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POSTERS

The NERIS Strategic Research Agenda: status and perspectives.

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An integral part of the mission of NERIS is to identify gaps and needs for further research and developments and addressing new and emerging challenges in the field of preparedness for nuclear or radiological emergency response and recovery. The Strategic Research Agenda (SRA) of NERIS, coordinated by the NERIS R&D Committee, identifies these research needs.

The first NERIS SRA was based on the outcome of a brainstorming workshop between 37 experts from 14 European countries, taking as basis the findings and conclusions obtained in the EURANOS, FP7 NERIS-TP and DETECT projects and the first lessons identified from the Fukushima accident. A further refining, based on consultation with different stakeholders and the conclusions from the ICRP workshop organized in Bratislava in February 2012, was made to conclude in the final form of the text, as it was published on the NERIS website in March 2012. The second and current version of the NERIS SRA was launched in April 2014. It is largely based on the first version, maintaining the same grouping of the individual research topics into three areas: 1) new challenges in atmospheric & aquatic modelling – needs for improvement; 2) new challenges for better dose assessments and decision support based on improved knowledge: source term, scenarios, etc. ; 3) new challenges in stakeholder involvement and local preparedness and communication strategies. The tabular structure was simplified to focus on the research goals, adding links to the SRAs of other platforms (ALLIANCE, MELODIE, EURADOS) as well as to finished and running projects (NERIS-TP, PREPARE, …). High priority and priority topics were identified. Also some new research topics were introduced and some topics modified.

Recently, in the framework of the CONCERT project, the SRA, complemented with different consultations, was the basis for the NERIS statements drafted in August 2015 and July 2016 as input for the CONCERT calls.

The NERIS SRA is a living document open for evolution to cope with the main issues at stake for defining the key research challenges in nuclear and radiological emergency response and recovery. In this context, the update of the NERIS SRA was discussed during the last NERIS R&D Committee meeting organized at the beginning of the Radiation Protection week in Oxford in September 2016. The need for an update is mainly driven by challenges such as updating the structure of the SRA taking into account the evolution of priority identification, with an improved and common understanding of the research problems with input and distinction from operational challenges, the need for the development of a NERIS and common Radiation Protection Research roadmap within CONCERT context, as well as further considerations on Social Science and Humanities identified in a specific SRA.

A new possible structure was proposed with 3 or 4 areas identified, which are also used as sessions within this workshop. The status and perspectives related to this update will be discussed.

Crisis Management Yesterday and Now – Societal Changes in Challenges related to Decision-Making and Protective Measures

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The field of crisis management of nuclear or radiological events has developed over many decades. Since the Chernobyl accident in 1986 and the emergence of international conventions and bilateral agreements on early notification, information exchange and assistance, and through experience from several major and minor events in the years after, there has been a continuous work nationally and internationally on developing and updating plans and strategies for crisis management and protective measures.

Decisions are made and protective measures implemented in order to protect lives, health, the environment and other important societal interests. However, public expectations, cultural interests and societal issues needs to be taken into account during the crisis management. Experiences from the Fukushima accident in 2011 and other events the latest years show that current crisis management needs to address a different reality than 10-30 years ago. This paper addresses some of the changes and differences that has been in the last decades.

The new media reality, with continuous news updates with no deadlines, fast and unconfirmed information from sources close to an event site, and extensive use of social media and information channels outside editorial control, place very different demands and challenges on pubic communication and crisis management than the situation ten years ago. There is also an ever increasing number of voices in the public domain, both experts, non-experts and NGOs.

In addition, many more members of the public have more knowledge on technical issues related to the event, they have their own measuring equipment, they publish their own measuring data and make their own assessments of the situation in a much larger degree than earlier.

Roughly put, earlier the authorities assessed a situation, decided on applicable protective measures, informed the public and implemented the decided measures. Now, there is a public demand for more transparency in the assessments and the decision-making process. They want more detailed information in order to assess the situation and take appropriate actions themselves. The public, and affected stakeholders in particular, want to be involved in the decision-making process to a much larger degree than earlier.

Organisations and authorities with responsibilities in crisis management during nuclear or radiological events need to take this new reality into account, in order to plan and make strategies for future events.

An investigation of the effectiveness of sheltering versus evacuation

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This is an international collaboration between PHE (UK) and BfS (Germany) to investigate whether sheltering or evacuation is the consistently better countermeasure option for reducing exposure of the public in the event of an airborne release of radioactive material. The study compared the dose reduction potential of the two countermeasures for the scenario of an accident at a nuclear power plant over a wide range of weather conditions, source term characteristics, evacuation routing and location options.

The collaboration involved two different modelling approaches. Both methodologies are based on consistent input parameters (including the release source term) as much as possible and include a large set of simulations to probabilistically assess the influence of atmospheric dispersion in a wide range of weather conditions. The method used by PHE employed the PACE (Probabilistic Accident Consequence Evaluation) tool to model atmospheric dispersion and dose rates and a subsequent network analysis tool to generate realistic evacuation routes based on real road networks. The BfS approach used the RODOS (Real time On-line DecisiOn Support) tool to model atmospheric dispersion and resultant doses with simplified evacuation routes.

It is clear from the results that the performance of one countermeasure against another is dependent on the circumstances and geographical features around the release. One major factor next to the total magnitude of the release is the impact of the duration of release: for longer releases, evacuation is likely to be a more attractive option. Probability distributions have been created that display the extremes and most common equivalent results from the two countermeasure regimes. Some broad conclusions about the effectiveness of sheltering versus evacuation for a combination of local properties can be made on the basis on these. Significantly, it has been demonstrated that under the circumstances considered in this study neither the evacuation or the sheltering option is consistently the best. Under some circumstances, evacuation results in larger radiological impact and in other circumstances sheltering gives rise to greater impact.

Importantly, consideration is also given to factors affecting the favourability of countermeasures other than reduction of radiological exposure. Some of the risks associated with evacuation – such as road traffic accidents, moving people with special care needs – are not quantified in this assessment but are relevant, potentially increasing the favourability of sheltering as either a stand-alone countermeasure or as a precursor to evacuation.

Further work is planned to investigate a wider range of source term configurations and evacuation routing options, for example allowing routes and evacuation centres to be adapted in the light of more (but still uncertain) information about the plume direction.

A Case Study of the Use of ERMIN in Portugal After a Radiological Emergency Scenario

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The European Model for Inhabited Areas, ERMIN, included in the RODOS Decision Support System, was used as a tool to assist in the development of the appropriate response strategy for an inhabited area, following a radiological emergency event. The current work is focused in the Belém area of Lisbon, where several monuments and recreation and cultural facilities attract numerous people on a daily basis, thus becoming a sensitive spot if an emergency situation should occur. The impact of a malicious act, such as the use of a radiological dispersal device (RDD) in an inhabited area in different weather conditions was the chosen scenario in this study. These results are presented and discussed and include the contamination dispersion maps, the radiation doses estimated for the population as well as some recovery countermeasures strategies to be considered.

Short presentation of topics covered at the latest ARGOS User Group Meetings in Tallinn and Copenhagen

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Since year 2000 the users of the ARGOS DSS has been organised in the ARGOS Consortium. Through the ARGOS Consortium the users has meet on a yearly basis to exchange experiences, research results and lessons learnt as well as to discuss the future development path for the ARGOS DSS.

This short presentation is to give an overview of the topics covered a the last two meetings; in Tallinn in the spring of 2016 and in Copenhagen in the autumn 2016.

In Tallinn the main purpose of the meeting was to perform a joint table top exercise amongst all the participating organizations. All organizations where given the same release scenario for a simulated accident at the Leningrad NPP. Each organization gave a presentation of their SOPs (Standard Operational Procedures), explained about used Intervention Levels and about the end products produced for decision makers as well as to the public.

In Copenhagen in September the focus was on utilizing existing and new functionality in the ARGOS DSS. SSM, Sweden gave a presentation on their approach to assessing revised Emergency Planning Zones for the Swedish NPPs including new options in ARGOS for automated execution of RIMPUFF-model runs. Danish Technical University gave a number of presentations related to RIMPUFF; caused by the retirement of Poul Astrup. PDC-ARGOS presented new functionality in the coming version of ARGOS including completely new developed functionality for incorporating EPZs in the dispersion calculation results – ordered by CNEN, Brazil. Lastly PDC-ARGOS presented their visions for a completely new developed web-based DSS – project name ARGOS X.

On the needs for revision of European countermeasure information for management of contaminated areas

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On the needs for revision of European countermeasure information for management of contaminated areas

In building an operational emergency preparedness it is essential to have developed descriptions of each countermeasure that might be considered for a given type of environment at a given time scale. Important elements of such descriptions include an outline of the method and associated equipment and consumables, its potential scale of use, its dose-reducing and other effects on the environment, feasibility and various potential constraints, and costs (direct and indirect). Countermeasure description compilations in standardised 'datasheet' templates were first developed in the mid-1990's in connection with the European Experimental Collaboration Project No. 4, and extended considerably several times to in 2009 become part of the Euranos project's European handbooks for assisting in the management of contaminated environments in Europe following a radiological emergency.

The 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.

Following up on 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 has been reinvented. This was tried in Denmark for road decontamination already before the Chernobyl accident, but not found to be as effective as the new Japanese findings report. Also a number of other 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, 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.

Further, all present handbook countermeasure descriptions (European and Japanese) are generally focused for cationic radiocaesium contamination. Different type of incidents will give different types of contaminants with different forced removal efficiencies. Examples will be provided of how much this can matter. Also sampling strategy guidelines to ensure in practice under field conditions the optimal effect of implementing a countermeasure are needed in Europe and examples will also be given of the importance of this.

Countermeasures on agricultural areas after the Chernobyl and Fukushima accidents

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Context

Extensive countermeasure actions were conducted on contaminated landscapes after the Chernobyl accident in 1986 and the Fukushima Daiichi accident in 2011. Effectively, for both accidents, ^{131}I, ^{134}Cs and ^{137}Cs were the most important dose-forming radionuclides. Following the accident at the Chernobyl nuclear power plant on 26 April 1986, a vast amount of radioactive materials was released into the atmosphere, contaminating the food and livestock feed of several European countries at significant levels from a health point of view. As a result, this accident significantly impacted the agricultural sector. For instance, about 23 % of Belarus territory (46 thousand km²), populated by 2.2 million people and 1.8 million ha agricultural land were contaminated with ^{137}Cs (37 kBq.m^{-2} was a definition of contaminated land) of which 265 000 ha were totally excluded from the agricultural system [2, 3].

In contrast with Chernobyl, the land around the Fukushima Daiichi power plant is ~70% forest on mountainous catchments with agricultural land confined to the lower slopes and valley floors where there are many paddy fields. And the most contaminated area (29 million Bq/m² to $^{134+137}Cs$) is immediately west of the Fukushima Daiichi nuclear power plant. As a result, 600 km² are exceeding 600 kBq.m^{-2} against 13 000 km² around Chernobyl.

Countermeasures in agriculture areas in Belarus after the Chernobyl accident

In this context, a large program of countermeasures was conducted to protect the human health from radioactive contamination of great magnitude. Environmental countermeasures have been applied since 1986 to urban, forest, aquatic and agricultural ecosystems [1]. These measures have been taken to ensure that agricultural products were only introduced into the European Union market according to common arrangements which safeguard the health of the population while maintaining the market unity. The implementation of agricultural countermeasures after Chernobyl accident has been extensive, both in the most severely affected countries of the former USSR and in Western Europe. In the first weeks after the accident, the main aim of countermeasures application in the USSR was to lower ^{131}I activity concentrations in milk or to prevent contaminated milk from entering the food chain. The measures concerned for example the exclusion of contaminated pastures from the animals diet (changing from pasture to indoor feeding of uncontaminated feed) and the processing of rejected milk (mainly converting milk to storage products such as condensed or dried milk, cheese or butter) [1]. From June 1986, other countermeasures aimed at reducing ^{137}Cs uptake into farm products were implemented. Particularly in the field of agricultural production for the contaminated territories, the radionuclides concentration in the main food products significantly decreased compared to the first years after the Chernobyl disaster. Impressive results were achieved between 1987 and 1990 through the implementation, for farms, of complex agro-technical and agrochemicals measures, zootechnical and veterinary measures designed to reduce the transfer of radionuclides (^{137}Cs and ^{90}Sr) in the chain "soil - plants - animals - agricultural production ".

Application of countermeasures aimed at lowering ^{137}Cs activity concentrations in milk and meat was the key focus of the remediation strategy for intensive agriculture. In 1986-1987, in the public sector the production of milk with a higher than the permissible content of caesium-137 amounted to 524.6 thousand tons. In 2008, in the most severely contaminated Gomel region, only about 90 tons of milk with the content of caesium-137 from 100 to 370 Bq/l was produced and supplied for further processing. The levels of caesium-137 in the milk produced by the farms of the Mogilev region and in the Brest region did not exceed 37 Bq/l and 65 Bq/l respectively (with a permissible level of 100 Bq/l). The main aim of agricultural countermeasures was to achieve a production of food products with radionuclide activity concentrations below action levels and to minimize the total quantity of radionuclide activity in agricultural production for consumption and/or distribution. From 1992 to present days (thirty years after the accident), the use of agrochemicals and agro-technical measures continued despite of financial constraints. For instance, in the Republic of Belarus, recommendations were developed with regard to the agricultural production management for the situation of radioactive contamination of lands, as well as the Republican Permitted Levels for caesium and strontium in food products and drinking water [4], [5]. The system of protective measures applied in the agrarian production is shown in the diagram thereafter and some will be detailed during the presentation (soil treatment, caesium binders, etc.) (cf. Fig. 1).

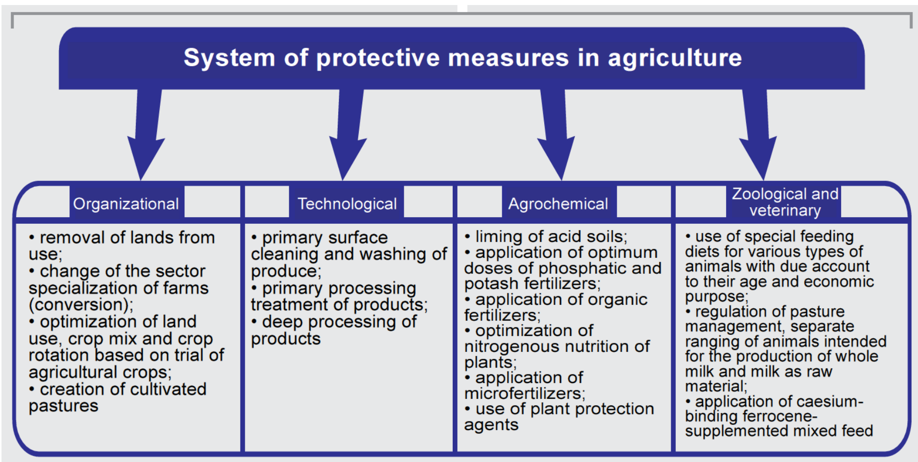

Fig.1: Protective measures System in agriculture in the Republic of Belarus [4]

One of the crucial problems related to agricultural production in the contaminated districts is to limit the entry of radionuclides in food products, to reduce the level of exposure as much as reasonably achievable. Both external and internal exposure pathways were important after Chernobyl accident. The importance of internal exposure pathways, for both agricultural and wild food from forests was highly dependent on the soil type and was often relatively high [7]. This issue can be solved by a set of actions to attenuate the migration of radionuclides in the links of the biological chain "soil to plant" and "plant (forage) to agricultural animals." For example, in Belarus, practice showed that the introduction of protective measures with proven effectiveness and specific processes in the cultivation of plants used to reduce the concentration of radionuclides in production (cereals, potatoes, vegetables) by a factor between 1.5 and 4.0. The introduction of protection measures in livestock (Prussian blue for example) decreases the radionuclides concentration in milk, meat and eggs by a factor of 3 to 7. Moreover, the re-specialization of farms in Belarus towards products minimizing radionuclide concentration is another route to reduce the input of radionuclides in the pathway to human body. These include revenues from the meat and dairy farming, breeding pigs, or the creation of poultry farms. Calculations show that a change in direction of current production (potatoes production, cereals production , dairy) to, preferably, beef, pork and bacon, chicken, fatty dairy products (cream , butter, ghee) would reduce the entry of radionuclides in food products by a factor of 1.5 to 2.0, and proportionally reduce the dose of internal radiation exposure. Currently in all three countries of the former USSR clean feeding remains an important countermeasure to ensure that meat from intensive farms can be marketed. For instance, in the Russian Federation, fertilizers are supplied to intensive farms. For private farms, Prussian blue is provided for privately produced milk and, on request, for privately produced meat intended for market [1]. The effectiveness of the different agricultural countermeasures in use on farms in Belarus is summarized in Table 1. The reduction factors (ratio of radiocaesium activity concentration in the product before and after countermeasure application) achieved by each measure are given.

Table 1: Efficiency of some protective measures in Republic of Belarus [4]

Working method	Efficiency
Combination of the primary and additional cultivation jobs, subsoil tillage (chisel, disk) and minimum cultivation, taking account of the soil type, moistening pattern, application of high-capacity equipment	Reduction of radionuclide accumulation in crops up to 1.3 times
Soil liming	Reduction of radionuclide accumulation in crops by 1.5-3 times
Application of organic fertilizers	Reduction of radionuclide accumulation in crops up to 1.3 times
Application of new forms of slow-acting nitrogen fertilizers	Reduction of radionuclide accumulation up to 1.4 times, nitrates in potatoes, vegetables and feed crops
Application of phosphorus fertilizers	Reduction of Cs-137 accumulation in crops up to 1.5 times, Sr-90 – by 1.2-3.5 times
Application of potash fertilizers	Reduction of Cs-137 accumulation in crops up to 2 times, Sr-90 – up to 1.5 times
Selection of species and varieties of crops with minimum accumulation	Reduction of radionuclide accumulation in crops depending on the plant species up to 30 times, depending on the variety – up to 7 times
Radical improvement of hayfields and pastures	Reduction of radionuclide accumulation in grass stand by 2.5–6 times
Surface improvement of hayfields and pastures	Reduction of radionuclide accumulation in grass stand by 1.5 – 2.9 times
Application of caesium-binding ferrocene-supplemented mixed feed for cattle	Reduction of Cs-137 accumulation in milk and meat by 2-3 times
Special feeding diets for various types of animals with due account to their age and other factors	Reduction of Cs-137 accumulation in milk and meat by 1.5 – 2.5 times

Countermeasures in agriculture areas in Japan after the Fukushima accident

After the Fukushima Daiichi accident, Japan faced a large caesium contamination of its land and countermeasures were also taken on agricultural productions. First, the experience gained during the response to the Chernobyl contamination was used as a start, and then specificity of Japanese crops (e.g. rice and soja) and soil was taken into account to adapt the countermeasures. The objectives were the same: to reduce radiation doses from the environment that have resulted from the accident. Food with radiocaesium activity concentration that exceeds the action level is not allowed to enter the food distribution system. Compliance with the action levels for food is demonstrated by an extensive and comprehensive food monitoring program for foods produced in contaminated areas. The low action levels applied in Japan led to extensive restrictions on the use of agricultural land, especially in 2012. To produce food below the action levels, it has necessary to remediate some agricultural land [6], [7]. After the Fukushima Daiichi accident, contaminated land was divided into the Special Decontamination Area (SDA), which was evacuated and divided into three subareas and the Intensive Contamination Survey Area (ICSA) where the additional annual effective dose is projected to be higher than 1 mSv. Also, the main types of remediation applied to farmland, applicable to both SDA and ICSA, depend on the radiocaesium activity concentration (Table 2). Remediation measures for each area of farmland are selected on a case by case basis, taking into account the farmer's opinion. For example, some fruit trees were decontaminated by high pressure washing and whittling (paring shavings from wood) of tree surfaces to remove a major part of radiocaesium. For other cases as the persimmon trees in Date, the choice was not to decontaminate the trees but to remove the upper layer of the land and to support financially the loss of one production year.

In the ICSA, the first decontamination action consisted in removing the topsoil by stripping, which conducted to reduce the dose rate, but has generated a large amount of waste and impoverished the soil. Alternative measures have been then applied to benefit natural caesium sorption in clay and its low transfer to crops (improved by addition of fertilizer and potassium in the soil). To ensure that ^{134}Cs and ^{137}Cs in soil used for agricultural production are not artificially enhanced by the addition of fertilizers, an action level of 400 Bq/kg has been applied for fertilizers, soil conditioners and compost used to grow seedlings. Sewage sludge from water treatment facility in the Fukushima prefecture is now radiologically controlled and contamination thresholds for using them as fertilizer, lower than 400 Bq/kg, are discussion topics between agricultural producers, municipality and population. Moreover, ploughing the soil proved to be as efficient to reduce the dose rate and the volume of waste as removal. This approach has allowed conserving the nutrients in the soil and reducing the amount of contaminated soil that should have been treated as radioactive waste [6]. Soil removal was yet considered when caesium activity concentration was high (cf. Table 2).

The ploughing of many kitchen gardens and orchards soon after the accident contributed to a reduction in the levels of radiocaesium in soils (through the dilution of the upper contaminated layers with deeper uncontaminated soil layers) [6]. Residents of contaminated areas can bring locally produced food from their kitchen gardens, freshwater systems or forests to local measuring facilities.

Table 2: Applicability of remediation measures to reduce both internal and external dose from utilization of farmland in Japan [6]

Applicable techniques	Radiocaesium activity concentration in soil (Bq/kg dry weight)			
	<5 000	5 000-10 000	10 000-25 000	>25 000
Cultivation with reduced transfer of ^{134}Cs and ^{137}Cs using potassium, fertilizer	x			
Reversal tillage (fields, rice paddies, grassland)	x	x		
Soil suspension in waste and/removal with extracted water (rice paddies)		x		
Topsoil removal (fields, rice paddies, grassland)		x	x	
Soil removal using a solidification agent		x	x	x
Weed/grass/pasture removal		x	x	x

After the Fukushima accident, the restrictions on food production and food monitoring, combined with generally lower soil to plant uptake, meant that external exposure pathways were more important. Moreover, overall, the comprehensive implementation of food restrictions and monitoring has protected people and improved confidence in farm produce, as reflected to varying extents by the improving market price of some crops. For instance, numerical criteria are used for the management of agricultural sectors (use of criteria lower than the permissible levels because taking into account all the upstream of the agricultural sector including waste used as fertilizer).

Conclusions

Finally, the remedial measures used after each accident for agricultural areas are compared below in Table 3. After the Chernobyl accident, the countermeasures essentially concerned measures for animal products. Radical improvement of agricultural land by combining ploughing, reseeding and additional fertilization was extensively used in the first 5 y and was very effective in improving the fertility of the land and reducing radiocaesium uptake onto fodder and other crops [7]. The countermeasures applied in the agriculture of Belarus proved to be highly efficient. The ^{137}Cs activity into food chain has decreased by factor of 20-22, ^{90}Sr – by a factor of 4. The contamination of all foodstuff and raw materials produced in state and cooperative farms are with radionuclide content below permissible level established in 1999 [5]. After the Fukushima accident, the development of countermeasures was focused on crops and particularly paddy fields where additional exchangeable potassium has often been widely applied.

Furthermore, rehabilitation programs need to consider not only radiological protection but also social and economic dimensions. The involvement of rural inhabitants in processes of self-rehabilitation and self-development could be a way to improve the people quality of life on radioactive contaminated territory as a common heritage. It is important that the objective of involving the stakeholders is not to promote the acceptability of the accident but to build trust and understanding between them. All those who were involved expressed that preparedness for managing contaminated goods is crucial to be ready, in order to react promptly if an accident would occur. Especially, long-term perspectives have to be considered while implementing the countermeasure actions (including restrictions over consumption and production, food quality control and redeployment of agricultural activities). Feedback provided by Japanese experts and stakeholders engaged in the follow-up of the Fukushima accident is of upmost importance and these lessons must provide us with reflection to improve our national emergency and post-accidental response.

Table 3: Comparison of agricultural countermeasures [1], [5], [6], [7]

Applicable techniques	**Chernobyl**	**Fukushima**
Countermeasures for animal products		
Clean feeding	X	X
AFCF to animals	X	
Live monitoring of domestic animals	X	
Countermeasures in agricultural land		
Radical improvement – ploughing, reseeding, additional fertilization	X	
Soil removal		X
Tillage reversal		X
Soil treatment with additional K and P	X	X
Soil amendement with liming	X	
Application of sorbents and organic fertilisers	X	
Drainage of wet peats	X	
Paddy fields puddling and removal of suspended sediment		X
Removal of plants		X
Soil hardening and removal		X

The presentation focuses both on Chernobyl and Fukushima response to the food and agricultural products contamination.

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Countermeasures in agriculture in emergency and long-term phases of the accident at the Chernobyl nuclear power plant. Experience of Belarus.

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Following a short-term period after the accident (3–5 days) when the most significant contribution to radiation doses is associated with external exposure and inhalation of radioactive aerosols, the dominant exposure pathway for the residents of rural areas and agricultural workers becomes via the food chain. In the longer terms after the accident, in case of the presence of ^{137}Cs and ^{90}Sr long-lived radionuclides, actinides and transuranium elements in the released substances, the contribution of internal exposure becomes even more significant.

In case there is no necessity in emergency evacuation of population, protective measures in the affected area may involve temporary restrictions on consumption of specific types of contaminated agricultural products, and in the following period – implementation of local measures designed to ensure safe food production suitable for consumption purposes.

The levels of contamination in foods and agricultural raw materials are derived based on the emergency annual dose limits of internal exposure to population. To provide an overall and rapid estimate of contamination in agricultural products, the standards are calculated to represent radionuclide content in a kilogram or a litre of a product, with reference to their validity period. Such standards are calculated, in the first place, for rural residents whose dominant part of total consumed foods originates from their private backyards (critical group of population). On the other hand, agricultural produce from contaminated areas will constitute a lesser danger to other groups of population (e.g. urban residents). This can be associated with reduction of its contamination levels due to radioactive decay in the process of procurement, storage or processing, or due to mixing it with products that are clean from radionuclide contamination.

The main task of this period is to determine contamination levels of the areas from long-lived radionuclides that will be safe for the longtime residence without any restrictions for agricultural production, or subject to implementation of specific protective measures.

Countermeasures can be implemented at different production stages and in different key segments of radionuclide transfer in ‘soil–plant’, ‘feed–animal’, or ‘raw material–end product’ chains.

Contribution of cow’s milk, being the most critical food product in terms of 137Cs contamination, into internal doses of radiation received by population can reach 40–80 %. In order to reduce internal exposures to population, it is necessary to apply countermeasures that reduce transfer of radionuclides into animal fodders. One of the most popular protective measures in Belarus agriculture in the first months after the accident was feeding cattle ‘clean’ forages at the final fattening stage. Due to this countermeasure, production of contaminated meat was acutely and rapidly reduced to insignificant figures.

Replacing contaminated milk in the human diet with its derivates is an effective protective measure to reach more than 10 times reduction of radionuclide intake into human body. 8–10 times reduction of 137Cs and 90Sr concentrations in the end products can be reached through processing whole milk into butter and rennet cheese. Whole-milk processing for cream, sour cream and cottage cheese leads to 4–6 times reduction.

The most affective in dose reduction are countermeasures implemented on pastures and grasslands that are used for meat and milk production purposes (e.g. core improvement of natural grasslands, renovation of cultivated pastures). Disc harrowing and tillage of grasslands on mineral soils together with application of mineral fertilizers leads to 3–5 times reduction of 137Cs and 90Sr uptake by grasses.

Core improvement of cultivated meadows also reduces 137Cs transfer grasses, but this approach is less effective in relation to 90Sr. With the course of time however, increased concentration levels of radionuclides in forage and hay may occur due to degradation of cultivated grass stands.

Therefore, it is important to ensure renovation of forage lands every 3–6 years, depending on the type of grassland and soil characteristics. At the first stage (i.e. during 1986–1990), half-life periods (T1/2) of 137Cs transfer to field crops were between several months and 1.5 years (T1/2 1.0–1.8 years for grain crops and 0.8–1.2 years for potatoes). During the second stage (1991–1998), T1/2 was from 5 to 13 years.

Application of agricultural countermeasures in the first years after the Chernobyl disaster (1986–1992) had resulted in 3–8 times reduction of ^{137}Cs transfer to crop yields. In the following years after the accident (1992–2010), contribution of natural processes (cesium fixation by clay minerals and radioactive decay) prevailed over the effect of cesium-reducing countermeasures which dropped down to the average of 50–80 %.

In some cases it appears very hard or even impossible to implement core improvement of pastures. This is where special drugs are introduced into animal diets to prevent absorption of radioactive cesium in gastrointestinal tract and therefore its transfer to meat and milk products and further into the human body. The most widely known and used are such cesium-binding sorbents as Prussian blue, ferrocynes, Giese salt, Nigrovitch salt. Introduction of these drugs has been proved reliable countermeasures with sustainable effect, resulting in 2–5 times reduction of 137Cs concentrations in milk and muscle tissues of dairy and beef cattle.

In cases when contaminated lands make it impossible to produce crops in compliance with the established standards, or when consumption of animal products contributes to high doses of internal radiation of population, an effective countermeasure would be to change the production purposes of a farm enterprise. For instance, a collective dose due to strontium and cesium contribution would be 28 times less, when contaminated feeds are used for the purposes of meat production instead of dairy purposes. Thus, by changing the purpose of the usage of grown farm crops it is possible to lower the levels of exposure to population by 20–30 times.

Session 2 – Challenges in radiological impact assessments during all phases of nuclear/radiological events

Radiological impact assessment as basis for a review of protection strategies in Germany

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The implementation of the EU Basic Safety Standards triggered a new radiological impact assessment for nuclear and radiological events in Germany. Nine different categories of events were considered in this assessment, including e.g. domestic NPP accidents, NPP accidents in foreign countries, accidents in nuclear facilities, transport accidents, terroristic acts involving radioactive substances, satellite crashes. The radiological impact was assessed for a set of exemplary radioactive releases in each category, taking into account of several thousands of realistic weather scenarios in total. The decision support system RODOS was used for the assessment. The impact was assessed in terms of e.g. radionuclide contamination of the environment, exposure of the public, affected areas and persons. Furthermore, the response of various radiological monitoring systems (e.g. the gamma dose rate monitoring network) was investigated. The results of the assessment finally allowed for a review of protection strategies for nuclear and radiological events in Germany.

Rapid prediction of haematological acute radiation syndrome in radiation injury patients using peripheral blood cell counts

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Rapid clinical triage of radiation injury patients is essential to determine appropriate diagnostic and therapeutic interventions. We examined the utility of blood cell counts (BCC) in the first three days after irradiation to predict clinical outcome, specifically haematological acute radiation syndrome (HARS).

Material and Methods
For the test sample we analyzed BCC from radiation accident victims (N = 135) along with their clinical outcome HARS severity scores H1-4 using the database SEARCH (System for Evaluation and Archiving of Radiation Accidents based on Case Histories). Data from unirradiated individuals (H0, N=132) were collected from an out-patient facility. We created binary categories of (1) H0 versus H1-4, (2) H0-1 versus H2-4 and (3) H0-2 versus H3-4 severity scores to assess the discrimination ability of BCC using unconditional logistic regression analysis. The test sample contained 454 BCC from 267 individuals. We validated the discrimination ability on a second independent group comprising 275 BCC from 252 individuals originating from SEARCH (HARS 1-4), an outpatient facility (H0) and hospitals (e.g. leukemia patients, H4).

Results
Those individuals with H0 score were easily separated from exposed persons based on developing lymphopenia and granulocytosis. The separation of H0 and H1-4 became more prominent with increasing hematological severity scores and time. On the first day, lymphocyte counts were most predictive for discriminating binary categories followed by granulocytes and thrombocytes. For days 2 and 3, an almost complete separation was achieved when combining BCC from different days, supporting the measurement of sequential BCC. We found an almost complete discrimination of HO versus radiation exposed individuals during model validation (negative predictive value, NPV >94%) for all three days while the categorization correct prediction of radiation exposed individuals increased from day 1 (positive predictive value, PPV 78-89%) to day 3 (PPV > 90%). The models were unable to provide predictions for 10.9% of the test samples, because the PPVs or NPVs did not reach a 95% likelihood defined as the lower limit for a prediction. We developed a prediction model spreadsheet to provide early and fast diagnostic predictions and therapeutic recommendations.

Conclusion
Clinical outcome of radiation injury patients can be rapidly predicted within the first 3 days after radiation exposure using peripheral BCC.

Region-specific parameterisation of spanish mediterranean areas to reduce the uncertainties in the management of the long-term rehabilitation

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Introduction

The prediction of food contamination and doses to humans in existing exposure situations, after a nuclear accident, is a key element in the implementation and management of the long-term rehabilitation process. The assessment relies on the ability of the modelling to predict the time dependence of the transfer processes, namely food chain pathway, but also on the availability of reliable parameters. This issue has a significant influence on reducing the uncertainties of the estimated doses and the response of the potential recovery strategies to be applied, as the use of region-specific parameters implies a more realistic assessment of the radiological impact.

The European Decision Support System JRODOS, integrates for this assessment, the Terrestrial Food Chain and Dose Module (FDMT), where the region-specific parameters are covered by Central European values, as default values, being not sufficiently representative of other European regions. Such may be the case of the Mediterranean area, were the parameterisation of the information needed to represent its agricultural and grazing practises is restricted to the constraints imposed by default.

In the European R&D framework some initiatives have been undertaken to improve the food chain modelling and the parameterisation of region-specific values. Within the COMET project (Coordination and Implementation of a pan-Europe Instrument for Radioecology), in particular under the task: Initial Research Activity on Human Food Chain Modelling, an exercise to study the effect of regional parameters (Mediterranean and Nordic regions) on the food chain modelling has been developed.
For this purpose, it has been necessary to derive updated food chain parameter values appropriate for Mediterranean and Nordic terrestrial ecosystems, and apply them in a defined scenario, allowing the comparison of the results obtained in terms of activity concentrations in selected foodstuffs and intake doses for different age groups, to the results obtained from the default parameters.

This paper summarizes the case study for the Spanish Mediterranean region using FDMT-JRODOS.

Mediterranean parameterisation

The selected region-specific parameterisation has been focussed in the following: foodstuff consumption rates, sowing and harvesting periods, leaf area indices, crop yields, feedstuffs and the animal feeding regimes. Where possible, all the information needed has been collected from National statistics, however, assumptions have been necessary in order to adapt the information to the parameters considered and to meet the requirements of the database structure of JRODOS.

Food Consumption rates

The Spanish parameter values on food consumption rates have been obtained from the National Food Survey ENALIA [1], in an individual basis, carried out by the Spanish Food Safety and Nutrition Agency (AECOSAN). It has been conducted according to a harmonized and agreed approach in Europe, provided by the European Food Safety Agency (EFSA) [2]. The parameter values and databases have therefore a common structure along the European countries, facilitating comparison purposes.

Five age groups are included in ENALIA: 3-11 months, 1-3 years, 4-9 years, 10-18 years and adults. These, are very similar to the age groups considered in JRODOS, and in spite of the slight differences in the age range of children, they have been assumed as representative of them. Regarding the foodstuffs, the selection considered for JRODOS has been kept, although some of the products are not so important in the whole of the Mediterranean diet, while others which are basic components of it, are missing. In order to match both, several assumptions have been necessary, including different grouping and equivalences [3].

Parameters related to the sowing, harvest, growing periods and crop yields

The National crop calendar [4] has been the source for the sowing, harvesting and mean growing period dates of crops, as indicated in the JRODOS database. The data are given at province and National levels, being these used to obtain the most representative values, for each crop, with the following assumptions:

- The sowing date (D_S), in Julian days, is set the first day of the month with the maximum percentage of seeded surface.
- The date of harvest (D_H) in Julian days is set the last day of the month with the maximum harvested production.
- The mean growing period (MPG), comprises, in days, the D_S and the D_H.

The leaf area development, described as the Leaf Area Index (LAI), is a function of the plant´s growing period. The reference used to estimate the data for the Spanish crops is the plant growth database of the SWAT model [5]. It has been assumed that the growing period is divided into four growing stages, as seen in Figure 1, where,

1. Initial stage (L_{ini}): covers from D_S until the crop covers about 10% of the ground.
2. Crop development stage (L_{dev}): covers from the end of L_{ini} until the crop covers 70-80% of the ground; (not necessarily is the crop at its maximum height).
3. The mid-season stage (L_{mid}): covers from the end of L_{dev} until maturity; it includes flowering and grain-setting.
4. The late season stage (L_{lat}): from the end of L_{mid} until D_H, it includes ripening.

The duration (as fraction of the total growing season) of the various growing stages for the Mediterranean crops of concern, have been extracted from values compiled in the report FAO 56 [6]. Applying these to the values of MPG of the Spanish crops and beginning from the D_S, the dates D_{dev}, D_{mid}, D_{lat} are established. The respective LAI values are calculated for these dates, intermediate point of the sigmoid part of the curve (crop development stage) and intermediate point of the descending straight line (last season stage).

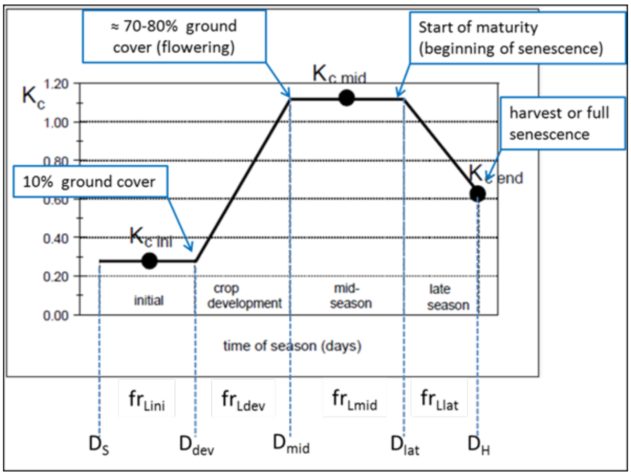

Figure 1. Typical curve of the temporal evolution of crop growing (in this case, represented by the Crop coefficient Kc).

The Spanish crop yield values have been taken from the National agricultural statistics [7], in terms of mean values (kg m^{-2}) per crop type, on dry and irrigated surfaces, at province and National levels. Several assumptions have been made to adapt this information to the JRODOS database, among them the grouping of some crops and in other cases the crop taken as reference [3].

Feedstuffs and animal feeding regime

Feed resources for animals are set out in the National agricultural statistics under the headings of forage crops, grassland and grazed forest and shrub land [7]. Two feeding regimes are distinguished, extensive, outdoor, with a diet based on natural pastures and intensive, indoor with a diet based on fodder and forage crops. For the Mediterranean parameterisation, it has been assumed that extensive systems are the feeding basis of the livestock for meat, including beef cattle, pork, lamb and goat while the intensive ones are mainly to production of cow's milk. The feeding diets, as daily intake rate throughout the year, have been estimated taking into account the nutritional needs of an animal-type, under each specific feeding regime, the distribution of the forage and grass production along the year and the stocking capacity of the grazing areas [8, 9, 10]

JRODOS Results

To study the effect of the region-specific parameters, two scenarios were specified within the COMET project: a dry and a wet deposition scenario, the latter with a specified amount of rainfall. For both, the deposition date was set to 1^{st} of August. Four radionuclides were selected: ^{134}Cs, ^{137}Cs, ^{90}Sr and ^{131}I with a deposit value of, 1000 Bq m^{-2} each. The model used in the Spanish case study is the FDMT included in JRODOS. The calculations have been performed with the JRODOS July 2014 Update 3 version.

The results obtained in terms of activity concentrations in selected foodstuffs and feedstuffs (cow milk, beef cow, leafy vegetables, winter wheat, flour wheat, pork, grass intensive, hay intensive and grass extensive), as well as intake doses for different age groups, have been compared to the results obtained from the default parameters.

The results obtained show clearly that the highest values occur in dry scenarios, both Default and Mediterranean, rather than in wet scenarios. The magnitude and temporal development of the activity concentrations in these foodstuffs, are clearly season dependant. During the selected deposition date, the winter cereals in the Mediterranean areas are already harvested, so the activity concentrations of winter wheat and flour wheat, in the following years, come from the root absorption of the radionuclides deposited on the bare soil and are several orders of magnitude lower. Figure 2 shows the winter wheat as example.

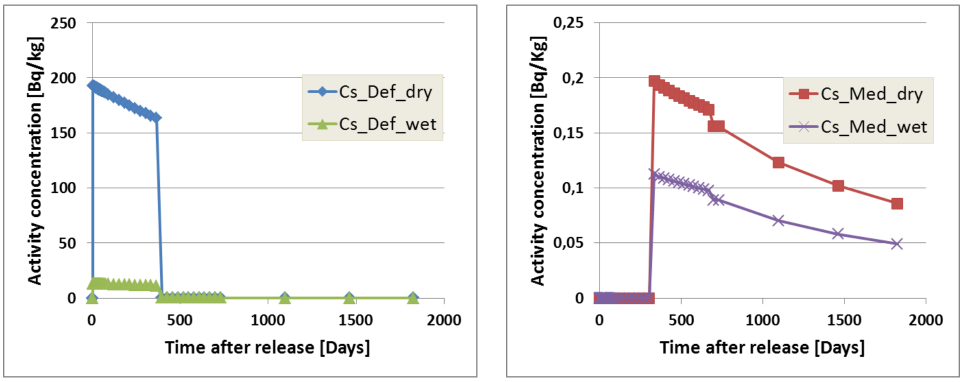

Figure 2. Activity concentration over time of cesium isotopes in Winter Wheat for the scenarios “Default” (left) and “Mediterranean” (right).

This seasonality will also affect the activity concentrations of the animal products due to the time schedule of the animal diet (grazing periods and feedstuffs ingestion). Figure 3, compares the evolution of the activity concentrations of cesium isotopes in Cow milk and Beef cow.

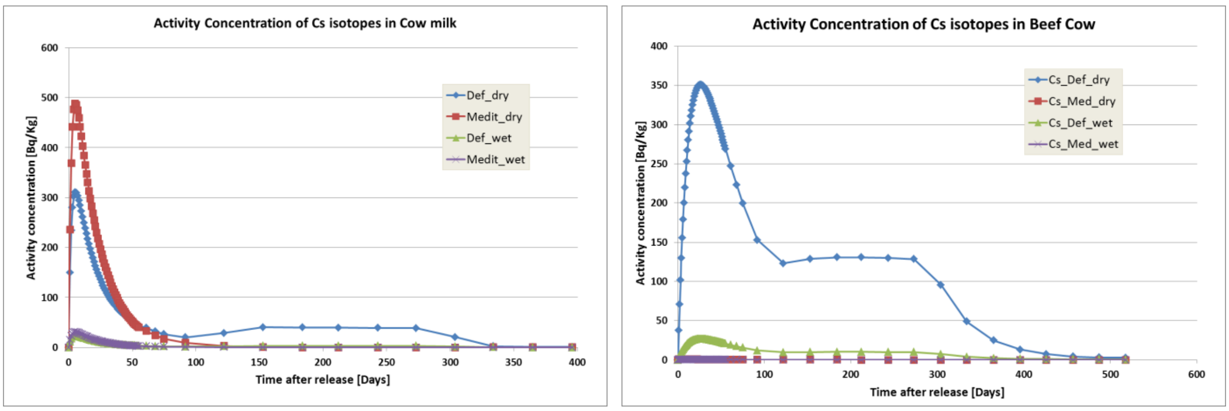

Figure 3. Activity concentration over time of cesium isotopes in Cow milk and Beef cow for the scenarios “Default” and “Mediterranean”.

The ranking of activity concentrations from the highest to the lowest values, among the different scenarios show the following trend:

- **Dry default > Dry Mediterranean >Wet default > Wet Mediterranean**, for the Leafy vegetables and Hay intensive products.
- **Dry Mediterranean > Dry default > Wet Mediterranean >Wet default**, for the intensive and extensive Grass, as well as Pork and Cow milk.
- **Dry default > Wet default > Dry Mediterranean > Wet Mediterranean**, for the Beef cow and Winter wheat products.

The values of the intake doses from Mediterranean scenarios are lower than the respective values from Default scenarios, for the three groups of isotopes studied (cesium, iodine and strontium isotopes). Only the values for cow milk are in the same range of magnitude; in the case of leafy vegetables, pork and winter wheat the doses are between one and two orders of magnitude lower (except for the iodine isotopes, than result irrelevant in the Mediterranean scenarios); in the case of beef cow and wheat flour the values are reduced in 3-4 orders of magnitude.

Regarding the contribution of the different foodstuffs to the intake dose, in each age group, the Default scenario shows, for the age group of 1 year, that the Cow milk is the product that contributes most to the doses, for the three radionuclides considered. For the age group above 10 years the doses come mostly from the ingestion of leafy vegetables, followed by the cow milk and the wheat flour. In the Mediterranean scenarios, the cow milk ingestion, in every age group, is the product that contributes most to the doses, followed by the leafy vegetables. In this scenario, there is a small contribution of Cs and I, due to pork and beef ingestion. Figure 4 shows the contribution of the most relevant products to the effective dose, five years after the accidental release.

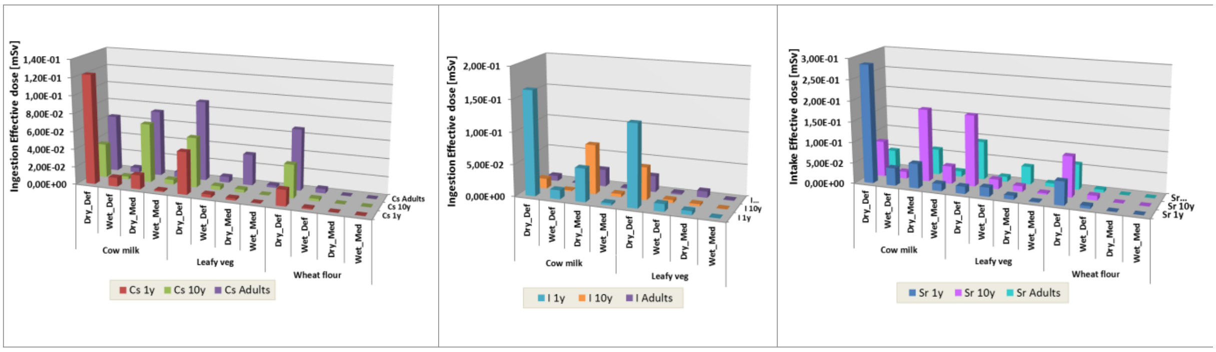

Figure 4. Contribution to the effective dose by ingestion, five years after of the accidental release, of the most relevant foodstuffs according to the isotopes group and age group. From left to right, the graphs show cesium, iodine and strontium isotopes, respectively.

Conclusions

In relation to the parameterisation, some difficulties have been encountered, related to both the structure and the parameters considered in the JRODOS databases. The structure, as it is right now, is not flexible enough preventing the incorporation of new foodstuffs and hindering the modification of some of the parameters considered. These have been solved in the best possible way, through various assumptions and guesses. However a more accurate parameterisation would need a new and more flexible structure of the database.

Regarding the execution of the case-study, several problems associated to the JRODOS system have been encountered. Among them, the module DEPOMPP (which should facilitate the input of the deposition values directly to the system) failed. For this reason, in order to fix the deposition values of the radionuclides selected an interpolation from a release scenario was needed. The availability of this module is foreseen as very useful in the long term management of contaminated areas, where the starting point of the assessment are the ground deposition values.

The results in terms of activity concentrations in the selected foodstuffs and feedstuffs show higher values in dry scenarios for both set of parameters, Mediterranean and default. In general, the results show important differences between the Mediterranean and the Central European (default) regions. The seasonality, in terms of deposition date versus growing period of the crops, is a key factor to determine the intake doses over time and consequently remediation strategies to be applied.

The values of the intake doses from Mediterranean scenarios are lower, for the three groups of radionuclides considered, than from the default scenarios; only the intake of cow milk give the same range of doses. These results are directly affected by the food consumption rates, therefore influencing the radiological impact on the population.

This case study has shown that if a realistic assessment of the radiological impact and an effective and optimum recovery strategy are pursued, it is necessary to use region-specific parameters.

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Towards Inverse Source Term Estimation using Big Data Technologies

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In the field of atmospheric dispersion modelling and its application for supporting decision making during events of atmospheric releases of hazardous substances (including radioactive), "inverse source term estimation (STE)" and "source inversion" refer to computational methods aiming at estimating the location and / or the emitted quantities of the hazardous material using both observations (measurements) and results of dispersion models. Such methods are typically used when the presence of a hazardous substance above the background levels in the air is detected by an existing monitoring network, while its origin is unknown. The most characteristic example of a real case involving radioactive substances that have been detected before the release was officially announced is the Chernobyl Nuclear Power Plant accident. The Algeciras incident is another example of an unknown radioactive release that was traced back after radioactivity levels higher than the background have been observed at very long distances from the release location.

Most commonly, inverse STE methods employ a (potentially large) number of forward or backward, in time, runs of dispersion models for the specific meteorological conditions that prevail at the times when the observations were made. Forward in time dispersion calculations can be made using as sources the potential (suspected) release locations, if these are fewer than the monitoring points where measurements exist. Backward in time dispersion calculations can be made by using the monitoring locations as sources and inversing the meteorological fields of wind velocity, if the monitoring locations are fewer than the potential release locations. The results of forward or backward dispersion calculations are then compared with the existing measurements through objective cost functions (that also include uncertainties of computations and measurements) used to identify the most probable release location.

If the meteorological conditions are highly variable in time and space and the terrain is complex, the use of advanced dispersion models is necessary and therefore inverse STE can be very time-consuming, which is a drawback in the frame of emergency response. In this and in a complementary paper (I.A. Klampanos et al., "A Big Data Architecture for Learning-Based Source Term Estimation"), we present and evaluate an inverse STE methodology in which the bulk of computations by advanced meteorological and dispersion models is made before an actual emergency. The modelling results are stored and, in cases of emergency due to detection of hazardous substances in the atmosphere, they are retrieved and, combined with current measurements, they provide estimation of the potential source location. In this respect, the aid of Big Data software technologies is necessary.

The particular use case presented here, concerns release and dispersion of radioactive substances due to a hypothetical accident in a nuclear power plant (NPP) located in Europe. The restriction of potential sources to NPPs is only made here to reduce the computational times in order to evaluate the method. The method can be directly extended to take into account any location of potential sources within the considered computational domain, in this case Europe. Re-analysis weather data covering a period of 30 years are downloaded, with a time resolution of 6 hours and spatial resolution of 0.7 degrees. We made use of NCAR serviceshttp://rda.ucar.edu/datasets/ds627.0/, using data originating from ECMWFhttp://www.ecmwf.int/en/research/climate-reanalysis/era-interim. From these data a number of typical atmospheric circulation patterns are extracted aiming to represent almost all weather conditions observed so far over Europe. For each of these typical weather patterns, dynamical downscaling is carried out using WRF modelling system to a finer temporal and spatial resolution. Using the finer resolution meteorological data, dispersion calculations are performed with the model DIPCOT, taking as source locations all the NPPs considered in the frame of this evaluation study. In a real case of detected radiation levels above background, due to an unknown source, the actual weather is matched to one (or more) of the typical weather patterns. The corresponding pre-calculated dispersion results of the matched weather pattern are retrieved. The model-predicted dose rates at the locations of the sensors that detected the radioactive substance are compared with the measurements in order to identify the most probable source location.

European nuclear Risk Mapping by Kernel Density Estimation applied to air mass trajectories

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Currently, based on the information provided by the International Atomic Energy Agency (IAEA), 168 nuclear reactors are in operation in Europe. As a consequence of the Fukushima accident, countries have reviewed and improved their Emergency Preparedness and Response (EP&R) arrangements and capabilities and many are implementing improvements in the policies that may affect the management of a future nuclear release accident.
One of the issues that have received particular attention concerns the estimation of the spatial impact probability of a NPP release. A well prepared nuclear risk map facilitates to evaluate nuclear problems and make decisions on solution methods. Inherent to the nature of this type of incident, one of the key factors in the elaboration of these maps is the meteorological conditions. Within the set of meteorological parameters that influence the radioactive plume dispersion, the analysis of the wind field in each NPP provides useful information about the displacement of the plume in the first stage of the emergency situation for the decision makers to face and mitigate the impact of the release, without taking into account the amount and the properties of the release material (source term).
The purpose of the present work is to estimate the probability of an area to be affected following a hypothetical release from each EU NPP by the analysis of the wind dynamic in each one.

One of the main tools to describe the wind dynamic in a specific area is the calculation of forward trajectories, which represent, by a sequence of points (latitude/longitude), the path followed by the air parcel with time from a starting location. Considering this, the methodology used in this work is the elaboration of a density map for each EU NPP based on the collection of trajectory points for each NPP, obtained by calculating four trajectories per day with a temporal coverage of 96 hours during the period 2011-2015 (701184 total number of trajectory points = 7304 trajectories*96 points). Among the techniques to convert data from point to continuous fields and therefore to make more readable this information, the nonparametric kernel density estimation (KDE) method has been used in this work.

Figure 1 displays the density maps of three NPPs in Europe, such as Almaraz in Spain, Paks in Hungary and Heysham in the United Kingdom during 2011-2015. More than the logical maximum number of hits reached in the surroundings of each NPP, as it was expected, the spatial coverage and the distribution of the affected areas are quite different for each NPP: this is associated

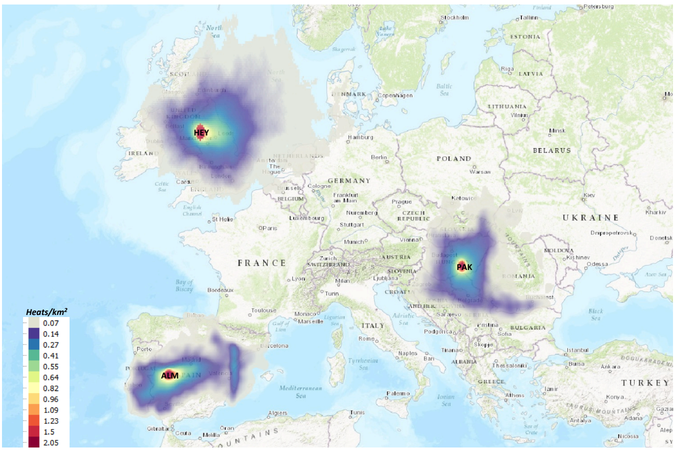

Figure 1. Example of heat map in three EU NPP

with the combination of different meteorological conditions and geographical conditions.
This analysis and related results may provide useful statistical information for the civil protection authorities in planning the actions to be taken, and more than this, it may constitute a strategic operational advantage to develop a proper system in which the necessary actions can be taken according to their spatial and temporal priorities inside the high risk zones. In addition, the combination of the risk maps would allow for the identification of the most affected areas in Europe.

UPCAST – Unified Platform for CBRN Accident/Attack Scenario Management

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UPCAST's (Unified Platform for CBRN Accident/Attack Scenario Management) main objective is to improve information management and situational awareness in the response to contamination and exposure events to chemical, biological, radiological and nuclear (CBRN) agents. UPCAST is co-financed by PT2020, the Portuguese national framework programme.
UPCAST proposes the development of a unified platform that can gather, process and distribute all the available information during an incident involving CBRN agents in order to obtain a more effective and efficient response. UPCAST will give operational forces the means to easily upload observed data regarding victims' conditions and receive instructions on how to proceed.

The information platform will be divided in seven modules, encompassing the whole event management process, as shown in figure 2. This paper will discuss the requirements definition process and will present the UPCAST platform architecture. User requirements (130) have been gathered for these modules taking into account feedback from Portuguese end users, such as first responders, civil protection authorities, law enforcement agencies and multiple national entities. The Portuguese directive for an integrated response in CBRN events [1] was used as the basis for the definition of interfaces between stakeholders and for the definition of information which is vital for an efficient response.

The UPCAST platform consists of a mobile application, for first responders, law enforcement agents, medics and CBRN specialised personnel, and a desktop application for command and control centres, 112 services, reference laboratories and other agencies. Multiple user types are defined, together with communication flows. These interfaces will enable not only information collection and description of the CBRN scenario but also data processing, including validation of obtained results, meteorological and plume dispersion prediction, work force and asset management, and event tracing.

Technical requirements were defined leading to a detailed list of 80 items that satisfy all user requirements to be considered for architecture specification. Additional information was gathered to define the specific data fields to be included in the interfaces, such as triage and sampling processes to be followed and integrated in the mobile interfaces.

UPCAST will enable rapid access to complete and valid information, paving the way for an adequate response and situation management to mitigate CBRN events' impacts on the population and environment.

Fig. 1: UPCAST logo

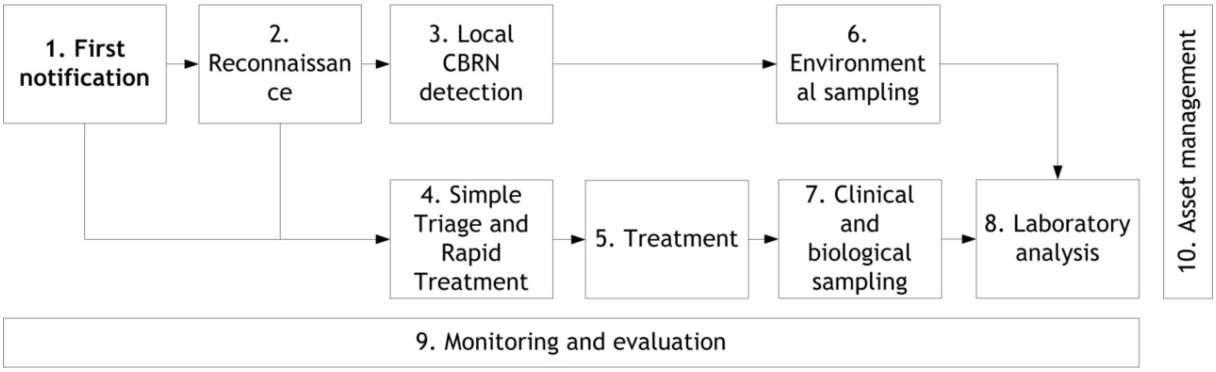

Fig. 2: UPCAST modules

[1]. Directiva Operacional Nacional nº 3, Portuguese Civil Protection Authority, October 2010

Session 3 – Uncertainty handling issues for emergency and recovery

Coping with uncertainties: The new research project CONFIDENCE

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In emergency management and long-term rehabilitation the uncertainty of the information on the current situation, or its predicted evolution, is an intrinsic problem of decision making. To protect the population, conservative assumptions are often taken which may result in more overall harm than good due to secondary causalities as observed following the Chernobyl and Fukushima accidents. Therefore, the reduction of uncertainty where practicable, and approaches to deal with uncertainty, are crucial to improve decision making for the protection of the affected population and to minimise disruption of daily life.

The H2020 CONFIDENCE Project aims to close existing gaps in several areas of emergency management and long-term rehabilitation. It concentrates on the early and transition phases of an emergency, but considers also longer-term decisions made during these phases. The project brings together expertise from all four Radiation Protection Platforms and also from Social Sciences and Humanities, such that it can address the scientific challenges associated with model uncertainties and improve radioecological predictions and emergency management (NERIS and ALLIANCE), situation awareness and monitoring strategies (EURADOS), risk estimation in the early phase (MELODI), decision making and strategy development at local and national levels (NERIS) including social and ethical aspects (Social Sciences and Humanities).

The work-programme of CONFIDENCE is defined to understand, reduce and cope with the uncertainty of meteorological and radiological data and their further propagation in decision support systems, including atmospheric dispersion, dose estimation, foodchain modelling and countermeasure simulations models. Consideration of social, ethical and communication aspects related to uncertainties is a key aspect of the project activities. Improvements in modelling and combining simulation with monitoring will help gaining a more comprehensive picture of the radiological situation and will clearly improve decision making under uncertainties. Decision making principles and methods will be investigated, ranging from formal decision aiding techniques to simulation based approaches. These will be demonstrated and tested in stakeholder workshops applying the simulation tools developed within CONFIDENCE. A comprehensive education and training programme is fully linked with the research activities.

This paper presents the key objectives of the project and highlights the expected improvements for coping with uncertainties for improved modelling and decision making in nuclear and radiological emergency management and long-term rehabilitation.

The new European Research Project TERRITORIES (To Enhance unceRtainties Reduction and stakeholders Involvement TOwards integrated and graded Risk management of humans and wildlife In long-lasting radiological Exposure Situations)

M. Simon-Cornu
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TERRITORIES is a three-year project (jan 2017-dec 2019), funded by Euratom research and training programme in the framework of the CONCERT grant agreement No 662287. The proposal addressed topic 2 (Reducing uncertainties in human and ecosystem radiological risk assessment and management in nuclear emergencies and existing exposure situations, including NORM) of the First transnational CONCERT call.

The TERRITORIES project targets an integrated and graded management of contaminated territories characterised by long-lasting environmental radioactivity, filling in the needs emerged after the recent post-Fukushima experience and the publication of International and European Basic Safety Standards. A graded approach, for assessing doses to humans and wildlife and managing long-lasting situations (where radiation protection is mainly managed as existing situations), will be achieved through reducing uncertainties to a level that can be considered fit-for-purpose.

The integration will be attained by:

- Bridging dose and risk assessments and management of exposure situations involving artificial radionuclides (post-accident) and natural radionuclides (NORM),
- Bridging between environmental, humans and wildlife populations monitoring and modelling,
- Bridging between radiological protection for the members of the public and for wildlife,
- Bridging between experts, decision makers, and the public, while fostering a decision-making process involving all stakeholders.

This project interlinks research in sciences supporting radiation protection (such as radioecology, human or ecological dose and risk assessments, social sciences and humanities, etc.), providing methodological guidance, supported by relevant case studies. The overall outcome is an umbrella framework, that will constitute the basis to produce novel guidance documents for dose assessment, risk management, and remediation of NORM and radioactively contaminated sites as the consequence of an accident, with due consideration of uncertainties and stakeholder involvement in the decision making process. The results will be widely disseminated to the different stakeholders and accompanied by an education and training programme.

The eleven partners of TERRITORIES (P1 IRSN, P2 BfS, P3 CEPN, P4 CIEMAT, P5 NMBU, P6 NRPA, P7 PHE, P8 SCK.CEN, P9 STUK, P10 University of Tartu, P11 Mutadis) will develop a common coherent guidance with a greater understanding of multiple sources of uncertainties along with variabilities in exposure scenarios, making the best use of scientific knowledge to characterize human and wildlife exposure, integrating this knowledge and know-how to reduce uncertainties and finally taking consideration of social, ethical and economic aspects to make decisions.

The dissemination of such guidance to broad audience at the regional and international levels will promote the fact decisions can be made through dialogues with stakeholders, where environmental, social and radiological sciences underlying decisions will be better understood and therefore gain public confidence.

Handling Uncertainty in the Threat and Early Phases

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That estimating the consequences of radiation accidents in the emergency phase is beset with uncertainties, particularly in the threat phase and the very early hours of a release, is uncontentious and has long been recognised. But despite huge developments in decision support systems and processes for nuclear emergency management over the past 25 years, it continues to be the case that little attention is paid to developing a full – or even, sometimes, any - understanding of uncertainty in the formal analyses. Uncertainty analyses, where performed, are limited to consideration of weather permutations. But often, emergency managers are presented with deterministic analyses based on specific assumptions and left to factor in allowances for the uncertainty through informal discussion and unsupported judgement. Moreover, the assumptions on which the analyses are built are often pessimistic, reflecting some type of worst case situation from the viewpoint of doses (but not for other outcomes, such as agricultural effects or economic impact), with no attempt to consider the uncertainty range in the evolution of the accident and the amount and type of radioactivity released. Note that uncertainty on weather and uncertainty on release content and duration also need to be treated in combination in consideration of the range of possible outcomes as they are not independent.

It is over 30 years since Chernobyl and 5 years since Fukushima, and we should now attempt a more comprehensive treatment of the key uncertainties in our analyses. The paper will discuss the sources of uncertainty and how we might reflect these in preparing advice to emergency managers.

Building a dataset for near-range validation of dose rate estimations from atmospheric dispersion calculations

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For real-time dose and impact assessments based on atmospheric dispersion modelling during a nuclear or radiological event the knowledge of the released quantities to the atmosphere as a function of time is of utmost importance. If this source term and/or its time evolution is not available from, for instance, stack monitoring, source term estimation or data assimilation techniques based on measured data in the environment can complement the missing information. Data from early warning stations, installed around nuclear installations (fence monitoring), are optimal for this purpose because of the short time delay they allow a fast feedback between measurements and models. However, for the development of and building confidence in models and data assimilation techniques, validation datasets of high quality are required. Although far below any health standard, routine releases from specific nuclear installations in combination with environmental monitoring can offer datasets over extended periods covering for instance a large range of meteorological conditions.

In this paper we discuss the construction of a data set based on the routine releases of the Belgian Reactor 1 (BR1) at the Belgian Nuclear Research Centre (SCK•CEN), gamma sensors of the environmental network at SCK•CEN, fence monitoring stations comprising NaI(Tl) detectors of the TELERAD early warning network of the Belgian Federal Agency for Nuclear Control (FANC-AFCN) and on-site meteorological data from a meteorological tower. All these data are collected with a relative high temporal resolution (5-10 minutes) and are available for many years. Although far below any regulatory limits, during operation, the released Ar-41 which is produced by neutron activation of Argon in the reactor air stream (air-cooled, graphite moderated reactor) can give rise to limited but increased dose rate levels in the surrounding environmental stations. The spectroscopic capabilities of the fence early warning stations allow to correlate increased dose rate levels with Ar-41 releases. Dose rate results are also in emergency situations the primary data available.

The use of the data set for model validation will be illustrated based on calculation results with different atmospheric dispersion models. Because of the proximity of the environmental measurement stations to the point of release, the BR1 chimney, building effects and 3 dimensional extent of the plume can have an influence on the dose rate from the plume. Also the possibility of collecting high temporal resolution monitoring data (at the level of seconds) for dedicated time periods with large volume detectors, complementing the standard data set, for studying the variability of the dose rate at the near-range will be discussed. Finally, a short overview will be given of other potential locations for collecting similar data sets allowing model and data assimilation validation for different environments, radionuclides and meteorological conditions.

Nordic research on uncertainty of atmospheric dispersion prediction for nuclear emergency preparedness

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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],
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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, and the influence of meteorological uncertainties on real-time assessments of atmospheric dispersion and deposition was investigated, imitating real-time emergency management. The project examined how predictions with uncertainty estimates can be presented to experts as well as to decision makers in a manner that meets requirements of both the experts using the DSS and the decision makers relying on practical decision support.

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.

In the presentation, the methodology developed will be described, and results of MUD, FAUNA and MESO presented. In addition, an outlook will be given to a proposed project 'Added Value of uncertainty Estimates of SOurce term and Meteorology' (AVESOME), in which source term uncertainty and its interaction with the meteorological uncertainty will be studied as well as possibilities for implementation in DSSs.

Uncertainty quantification of atmospheric transport modeling of radionuclides

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Atmospheric transport and dispersion modelling is indispensable for emergency and recovery preparedness and response in case of airborne radioactive releases. Results from such models, however, contain errors that are difficult to quantify. Therefore, an uncertainty quantification is of great value for decision makers in case of a nuclear accident.

We have used the Flexpart model with meteorological data from the European Centre for Medium-Range Weather Forecasts to simulate radioxenon concentrations from regional sources in Europe for a full year. We use the ensemble method to quantify uncertainty.

Results are validated by using radioxenon observations from the International Monitoring System that is being set up to detect violations to the Comprehensive Nuclear-Test-Ban Treaty. The ensemble method will be discussed.

Session 4 – Challenges in setting-up a holistic framework for preparedness for emergency response & recovery

Facing a challenging path toward a holistic framework for EPR&R

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The Fukushima accident in 2011, together with complex natural or manmade hazardous activities which emerged, has in recent years activated a new priority attention towards nuclear safety, security and emergency response.
The great challenge is to start implementing, in the medium term and with new technological means, a real common approach to strengthening preparedness by implementing risk analysis, risk reduction, and early warning methods.

A first step in taking this challenge could be to also look at risk situations which have occurred in areas unrelated to nuclear or radiological emergences[1], and understand which elements worked better in risk reduction, what factors allowed this effect, and what shortcomings became evident. Considering the cross-sectional aspects in the nature of an accidental event, a wide-open dialogue should be part of the preparation, paying attention to a wide range of deriving vulnerabilities, not only structural, physical or environmental, but also social, economic and political, and a combination of these factors. Cross-national border concerns also need to be considered, since they have shared issues in nuclear emergencies.

A challenge that promises more and more attention is the synergy between Safety, Security and Safeguards, with respect to industrial installations. This perspective, also referred[2] to as '3S', leads to the consideration of better communication among parties, with an exchange of experience and expertise when considering future installations, in order to: provide complete and solid answers to various types of related challenges; reduce duplication; reduce potential conflicts. The synergies are not improved through ex-post integration: an effective and efficient system needs to be constructed to manage them, which should be implemented at the very beginning of a work program, for example a nuclear installation program. In addition, in the presence of several legal frameworks, players and responsibilities involved, an increase in this type of synergy is seen as key to improving sustainability also in emergency preparedness. Involving political, scientific, technical and operational players in planning for implementation at a national level, would ensure a better understanding of the related needs and potential challenges; this cohesive mode would also ensure a more effective and certainly more efficient implementation of the '3S' approach.

Key factors in promoting a holistic approach include the cultural aspects present in education, research, development, and policy making, allowing appropriate communication, cooperation and coordination in the conceptual, design and implementation phases, at regulatory, procedural and technical levels.

Another significant challenge towards a holistic framework for preparedness is precisely to 'be prepared for emergency', making those who are responsible and involved in the decision making phases, as well as the operators, aware of the fact that the characteristics of emergencies will also be significantly different from the ones seen and studied in previous emergencies.

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[1] *Disaster Preparedness for Effective Response. Guidance and Indicator Package for Implementing Priority Five of the Hyogo Framework. United Nations UNI/ISDR and UN/OCHA,Geneva, 2008.*

[2] *EU efforts to strengthen nuclear security. Joint Staff Working Document (SWD (2016) 98 final).*

Ethical considerations on the empowerment of people living in contaminated areas after a nuclear accident

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Fukushima as previously Chernobyl highlighted the importance of involving the population with the support of national and local experts and authorities to ensure the effectiveness and sustainability of protection actions in contaminated territories.

The empowerment of inhabitants is a key factor for the success of this involvement but it also raises important ethical issues because it can be seen as a strategy to let inhabitants alone to face the post-accident situation and for authorities and experts to be relieved of their responsibilities.

After the Chernobyl and Fukushima accidents, stakeholder involvement processes have been implemented in a few communities in Belarus, Norway and Japan. In these contexts, the availability of measurements devices for the inhabitants was crucial to allow them to assess their own radiological situation. Measurements allow to make radioactivity visible and to talk about it with others. Progressively people build their own reference and regain power to make choices and to retrieve control on their daily-life. Experience shows that to protect effectively the inhabitants living in contaminated areas, experts must work in cooperation with the local actors and develop together a co-expertise process.

But helping people to protect themselves does not mean that authorities and experts have no responsibilities and call for strong ethical principles. First of all is the refusal to take decision for the people about their future. To be helpful, scientists need to understand that, as necessary as radiation protection is, it is not the only issue inhabitants are facing and it cannot handle people's lives. Radiation protection experts must commit themselves to be at the service of individuals and the community and the issues they want to address.

It’s the responsibility of authorities and experts to implement the conditions based on a governance involving the inhabitants allowing respect of freedom and justice. They have also the duty to address collective challenges such as ensuring equity between individuals and communities.

The paper discusses the ethical considerations to be addressed by experts and authorities in the empowerment process for people living in contaminated areas after a nuclear accident.

Investigating social, ethical and communicational aspects of uncertainty management in emergency and post-accident situations- a multi-disciplinary approach in the CONFIDENCE project

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Experience from past nuclear accidents and incidents, notably the Chernobyl and Fukushima accidents, showed that stakeholders' values, ethical considerations, requirements for public communication and the contrasting needs and concerns of people in different environments are key factors influencing the effectiveness of risk assessment and management. In particular, the inherent scientific and societal uncertainties, the different perceptions of risk, and the societal (dis)trust issues pose important challenges to radiological risk governance.

Previous studies in social science and humanities research attended to several aspects of accident and post-accident decision-making. However, the social, ethical and communication aspects of uncertainty management have not been addressed yet in a structured and multi-disciplinary way. Furthermore, there is a need to elucidate the uncertainties that citizens, decision-makers and other stakeholders face during or after an emergency, and to investigate how they make sense of and respond to scientific and societal uncertainties, since this can have a strong impact on the efficiency of the overall decision-making process.

The H2020 CONFIDENCE project aims to improve decision making in the case of a nuclear accident by, among others, identifying social and ethical issues related to uncertainty management in emergency and post-accident situations and clarifying how stakeholders at the various levels deal with uncertainty in their own decision making processes. At the same time, the project will support and improve the communication of uncertainties.

For this purpose, a dedicated work package in CONFIDENCE (WP5) will investigate:

i) Lay persons' and emergency actors' understanding and processing of uncertain information and their subsequent behaviour in nuclear emergency situations;

ii) Societal uncertainties and ethical issues in emergency and post-accident situations from the early phase to recovery;
iii) Improved tools for communication of uncertainties, specifically for low radiation doses.

This paper outlines the multi-disciplinary approach undertaken in CONFIDENCE to address these issues, drawing on risk perception and communication, behavioural sciences and science and technology studies, and using qualitative and quantitative research methods and empirical investigation of case studies.

Enhancing CBRN first response in the framework of the CBRN Centres of Excellence initiative: the case of South-East And Eastern Europe region.

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Project 44, "Strengthening CBRN first response capabilities and regional cooperation in South East Europe, Southern Caucasus, Moldova and Ukraine", is a EuropeAid CBRN centres of excellence project, led by SCK•CEN. The project is divided into 6 work packages where 5 partners share the responsibilities to meet the set objectives in 36 months starting January 2015. Project 44 aims at improving the preparedness and response capabilities for accidental, malevolent and natural events that would lead to releases of chemical, biological radiological or nuclear (CBRN) material. The main objective of the project is to enhance the response capabilities and promote inter-agency and regional cooperation in CBRN first response in the South-East and Eastern Europe region. The project activities include improving or building capacity for detection and ensure well trained first responders. This is obtained by investigating what is already existing in this framework, both from the legal point of view and from the technical point of view (equipment and knowledge). To enhance the legislative part, the national legal frameworks were investigated. A focus on the existing working procedures lead to a significant improvement. Furthermore a gap analysis of CBRN first response equipment was performed, resulting in a new project via which CBRN first response equipment is provided to the partner countries in this region. Training in CBRN first response for local trainers is developed and several CBRN exercises are being organised and held.

Every country has its CBRN risk profile. Based on this specific scenarios for exercises are being developed. During the year 2016 table top exercises were carried out in 3 different countries Albania, Bosnia & Herzegovina and Montenegro. We aim to share with the participants the different challenges and progress achieved in this project so far.

Considerations about the protection of emergency and recovery responders in affected areas

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Diverse people may be involved in the response to a nuclear emergency and the following recovery: emergency teams (firemen, policemen, medical personnel…), workers (from the damaged facility or involved because of their skills), and other people (elected representatives, members of NGOs, citizens…). Some of the responders are previously prepared to intervene under radiation, others not. When the event arises, it is a breaking and the responders should be adequately protected according to specific rules although inspired by those for radiation workers. A graded approach is needed, allowing for a response adapted to the prevailing circumstances. The graded approach should make a distinction between on-site (the damaged facility) versus off-site (the affected areas) and between the different accident phases: early, intermediate and recovery/long-term phases. The tasks likely to provide higher doses should be completed by responders already prepared and trained. The present paper is based on the Fukushima experience and focused on responders off-site, i.e. in affected areas.

The protection of the emergency and recovery responders is based on the justification and optimisation principles. The justification of decisions should balance the benefit, i.e. avoiding or reducing public and environmental exposures, with the disadvantages including the risk for responders. Because of the circumstances (unforeseen event, lack of experience, large uncertainties), the optimisation process should be implemented in a specific way in the early and intermediate phases. The application of the dose limits is a priori not relevant and should be replaced by the application of reference levels.

In the early and intermediate phases, outside the damaged facility, early countermeasures are implemented at the beginning, followed by actions aiming at the characterisation of the situation. Classical emergency teams (firemen, policemen, medical personnel), workers with specific skills such as bus drivers or people involved in the monitoring of the affected areas, as well as voluntary citizens may be involved. They are directly or indirectly under the responsibility of the response organisation. Their doses may be high, although less than on-site. The reference level may start at 100 mSv or lower and decrease to 20 mSv or lower in the intermediate phase, keeping in mind that the responders will intervene close to the population. The objective is to try to maintain doses below 100 mSv during the response.

In the recovery/long-term phase, the experience from Fukushima shows that many categories of people may be involved in the response (skilled workers, citizens…) in the affected areas. It also appeared that a significant discrepancy in the protection of the responders versus the population (e.g. in terms of individual protective equipment) is not welcome while they are at the same place at the same time. Consequently, when the operation is implemented in a restricted area (not open to the public), the exposure of recovery responders should be considered as occupational exposure and managed using the corresponding requirements with a reference level of 20 mSv per year or lower. However, when the operation is implemented among the population by a mixed group of workers and volunteers, a similar protection should be provided, using a reference level of 10 mSv per year or lower.

This paper reflect the work of the Task Group 93 of International Commission on Radiological Protection (ICRP), in charge of updating Publications 109 and 111 but does not necessarily reflect the views of the ICRP.

Session 5 – Stakeholder involvement and engagement in emergency and recovery

Citizens measurements: their role in radiation protection and emergency preparedness and response - the pros and the cons

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An important issue of involvement stakeholders and general public into the process of effective solving problems of emergency preparedness and response and of remediation of the affected territories is obtaining confidence of them to Information on radiation situation provided by the authorities.

Experiences gained from the Fukushima Dai-ichi NPP accident in Japan in 2011 have shown, that especially in case of severe accident with significant consequences in large inhabited areas around lack of public confidence to officials was caused mostly by rather poor communication between official authorities and the public and the stakeholders, as well by restricted access to the information for them, what may have extremely negative impacts on the public and stakeholders understanding of actual situation and its possible risks, and on their acceptance of necessary protective measures and their participation in remediation of the affected areas.

A rather effective way to improve the situation can be implementation of citizen radiation monitoring on voluntary basis in this field. Making sure, the official results are compatible with public self-measured ones, the public probably gain more confidence in them.

In the Czech Republic the implementation of such approach is tested in the framework of security research founded by the Czech Ministry of the Interior - the research project RAMESIS solved by SURO, aimed at supporting establishment of a citizen monitoring network based both on net of fixed monitoring point, based on newly developed simple and cheap fixed monitoring stations, and on mobile monitoring performed using the Safecast Geigie nano portable devices, and prepare methods and tools for incorporation of these citizen networks into a national radiation monitoring network operated by the state to improve efficiency of obtaining information necessary for fast and effective evaluation of the radiation situation ion case of accident.

Analysis of possible capabilities of such networks shows, that with their help all roads on the whole territory of the CR can be monitored in one day using only about 300 devices, and areas with higher levels of contamination which need professional monitoring can be easily identified. From our survey it is clear that the civil monitoring network can provide useful information not only during the first phase of a radiation accident, but also in the phase of remediation of the territory as details for the population as well as for the assessment of development of radiation situation and the effectiveness of remedial measures.

The paper shows selected results of selected security research projects aimed this field, supported by the Czech Ministry of Interior (“RAMESIS” and “STRATEGIE ŘÍZENÍ NÁPRAVY ÚZEMÍ PO RADIAČNÍ HAVÁRII”).

Politics, populism and radiation risk: learning from Japan's anti-nuclear movement

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I. Introduction

G.K. Chesterton observed that "art, like morality, consists of drawing the line somewhere" (in Clarkson, 2014:1). So too does radiological protection. At every turn, practitioners are asked to ink boundaries: between the habitable and the uninhabitable; the edible and the inedible; those who need additional care (Iodine pills, for example) and those who can do without. The essential questions of governing radiological risk pertain to how these lines are established. Where are they drawn? On what basis? And by whom?

This paper reflects on two models for addressing those controversies that arise when a new line is drawn. Specific reference is made to Japan's contentious decision to raise the threshold for civilian exposure from 1mSv/yr to 20mSv/yr in responding to the 2011 Fukushima Daiichi nuclear power plant disaster, which was met with suspicion and resistance. I criticise the orthodox "deficit" model, in which experts seek to "correct" public opinion through risk communication and call for a participatory approach in which scientists engage public stakeholders as co-experts.

In so doing, I draw attention to the importance of popular discourse, focusing particularly on how the anti-nuclear movement has narrated against establishment attempts at risk communication. By framing the issue of civilian exposure as part of a wider struggle between "the people" and a pro-nuclear elite, the movement has called the integrity and motivation of the government into question, severely limiting the efficacy of its risk communication initiatives.

II. Methodology

This paper draws on ongoing PhD research into how expert authority is claimed and contested in conditions of low public trust. Specifically, its analysis of the anti-nuclear movement's narratives draws on: observation of public demonstrations; textual analysis of a corpus of materials circulated by demonstrators; and 15 semi-structured interviews, of one to five hours in length, with prominent members of the anti-nuclear movement. For the purposes of this study, "prominent members" were defined as those engaged in an organisational capacity, or invited to speak on behalf of anti-nuclear NGOs. All interviewees were offered anonymity, but some volunteered to waive this right, including: Dr Tetsuji Imanaka, a former Assistant Professor at Kyoto University and one of the vocally anti-nuclear researchers dubbed the "Kumatori Six"; Dr Hiroaki Koide, another member of the "Kumatori Six", who has been described as the "rockstar" of the nuclear debate; and Dr Hisako Sakiyama of the Takagi School, who was a member of the Diet's Nuclear Accident Independent Investigation Commission and has provided expert testimony on behalf of plaintiffs protesting the 20mSv/yr limit.

III. Context: Fukushima Daiichi and the 20mSv/yr threshold

Damaged by the "3.11" earthquake and tsunami, Units 1 to 3 of the Fukushima Daiichi nuclear power plant began to haemorrhage radiological material in March 2011. Recognised as a level 7 ("major accident") on the IAEA's INES scale, Fukushima is the most serious nuclear disaster the world has faced since Chernobyl: responsible for an estimated $219 billion in damages (including the cost of decommissioning the reactors and compensation) and the displacement of more than 160,000 people.

The evacuation of the area surrounding the Fukushima Daiichi plant has been iterative. As an emergency response, Japan evacuated citizens on the basis of proximity – successively ordering those within a two, three, 10 and 20km radius of Fukushima Daiichi to evacuate during the first 48 hours of the crisis. On 22 April 2011, Japan began its shift to a model of evacuation based on exposure, when

those living in areas with an air dose of more than 20mSv/yr were asked to leave within a month. This policy remains in force today, with evacuation orders being lifted in areas where decontamination has lowered the air dose to less than 20mSv/yr, such as the Miyakoji district of Tamura City and Naraha Town in the Futaba district.
In justifying the 20mSv/yr limit, government representatives have emphasised that it is consistent with ICRP recommendations, which suggest a threshold effective dose for public exposure of: 1mSv/yr in normal conditions; between 20 and 100mSv/yr in an emergency exposure situation; and between 1 and 20mSv/yr in an existing exposure situation, such as the wake of a significant accident (ICRP, 2007)[1].
The decision to draw the line at this value has nevertheless proven controversial from the outset. On 29 April 2011, Special Advisor to the Cabinet on issues of radiation safety, Professor Toshiso Kosako tearfully resigned in protest of the week-old threshold. Insisting that emergency limits should be applied for "two to three days, or at most, one or two weeks," he called for the use of a reference value between 1mSv/yr and 5mSv/yr; arguing that the principles of "common sense and humanism" dictate that "babies, infants and primary school students" should not be exposed to any greater risk (Kosako, 2011). He was not alone in his objection. At the time of Kosako's resignation, 800 organisations and 34,000 individuals had signed a petition requesting that the limit for civilian exposure be lowered significantly. In the years that have followed, the 20mSv/yr policy has remained a subject of public debate, owing to its influence on compensation and state financial support for evacuees, as well as resettlement.

IV. Deficit model

In responding to this public controversy, the Japanese government has adopted an attitude to risk communication akin to Wynne's (1993) famous (knowledge) "deficit model", attributing public criticism and hostility to a lack of understanding. Confident that the public would support the policy, if only they knew the relevant facts, scientific advisers have emphasised that the critics "are not scientists…doctors…[or] radiation specialists" and "do not know the international standards, which researchers worked on very hard" (Yamashita, 2011). The problem - as the Adviser to the Governor of Fukushima Prefecture on Health Risk Management, Professor Shunichi Yamashita describes it - is "that people believe gossip, magazines, even Twitter" (ibid).
This understanding has manifested itself in a series of top-down risk communication strategies, aimed at "correcting" public opinion by "fixing" the knowledge deficit. Scientists have entered public forums, not to engage in a participatory discussion about what constitutes an "acceptable" level of exposure, but to assuage public fear: emphasising that the object of the discussion is not "safety" (*anshin*) but "peace of mind" (*anzen*). Speaking to an audience of concerned citizens, Yamashita stated that he "tr[ies] not to use the word 'safe'" and was "talking to [them] in the hope that [they] will feel safer." The two concepts are "totally different," he insisted, positing safety as an objective quality, that "can be recognised by anyone" and "feeling safe" as a subjective experience that "differs from person to person": "the meaning of 'safety' is really narrow, but safe is safe for everyone."

While the deficit model remains politically influential, it is the subject of extended critique within the academic community. Indeed, the "deficit model" is not a label claimed by actors or organisations to describe their own framework for action, but a term ascribed to them by outside critics. The phrase is a *Kampfbegriff* (battle term): coined by Wynne at a workshop in Lancaster during May 1988[2] to name and criticise a common set of assumptions (Wynne, 1993:335). Our very recognition of the phrase is an implicit recognition of the model's shortcomings.

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[1] ICRP Publication 103 defines an emergency exposure situation as "unexpected situations such as those that may occur during the operation of a planned situation, or from a malicious act, requiring urgent attention"; while existing exposure situations are "exposure situations that already exist when a decision on control has to be taken, such as those caused by natural background radiation" (ICRP, 2007:13-14).

[2] Wynne writes that he first used the term in a draft paper for a workshop held by the Economic and Social Research Council – Science Policy Support Group under the Phase I Public Understanding of Science Research Initiative.

Perhaps the most common criticism of the deficit model is that it is used to marginalise legitimate democratic discussion. As Edward Lazo of the OECD-NEA has emphasised, the choice of a threshold value is a political decision, informed by science but not dictated by it: "1mSv, 10mSv, 20mSv – that is not science, that is a political judgement" (Lazo, 2016). To present a question-with-technical-aspects as a purely-technical-question is problematic, as it forecloses the possibility of lay stakeholders engaging in the political process.

A related objection is that the deficit model promulgates an unsophisticated view of "the public" as a monolithic entity whose attitudes to risk are determined solely by scientific literacy. Dan Kahan of Yale's Cultural Cognition Project, and his colleagues have shown this characterisation to be inaccurate; finding that it is often ideology that most strongly determines our perception of risk (Kahan et al, 2012). Indeed, ideological groups can become more polarized as scientific literacy and numeracy rises, they report. These findings invite us to develop a more sophisticated understanding of "the public" and its perceptions.

Such a reading would recognise that "the public" is not homogeneous and people are not "blank slates": they enter political debates with their own interests and ideologies, which shape how they engage with new information. It must also recognise that publics are not just passive "recipients" of information "donated" to them by experts. Publics engage in political controversy actively, bringing their own facts, meanings, and narratives to the table, including reflexive narratives about the nature of the risk communication schemes they are subject to and the interests of the expert organisations engaged in these activities.

V. Populism and the Anti-nuclear Movement

The anti-nuclear movement has narrated the debates over radiation risk management as a struggle against vested interests. Nuclear policies are "an expression of our beliefs and the way we run our society," one activist explained – adding that the controversy is understood to reflect a "division between the people who get the benefit and the people who get the bad stuff." More specifically, it is narrated as a struggle between "the Japanese people" and "the nuclear village" (*genshiryoku-mura*): a powerful pro-nuclear interest group, that draws its members from government, civil service, nuclear industry, media and academia.

This notion of a nuclear village can be understood as a populist discourse. Populism is not an ideology, the late Belgian scholar, Ernesto Laclau (2005) argued; but a way of articulating politics as a conflict between "the people" and what is variously called "the elite", "the establishment", "the system" or, in this case, "the nuclear village". Compatible with the demands of both the political right (e.g. the UK's Vote Leave campaign, with its rejection of "experts" and "the liberal elite", demanded stricter controls on immigration) and the left (e.g. Occupy Wall Street campaigned for the reallocation of wealth), populism is defined by its form not its content. The shibboleth of a populist movement is the claim to be *vox populi* (i.e. the voice of the people).

Given their common populist logic, it should be no surprise that the boundaries between Japan's 2011 anti-nuclear demonstrations and Occupy Tokyo were so porous. Gas masks inscribed with "99%" were no strange sight at the former, just as placards that collaged the message "no nuclear" with "occupy together" were not unusual in the latter. Nor should we be surprised that in 2016, anti-nuclear demonstrators marched shoulder-to-shoulder with those protesting against exploitative employment practices (*Black Kigyou*) or reforms to Article 9 of the Japanese Constitution, meandering between the issues in their chants. In each instance, the root of the problem is perceived to be the abuse of power by a parasitic "elite", demanding correction by "the people".

This populist framework engenders fierce resistance to top-down efforts at risk communication, which are experienced not as an education but as an establishment tool of oppression. In 2012, Founding Director of the NGO Green Action, Aileen Mioko Smith published "*The 10 strategies taken by the state, prefectural governments, academic flunkies and companies in the cases of Minamata and Fukushima*." The list accuses the nuclear village of deliberately "conduct[ing] tests or surveys that will produce underestimated results on damage" (strategy no. 6) and "creat[ing] an official certification system that narrows down victim numbers" (strategy no. 8). Similarly, the organisation of international conferences (strategy no. 10) is interpreted as part of a broader strategy to "stall for time" (strategy no. 5) and "wear victims down until they give up" (strategy no. 7). Examples like this are not uncommon. Like Smith, many derisively refer to the government's risk communication efforts as the "feel-safe campaign", or simply "propaganda". Others have translated *goyo-gakusha* (more literally) as "government patronised scholar", rather than "academic flunkie", but the derogatory connotation is the same: suggesting a perceived lack of independence that stems from the scholar's desire to maintain the government's favour, with its attendant financial benefits.

One could certainly argue that the anti-nuclear movement is not representative of the population. Japan's civil society is typically thought to be quite passive. For many Japanese citizens, "democracy is about going and voting", one NGO director stated: "anything else is only for special kinds of people - politicians or activists." Although this attitude changed somewhat in 3.11's immediate aftermath - enabling the anti-nuclear movement to stage the largest demonstrations Japan had seen in 50 years[3] - it has struggled to maintain mass engagement. The "Friday rallies" held in front of the Prime Minister's Office gathered 200,000 people in March 2012, according to the organiser: Metropolitan Coalition Against Nukes. By February 2016 they gathered less than 1000. Over time, the movement has become an increasingly atypical sample of "the people" it claims to speak for.

Nevertheless, the antinuclear movement has profoundly shaped Japan's popular discourse. The term "nuclear village" is believed to have been in use since the 1970s[4], but in the wake of the Fukushima Daiichi disaster it has become a touchstone of the Japanese political lexicon. Once used only by committed nuclear activists, the phrase is now, as Samuels (2013) documents, uttered by mainstream newspapers, politicians, and bureaucrats. Even Tatsujiro Suzuki, vice-chairman of the Japanese Atomic Energy Commission (JAEC), is reported to have admitted that "Yes, I am living in the village hall" (in ibid:118). The moniker is not always used explicitly, but the idea of a "tightly knit elite with enormous financial resources", promoting a nuclear program that is "immune to scrutiny by civil society," is now ubiquitous, implying that distrust (perhaps, even active suspicion) of the government and its risk communication initiatives is widespread (Kurokawa et al, 2012:9).

VI. Conclusions and policy suggestions

By narrating radiological policy as a struggle between "the people" and the nuclear village, the anti-nuclear movement has fostered a suspicion of the government's motives. The damage this has caused to the credibility of risk communication schemes highlights a need for a reflexive engagement with popular controversies: one that recognises that publics construct narratives about the identities and motivations of those that attempt to engage them. Shifting from the binary format of the deficit model to a participatory approach, in which experts engage stakeholders as "co-experts", may offer one means of disrupting the populist opposition of "the establishment" and "the people" and the possibility of rebuilding trust.

On the local and international level, efforts to stage participatory forums are already being made. One notable example of "co-expertise" in practice has been the ICRP Dialogue initiative, which hosted 12 stakeholder meetings between November 2011 and September 2015. Organised with the support of local (e.g. Fukushima prefecture, Date City, Iitate village, etc.) and international partners (e.g. OECD-NEA's committee on Radiation Protection and Public Health, CORE, ETHOS), each meeting brought experts and public stakeholders together for a dialogue held in the spirit of mutual co-operation. To date, however, the national government's engagement in such forums has been more limited.

State involvement in participatory forums would pose both new opportunities and new challenges. The authority of the state promises the possibility of "upstream" stakeholder participation: engaging in the

3 Although the 2012 demonstrations were still relatively small by European standards, participants described it as "a kind of revolution…in Japanese society…because it involved people who had never been to a demonstration – who had never thought that they would be involved in something like that…there were mums that came in with their baby buggies, or salary men that came before they went out drinking on Friday night."

4 In contrast to Samuels' claim that "the metaphor [of the nuclear village] originated in a 1997 critique by Iida Tetsunari who, like Professor Koide, became an outspoken insider critic of nuclear power", Koide has suggested that the term dates back to the 1970s.

normative debates about the costs and benefits of drawing the line higher or lower within the 1 to 20mSv/yr range. However, the same authority could threaten the integrity of participatory forums, creating environments in which prefectural officials and citizens are reticent to speak.

Hence, further research into best practice will be required if state representatives are to engage more fully. As Yamamoto and Yamakawa (2017:177) have argued, “small innovations and ‘tricks’ matter”; illustrating their point by describing how the moderator who asks a Japanese public forum the question: “does anyone have an opinion?” Is liable to be met with silence. Far more effective is the method of passing a microphone around the room, inviting each and every person to speak. As this vignette illustrates, the process of participation will not only involve learning about how stakeholders understand particular issues, but also how best to engage the stakeholders.

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Lessons learned from Living Conditions and Health Status of Populations living in affected territories after the Chernobyl and Fukushima accidents European Research Project SHAMISEN.

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SHAMISEN is an European research project under the OPERRA project that aims to develop recommendations for medical and health surveillance of populations affected by radiation accidents, building upon lessons learned from experiences with populations affected by Chernobyl, Fukushima and other nuclear emergencies.
This paper presents the results of the review of the health and concerns of populations living in contaminated areas following radiation accidents, as well as the identification of the impacts on living and social conditions, and the worries, needs and expectations of the affected populations with regards to their health and welfare.

This main objective has been achieved through a description and analysis of specific case studies in different situations observed after the Chernobyl accident (Belarus and Norway) and the activities carried out after the Fukushima accident. It notably incorporates an analysis of testimonies of medical experts and local stakeholders from contaminated territories in Japan within two case studies as well as through a dedicated workshop jointly organised with Fukushima Medical University in Japan in March 2016. The analysis addresses the following topics:

- Expectations and worries of the people regarding their health and welfare
- Role of the different stakeholders (health professionals, RP professionals, local population, authorities, etc.)
- Contribution to well-being of the implemented actions and direct benefits for populations
- Sustainability and continuity of the projects/actions
- Ethical considerations
- Stakeholder participation, dialogue, information and communication issues
- Education and training provision and needs

Thus, this paper will outline key lessons learned from each of these key topics, by providing tangilbles examples from the analysis of the various case studies (Belarus, Norway, Japan).

Among others, theses lessons learnt have been considered for the preparation of the final recommendations that will be shared and discussed with international stakeholders next March, at the occasion of the SHAMISEN final Workshop in Paris.

Recommendations for preparedness and health surveillance of populations affected by a radiation accident – Conclusions from the SHAMISEN Project

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Public concerns about the potential health consequences of radiation exposures rank high after an accident. However, strategies for health surveillance of populations are often at odds with the actual needs of the affected populations, and if not carried out properly can cause more harm than good. A striking example is thyroid screening carried out after Fukushima, which has been claimed to have exacerbated rather than alleviated anxiety in the participants and their families.

The EU SHAMISEN project, which started in December 2015, had the goal of producing a set of recommendations that would contribute to health surveillance after a nuclear accident or other disasters. Experience suggested that an update of emergency preparedness in this area was needed for a number of reasons. These include the fact that existing recommendations had a technical focus, with less attention paid to social, ethical, psychological issues and that the information tended to be directed towards the decisions made by experts rather than for support of affected populations. Finally, there have been a number of changes in legal and ethical requirements for health surveillance and epidemiological studies (e.g., related to data protection) that need consideration. This paper presents the main conclusions and recommendations of that project, with a particular focus on the ethical challenges related to health surveillance.

The SHAMISEN recommendations are based on reviews of guidelines in existence at the time of the Chernobyl and Fukushima accidents, and of the actions which were taken. These include case studies, highlights of successes and limitations, and lessons learnt. The recommendations aim at improving health and living conditions of potentially affected populations and cover health surveillance, epidemiological studies, dose reconstruction, evacuation and training of health personnel and other actors involved in liaising with affected populations. A draft was prepared for discussion with decision makers and radiation protection authorities through a stakeholder forum and a stakeholder workshop. The final recommendations are intended to be disseminated for translation into policy, as well as to scientific, medical and non-expert audiences.

The current results have been are divided into general recommendations, and those applying to emergency preparedness, early and intermediate phase and long-tern recovery phases. The general recommendations contain points on ethical issues (including respect for dignity and to be sensitive to inequities from variability in the distribution of risk), and the difference between medical surveillance, health surveillance and epidemiology, and their different objectives and data requirements. They address the need to review health monitoring systems and data registries in different countries, and provide advice on the different types of dosimetry and monitoring approaches. An overarching theme that is reflected in many recommendations is the promotion of a health surveillance strategy that targets the overall well-being of populations, that addresses not only radiation effects, but also aims to identify and alleviate psychosocial impacts. The development of communication strategies, and strengthening stakeholder and public engagement in health surveillance are other key issues that support many recommendations.

The paper will use case studies and concrete examples to illustrate the final version of the SHAMISEN recommendations and the way they can contribute to an improved understanding of the challenges of health surveillance and radiation risk.

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POSTERS

NUCLEU 2020 – The European Network of the National Contact Points (NCP) for Euratom

S. Vaz, Horizon 2020 National Contact Point (NCP) – EURATOM

NUCL-EU 2020 is a H2020 CSA (Coordination and Support Action) project aiming to create an European wide active network of EURATOM NCPs. The ultimate objective of NUCL-EU 2020 is to ensure support to Horizon 2020 potential applicants, raising awareness about potential topics and increase the average quality of proposals submitted under the EURATOM Framework Programme for Research and Innovation and the overall success rate at EU level. For this to happen there is a need for letting stakeholders – prospective EURATOM applicants – know of the existence and potential support of NCPs and in particular of a network of NCPs. For promoting more effective and successful participation in Horizon 2020, NUCL-EU 2020 offers training, partner search tools and brokerage events. NUCL-EU 2020 wants to contribute to a step forward on the R&D landscape at EU level.

ENEA fast internal contamination monitoring methodology for nuclear emergencies

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The Fukushima Dai-ichi accident stresses the necessity of organized and tested procedures for conducting large scale individual monitoring of internally contaminated public in a nuclear emergency. For the issue the implementation of a mobile whole body and thyroid counter (WBC-TC), able both to distinguish each emission line of the main interesting gamma radionuclides (^{131}I, ^{132}Te-^{132}I, ^{137}Cs and ^{134}Cs, ^{103}Ru, ^{60}Co) and to acquire useful data in a very short time, can represent the best solution. The ENEA Radiation Protection Institute has recently acquired a trans-SPEC-DX-100 detector with the purpose to develop, in a nuclear emergency situation, a procedure for fast internal monitoring. The instrument is equipped with a variable length tripod, whereon it can be mounted with a customized support tilted for WBC-TC measurements. Efficiency calibrations were performed by means of an adult BOMAB phantom, placed both sit on a chair and laid on a stretcher, and of three neck phantoms (5 y.o., 10 y.o. and adult); in all cases, no collimation was used in order to maximize the efficiency. The detector performance was determined in an emergency tent arranged in open field by the 7th NBC defense Regiment "Cremona" of the Italian Army by means of a set of 10 volunteers acquisition. Detection limit (DL) values in Bq have been evaluated using ISO 28218, instead "DL committed effective dose" in mSv (i.e. the dose corresponding to an in vivo amount equal to a DL) have been evaluated assuming an acute inhalation intake 5 days before measurement by means of the MONDAL3 software.
The system in WBC configuration showed (acquisitions of 3 min counts) DL values equal to 3200, 4500 and 4600 Bq respectively for ^{60}Co, ^{134}Cs and ^{137}Cs. This results in "DL committed effective doses", respectively, equal to 0.76, 0.10 and 0.07 mSv. The system in adult T configuration (acquisitions of 100 s counts) showed a DL value for ^{131}I equal to 120 Bq, resulting in a "DL committed effective dose" equal to 0.01 mSv and a "DL committed equivalent dose" to thyroid equal to 0.27 mSv.
Considering that the evaluated "DL committed doses" are lower than the annual limit of effective dose for public exposure reported on Council Directive 2013/59/Euratom (1 mSv), the described instrument has a significant sensitivity to be used for fast internally monitoring in nuclear emergency response. Performing the 3 min measurements, a large amount of individuals (up to 250) can be monitored daily. Furthermore the system can be used as a valid tool to evaluate nuclear dangers in a malevolent event involving a gamma emitter dirty bomb.
Acknowledgements: We gratefully acknowledge the 7th NBC defense Regiment "Cremona" of the Italian Army for its support and significant effort.

Monitoring strategies to assist dose modelling in the first year after a nuclear accident

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The OPERRA - HARMONE (Harmonizing Modeling Strategies of European Decision Support Systems for Nuclear Emergencies) project aims to address scientific, methodological and operational gaps in the considered Decision Support Systems (SYMBIOSE and RODOS) and to harmonize and expand the models used in these systems. This will allow the development of improved emergency management strategies for reducing doses to the affected population especially for the first year dose.

To predict the first year dose, from all relevant exposure pathways, apart from good models the availability of representative and good quality data is crucial. In this paper preliminary results are discussed on how monitoring (type of measurements, covered region and location, strategy, frequency …) can serve as input for improved modeling and/or confidence building in the model result for: i) the determination of the first year human dose at different locations, including urban areas; ii) the estimation of food activity levels, especially for the next growing season and iii) the estimation of the activity concentration in water bodies.

The presented results include the definition of minimal data sets required for robust impact assessment and obtained, in general from measurements in the preparedness or the response phase of a nuclear or radiological event. These minimal data sets are subsequently tested on a set of accident scenarios to highlight potential issues in the targeted impact assessments.

Airborne monitoring of radioactive ground contamination

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In Belgium, two identical instruments consisting of large-volume (4x4 liter) NaI(Tl) detectors for performing Aerial Gamma Surveys (AGS) are available and have been intensively tested over the past 4 years. They are primarily intended for mapping large scale radioactive ground contaminations, in the aftermath of a possible nuclear accident, or for searching a lost source. For these purposes, the AGS equipment is mounted on board of a helicopter or a small aircraft after which the area to be investigated is overflown. This allows fast and efficient mapping of any relevant gamma-emitting radioactive ground contamination, an extremely useful technique as for example has been demonstrated in the aftermath of the Fukushima accident.

First, the experience from several test-flights with different vectors and over different areas will be discussed. The test-flights include surveys over small scale historically contaminated areas with different helicopters and inter-comparing the two sets of equipment. In addition, flights over hilly areas were conducted to study ground clearance corrections and flights were scheduled as part of full-scale federal nuclear emergency exercises.

Secondly, based on the experience from the test-flights, scientific and operational challenges for further investigation are explored. Such challenges include the timing and planning of flights (residual releases and complex spectra after fresh fall-out), quantifying and establishing detection limits in function of the overall management and protection strategy, calibration aspects (especially fast methods and methods for relatively short-lived radionuclides and comparison with ground-based methods) and interpretation of results in case of non-homogenous environments.

A Big Data Architecture for Learning-Based Source Term Estimation

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Typically, after the detection of a radioactive substance of unknown origin in the atmosphere the source location is estimated via inverse modelling. Depending on various factors, such as the spatial resolution desired, traditional inverse modelling can be computationally time-consuming and therefore its application can be problematic when timing is critical. In a complementary presentation (S. Andronopoulos et al., "Towards Inverse Source Term Estimation using Big Data Technologies"), we will discuss a data-scientific approach to source term estimation, which allows us to perform the bulk of the processing prior to such an event taking place, therefore allowing for rapid estimation.

This presentation will be concerned with the Big Data Europe[5] (BDE) platform and application architecture which allows us to implement the algorithm above and perform experimental analyses. Part of the BDE project's goal is to create a big-data application aggregator which is versatile and easy-enough to encourage data-related progress in a diverse set of areas of societal impact. The BDE platform provides an aggregation of widely-used and specialised tools used for big-data storage, processing and analysis. Its architecture is based on containerisation (the current implementation makes use of Docker[6] containers), which is a form of lightweight virtualisation and ensures deployability over a host of different platforms.

The design and implementation of our use-case involves two parallel pipelines of data transformation and control. The first is a batch processing dataflow, which processes and analyses weather data to create plume dispersions based on previously learnt weather patterns. As part of this use-case, we make use of a dockerised version of the WRF model[7]. The raw data are pre-processed to obtain coarse representations of the European domain in the NetCDF format[8]. In a machine-learning (ML) container, the coarse data are being analysed and clustered using several statistics-based approaches, before they are downscaled to achieve higher resolution versions of the weather patterns previously learnt. Using the DIPCOT dispersion model[9] (also available in JRODOS[10]), we pre-compute plume dispersions for each of the resulting weather pattern, before we store and index the results in a geospatially-aware database. Once these dispersions have been indexed, we can match newly observed weather patterns and retrieve potential dispersions efficiently.

The second pipeline is interactive and can be used once the analysis described above has been completed. We use a web-based platform for visualising linked geospatial data. The user

[5] https://www.big-data-europe.eu
[6] https://www.docker.com
[7] http://www.wrf-model.org
[8] http://www.unidata.ucar.edu/software/netcdf/
[9] http://pandora.meng.auth.gr/mds/showlong.php?id=35
[10] https://resy5.iket.kit.edu/JRODOS/

selects one of a set of weathers previously unseen by the system (in an operational setting this would be the actual currently observed weather) and a few coordinates simulating locations where radioactivity has hypothetically been detected (or real detection locations, in an operational setting). Given this information the system estimates the potential release origin(s) by making use of the use-case's ML component, interrogating the pattern dispersions database as needed. The result is routed back to the user via the graphical user interface.

In this presentation, we will give more details about the BDE platform, the components used and implemented, as well as their performance, shortcomings and pointers for future work.

Establishing gene expression for early and high-throughput prediction of the hematological acute radiation syndrome

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We aimed to predict the later occurring hematological acute radiation syndrome (HARS) and its severity based on early detected changes in gene expression. Using peripheral blood from baboons irradiated with 2.5 or 5 Gy (whole body equivalent dose) we examined changes in gene expression occurring 1 and 2 days after exposure in relation to unexposed blood samples (pre-exposure samples). Utilizing whole genome microarrays and validating candidate genes with qRT-PCR finally allowed us to identify a set of 29 baboon genes forwarded for cross-species validation using human samples. Within this presentation we will provide first results on this cross-species validation and share preliminary results on our envisioned 1,000 sample exercise to examine the feature of high-throughput diagnostic of the HARS using gene expression.

Radioactivity Environmental Monitoring Measurements Evaluation and Dose Assessment for Radiation protection purpose in routine and emergency situations

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Regulating radiological safety is a national duty. However, radiation emergency may cross borders of individual countries, and it is necessary a close cooperation between all the Member States to promote and increase the radiation protection for the public and the information available to the public by exchanging data and knowledge and by improving competences to prevent accidents and control hazards, to respond to emergencies and to manage any contamination risk.

Under the terms of Article 36 of the Euratom Treaty, Member States shall periodically communicate to the Commission information on environmental radioactivity levels which could affect population in routine and emergency situations. Additionally, the Italian Legislative Decree 230/1995 (transposition of Council Directive 96/29/EURATOM) requires measurement of radioactivity in the environment surrounding a nuclear installation (in accordance with Article 54 of the Euratom Treaty). The environmental radioactivity monitoring data from EU countries must be communicated to the European Commission so that it can carry out evaluations and compare radiation exposure of the population in different countries.

On 03 March 2016, it was signed the ***Collaboration Agreement*** between the ***Radioactivity Environmental Monitoring Group*** of the ***Joint Research Centre (JRC) of the European Commission*** and the ***Radiation Protection Institute (IRP)*** of the ***Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)*** aiming at performing joint research activity on the project "**REMME & DARP- Radioactivity Environmental Monitoring Measurements Evaluation and Dose Assessment for Radiation Protection purposes**" . The aim of *REMME & DARP* is to summarize the available information about dose assessment for the public on the basis of the environmental radioactivity data in the European Union.

International overview

The European Union includes 28 countries in the European continent, in 14 Member States there are 128 operating nuclear power plants (Figure 1) and almost 30% of them are distributed in only two nations Britain and France (respectively 22.7% and 5.9%).

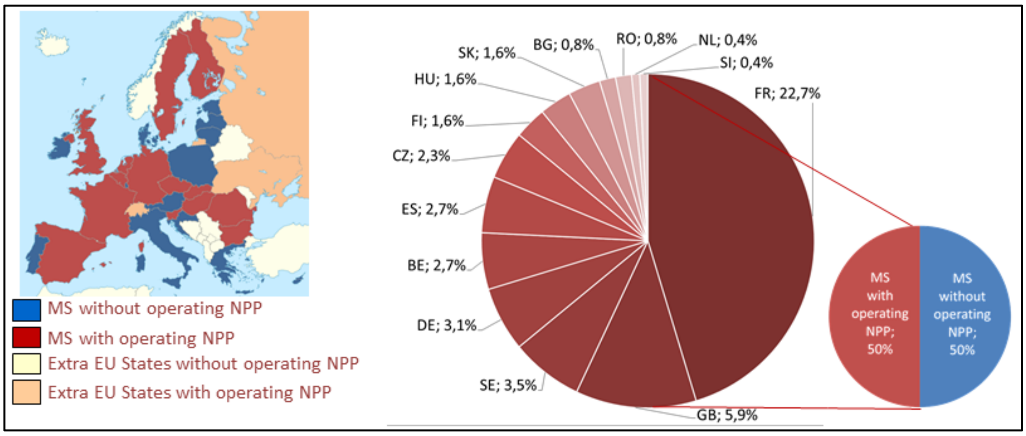

Figure 1 In 14 of the 28 Member States there are 128 Nuclear Power Plants (NPP). The states with the largest number of plants are France and Britain respectively with 58 and 15 nuclear installations.

One lesson learned from the experience during past incidents at nuclear plants is to assess globally the risk to the population in the European and extra European territory; it is obviously not possible to manage a nuclear or radiological emergency only in a national context.

The need for sharing information relating to the safety of the population has risen; the ***European Community Urgent Radiological Information Exchange (ECURIE)*** and the ***Radioactivity Environmental Monitoring (REM)*** database were instituted in the specific field of nuclear safety, managed by the European Commission as part of the Euratom Treaty applications. In addition, the ***European Radioactivity Data Exchange Platform (EURDEP)*** was established on the basis of bilateral agreements between individual member states and the European Commission.

Mobile based Application for Radiological Emergency Trainings

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SCK-CEN, Mol – Belgian Nuclear Research Centre Belgium)

Training is a core activity in preparedness for emergency management. Developing rich training experiences is crucial to ensure the readiness of emergency teams to respond to different crisis and situations. We present a mobile windows application to train emergency responders and different stakeholders for radiological emergencies. The work presented focuses on emulating the process of locating a lost source during training. The application supports emulating radiological measurements; in this poster we focus on the lost source scenario. We report on the application design and the different challenges to design the mobile application. We discuss the challenges of our future work. We show that our in progress approach is a practical useful technique to contribute to emergency exercises.

A semantic information service to support resilience after a nuclear accident

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In the last decade, people facing natural or human-made disasters have relied on social media to coordinate their response to the crisis. People - victims and volunteers - experiencing a crisis, have increasingly used social media platforms such as Facebook, Twitter or Flickr. In the aftermath of the Fukushima Daiichi nuclear disaster, people have used social media to gather more accurate information about radiation measurements than any other Japanese official source delivered.

Under the SCOPANUM project, we have conducted an exploratory study to analyse the diffusion of information produced by Twitter bots, and to assess their usefulness for citizens during the long-term period of a Nuclear Post-Accident situation. We have found that these bots mostly rely on citizen-powered radiometers that share their measurements through the Internet.

Even though Twitter bots are still quite popular three years after the accident, we have found that the information they deliver is not accurate enough to monitor the long-term radiological situation accurately. In fact, for example, we have observed the lack of some details about the measurement device, such as its degree of accuracy, and the place and time of the collected data.

On the strength of these outcomes and after having performed two survey with a bunch of nuclear experts and citizens, we have selected the most useful information and we have implemented them in a semantic Web service, called Ginkgo. This Web service, still under development, aims to support information access and sharing knowledge among the people affected by a nuclear disaster.

The SCOPANUM is a research project aiming to understand the use of Web Services during the resilience process during the nuclear post-accident phase. This project is a joint effort of ELLIADD laboratory and CEPN, supported by French Council for Strategic Research (CSFRS) and Montbéliard Metropolitan.

Session 5 – Stakeholder involvement and engagement in emergency and recovery

Four years of dialogue for the rehabilitation of living conditions in the area contaminated by the Fukushima accident.

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In November 2011, ICRP and a Japanese NGO launched the "ICRP Dialogue Initiative for the rehabilitation of living conditions in contaminated territories after the Fukushima accident" to allow local residents and professionals to share their concerns with experts from Japan and abroad and to find together ways to respond to the challenges in the areas affected by the accident. Twelwe dialogue meetings have been organized until the end of 2015 and an international workshop was held in Date City in december 2015 to draw the main lessons from these dialogue meetings.

One of the major lesson is the importance for the experts to work in cooperation with the local actors to help them to develop a pratical radiological culture to manage their individual situations. In this co-expertise process, the availability of measurements devices for the inhabitants is crucial to allow them to assess their own radiological situation. Measuring the radioactivity make it visible and allow them to discuss the results among the communities and build local projects to improve their daily life.

To be hepful, scientist need to understand that, as necessary as radiation protection is, it is not the only problem inhabitants are facing and it can not handle people's lives. It must be at the service of individuals and the community.

The webdocumentary Kotoba (http://www.fukushima-dialogues.com) has been realized to keep the memory of these dialogs and bear witness of the life in contaminated territories notably through the words of residents. It gather texts, audios, videos in three langages to be viewed in Japan, France, and wordwide.