performed with the aim to improve communication tools and planning.

The work will assess differences in mental models of uncertainty management in emergency situations for lay citizens and emergency actors in various national contexts. The method will be based on special protocol which will include the main understanding of uncertainties in EP&R and other socio-demographic variables affecting people's behaviour and information needs. The interviews will be performed within approximately 20 different individuals in several countries, tracing the concepts and understandings, but also other important points. These results will be compared with the findings of the interviews with professionals to obtain similarities and differences between the mental models. The analyses performed will be the base for improved communication strategies and tools. The partial available results will be presented at the NERIS Workshop.