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Summary report of the activities carried out during the ongoing reporting period

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SUMMARY REPORT FOR THE ONGOING REPORTING PERIOD (M49-M57)

Publishable summary

This document is the “D1.5-Fifth periodic report= Summary report of the activities carried out during the ongoing reporting period” and describes work carried out by CONCERT from June 2019 until February 2020

During the fifth year of the project, efforts have been devoted to keep track of tasks and project work and measure progress against predefined goals.

Work package 1 of CONCERT provides the financial, consortium and project management. The work carried out is result-oriented, aims at an efficient management of the project and quality control of results and deliverables as well as timely communication with the European Commission.

Through intensive collaboration with the nine CONCERT project-coordinators CONCERT ensures the smooth running of all CONCERT funded projects as well.

During the fifth year, the main activities in CONCERT **Work package 2** were to develop platform roadmaps for key research areas and to provide input and feedback to the joint roadmap. The work on long-term roadmaps of MELODI, ALLIANCE, NERIS and EURADOS has been carried out in parallel of the scenario-based joint roadmaps. Workshops on roadmaps for specific topics have been co-organised by the platforms and CONCERT and discussed during the European Radiation Protection Research Week in Stockholm 14-18 October 2019. Dissemination of the European radiation protection SRAs in global level has taken place in e.g. ICRP and OECD meetings.

CONCERT **Work package 3** focuses in the 5th year on updating the joint roadmap for radiation protection research, based on results of the consultations of Programme Owners, Programme Managers and Linked Third Parties, including the collection of information on national resources to fund research tackling the research challenges of the joint roadmap over the long-term, and the stakeholder group of WP5. The joint roadmap should provide the necessary information to enable the development of a long-term call plan, to enable research of high impact. Efforts have been done to align the joint and individual roadmaps.

Within this reporting period, Work package 4 was in charge of the follow-up of the nine research projects funded in the two CONCERT calls (three projects in call 1 and six projects in call 2). WP4 developed four different templates for the scientific reporting: one midterm report and one final report for each call, adapted to the respective topics and conditions. The collection of the midterm scientific reports for all 9 projects was successfully completed in March 2019. The collection of the final scientific reports started in November 2019 and was completed in February 2020.

To allow the EJP CONCERT to receive an independent assessment of the funded research, WP4 is currently organising the final evaluation of the nine funded projects.

CONCERT **Work package 5** concerns stakeholder engagement activities. In this reporting period, there have been three significant achievements: (i) Holding Stakeholder Group web meetings in 2019 and one face-to-face meeting in February 2020, (ii) substantial involvement in consultation amongst European radiation protection platforms on the evolving Joint Roadmap for Radiation Protection Research, and (iii) Revision of information on radiation exposure and risk to the CONCERT website (see <http://www.concert-h2020.eu/en/Stakeholders>) intended to inform public stakeholders.

During the last reporting period, the Work package 6 partners focused on the assessment of their common topic “Increase the visibility and use of key research infrastructures” in order to deliver a document which merges the four secondary tasks: (i) to develop a list of suitable infrastructures and to compile it in a database (ii) to prepare regular information about infrastructures, (iii) to develop actions to strengthen and expand databases from past radiobiological experiments and from stored biological material in STORE, (iv) to facilitate access to infrastructures.

Work package 7 of CONCERT is dedicated to education and training (E&T) for the development and maintenance of the expertise and competence of the community of research scientists working in the area of radiation protection research. The specific activities organised by the work package, and funded as integration activities, included: a) Setting up a programme of student travel grants to allow students to attend relevant training courses at other institutions, or attend conferences to present their work and b) Launching a call for short courses in topics important for radiation protection research, aimed particularly at students entering the field or young researchers.

As well as these initiatives, WP7 is holding an annual Forum in association with the European Radiation Protection Week (ERPW), to strengthen the integration of E&T institutions within radiation protection. WP7 contributed to WP2 and WP3 to promote the integration of E&T into research projects funding under the two CONCERT calls.

Work package 9 of CONCERT brings together RTD activities selected through two open calls for research projects launched by the CONCERT EJP in 2016 and 2017. In this reporting period, all nine selected projects have continued to perform the scientific work needed to reach the fixed goals.

At the ERPW2019 in Stockholm, Sweden 14-18 October 2019, CONCERT together with the ERPW organisers arranged the reporting of project results achieved so far to the scientific community of the funded projects in the respective platform session(s) during the ERPW.

Following the summary progress report of work per Work package carried out since 1st June 2019.

WP1 - Project coordination & management

Work carried out

The purpose of WP1 is to ensure the smooth and effective administrative and financial management of the project as well as reaching a good synergy between all partners. The overall objective of the managerial organisation is to provide necessary structures for participatory and efficient decision-making and coordination of activities, fluent day-to-day management, reporting to EC and supporting project activities respectively. Additionally WP1 is in intensive collaboration with the project coordinators in order to maintain continual supervision of funded projects to check their progress and to facilitate beneficiaries especially in view of financial assistance, project workflow and reporting.

The tasks of **Work package 1** have been implemented successfully. The project is on track and all the activities that were envisaged for the last year have been accomplished so far.

Task 1.1 – Overall legal, contractual, administrative management and financial management (BfS)

Planning and Co-ordination is led by the Executive Board (ExB) which is composed of WP leaders and is chaired by the coordinator. The ExB is responsible for aligning work across all WPs and through a continuous assessment of inputs and emerging results, make strategic implementation proposals to the Management Board (MB) that is composed of all beneficiaries, and the five research platforms MELODI, ALLIANCE, NERIS, EURADOS and EURAMED.

The following responsibilities have been allocated:

- Project coordinator: is responsible for the overall coordination of the project and for chairing ExB and MB as well as coordinating any issues with the EC.
- Project coordination team: is responsible for the daily management of the project including administrative and financial issues.
- WP and Task Leaders: are responsible for leading the work package/task according to the objective and description of work
- Project coordinators of funded projects: are responsible for the overall coordination of the respective and receive the necessary support of the CONCERT coordination team

The project coordination team answered numerous requests and prepared when necessary amendment to the GA of CONCERT.

Task 1.2 – Consortium, Executive and Management Board

Project meetings. During the last year, the following meetings were organised:

- Management Board meeting organised as satellite event to the European Radiation Protection Research Week in Stockholm, Sweden 14-18 October 2019
 - CONCERT had scheduled its MB meeting for the 14th Oct 2019 starting at 1pm until 5pm. It started with presentations of results/achievements by the coordinators of all nine CONCERT funded projects. The WP-leaders of CONCERT project gave reports about the work package achievements and future tasks. The coordination was reminding on duties to be done until the respective CONCERT projects ends and upcoming activities (deliverables, periodic and final reporting...)
- Each Work Package organised its own meetings as necessary during the ERPW.
- Meeting agenda and information on the venue were shared.
- During the meetings, partners reviewed the latest results and achievements of the different work packages and funded projects respectively.

Task 1.3 – Updating the rolling annual work plan (AWP)

No work on an AWP since CONCERT is in its final year and will end 31st May 2020

Task 1.4 – External Scientific Advisory Board (ESAB) for the evaluation of CONCERT

The ESAB received information about the CONCERT process as well as an overview of activities by the nine projects funded through the two CONCERT Calls. It will attend the final meeting of the project.

Task 1.5 – Negotiation of projects to be funded through open RTD calls

Within CONCERT, two major open RTD calls have been launched in 2016 and 2017, to support innovative research projects in radioprotection. Universities and research institutes from all over Europe and beyond had the opportunity to join research consortia and submit proposals. Comprising both CONCERT calls, 37 proposals have been submitted with nine projects funded in total.

The CONCERT partners have demonstrated with both open calls their wish to foster broad, international collaboration. This goal has been successfully achieved.

For more information please refer to the newly introduced deliverable 4.9. This document aims to summarise the outcome of both open transnational calls of the European Joint Program CONCERT to fund multidisciplinary innovative research projects in radiation protection.

Task 1.6: Funding decision process for integration activities listed in the approved annual work programme

Funding decisions on integration activities were made in the field on education and training (courses and grants) based on recommendations of WP7 and financial feasibility checks by WP1 by the CONCERT MB.

Task 1.7: Attracting new members to the CONCERT EJP Consortium

The aim of this task is to extend CONCERT's scope and its co-fund capability. Adding beneficiaries will be to the mutual benefit of the current consortium and the joining institutions and foster the integration of radiation protection research in Europe.

No further beneficiaries were added to the consortium

Task 1.8: Public CONCERT web page and a secure internal web-based workspace

The secure internal web-based workspace integrated with the project's public website to provide a medium for communication among project participants is maintained and looked after by SCK-CEN. The workspace allows the exchange of various types of information: datasets, results, coordination decisions, timetables, presentations, meeting agendas and minutes, and reporting among partners. It allows each partner, the work packages leaders, and the coordinator to regularly monitor progress in data collation, analysis, and accomplished deliverables.

The public website is designed to act as an information hub about the objectives, activities and results of CONCERT and serves as a prime public dissemination tool making available the project published materials. The website is being updated on a regular basis to keep the audience informed and ensure continued interest of already attracted visitors. In collaboration with WP5, information of interest to the public on radiation protection was collected (<http://www.concert-h2020.eu/en/Stakeholders>) and will be further elaborated during the course of CONCERT.

Task 1.9: Establishment of an expert database for the reviewing processes of CONCERT

The expert database has been set up as planned in year one. Experts from all over the world were proposed by the radiation protection research platforms and were contacted by the coordinator to inquire their willingness to serve as expert in the CONCERT call evaluation. The expert database was provided to WP4 to be used during the two CONCERT call evaluation processes.

Milestones and Deliverables

D1.5 Fifth summary progress report to the EC in accordance with the provisions of the consortium contract

WP2 – Integration and SRA development in radiation protection research

Work carried out

The main WP2 objectives for the fifth project year were:

- To provide input to Joint Programming (WP3) from all fields covered by WP2.
- To successfully complete the work for the preparation of the SRA on social sciences and humanities
- To find the best possible ways to implement the BSS in Member States.
- To develop roadmaps for research based on the SRAs

There are now six RP research platforms (MELODI, ALLIANCE, NERIS, EURADOS, EURAMED and SHARE), all well established and organised, having working groups for SRA development, infrastructures and E&T activities. The SRA working groups / RTD Committees nominated by the platforms developed SRA Statements on current research needs and identified research priorities.

During the fifth year, last updates of SRAs during the CONCERT EJP were reported in Deliverable D13. The updating of SRAs was initially foreseen to take place on a 5-year interval, which was considered as a suitable strategic planning period. The draft SRAs were typically prepared by the SRA working groups followed by an open consultation among the members as well as by any other interested party. Workshops organized by the individual platforms and, more recently, the European radiation protection week jointly organised by all RP platforms were used as a forum for the dialogue. Comments and feedback have also been collected via web and by e-surveys.

During CONCERT, the platforms have provided their annual statements on current research needs in order to guide the preparation of call texts for CONCERT as well as the Euratom work programs. Even though no calls are expected by the CONCERT or Euratom during 2020, Annual Statements on research priorities were prepared by the associations, hoping that highlighting the current research priorities will be helpful in the transit to Horizon Europe and for the radiation protection R&D programming at the national level. Planning for the next EU research framework, Horizon Europe, is underway and these Statements strongly recommend the continuation of EU-funded radiation protection research to ensure that citizens are adequately and appropriately protected from radiation health risks. This is at a time when exposures are increasing in the medical area, with continued concern of members of the public in areas surrounding nuclear installations, and when terrorist threats remain a concern for many.

The work on long-term roadmaps of MELODI, ALLIANCE, NERIS and EURADOS has been carried out in parallel of the scenario-based joint roadmaps. Workshops on roadmaps for specific topics have been co-organised by the platforms and CONCERT and discussed during the European Radiation Protection Research Week in Stockholm 14-18 October 2019. In the global level, dissemination of the European radiation protection SRAs has taken place in e.g. ICRP Committee meetings, OECD meetings and Radiation Research Society meeting.

Updating of the SRAs provided fresh input to the Joint Roadmap developed in WP3.

Task 2.1 (MELODI)

Key activities during year 5 were:

- The MELODI SRA to be updated by month 54.
- The list of priorities based on the updated SRA is prepared by month 54. Subject to extra funding, this is input to Joint Programming (WP3).
- Developing long-term roadmap
- Evaluate the impact of draft joint roadmap scenarios on SRA

A joint MELODI-CONCERT workshop on non-cancer effects of ionizing radiation was organised in Sitges, Spain, on 10-12 April and the main conclusions were reported in the ERPW2019 in Stockholm. Based on the workshop outcome, a set of review papers on state-of-the-art of research and recommendations for future research on cardiovascular/cerebrovascular effects, effects on the eye, cognitive effects, effects on the immune system, effects on the metabolic system, covering clinical, epidemiological and experimental aspects is being prepared, with the objective to publish them in Special Issue of Environment International during 2020. MELODI has been updating the SRA frequently, almost every year. The current version is from 2019 and passed the consultation round in November 2019. The research issues are restructured into two topics relating to disease types and two cross-cutting issues:

TOPICS

- (1) Dose and dose-rate dependence of cancer risk
- (2) Non-cancer effects

CROSS-CUTTING ISSUES

- (3) Individual variation in risk;
- (4) Effects of spatial- and temporal-variation in dose delivery

Task 2.2: (ALLIANCE)

Key activities during year 5 were:

- The ALLIANCE SRA to be updated by month 54.
- The list of priorities based on the updated SRA is prepared by month 54. Subject to extra funding, this is input to Joint Programming (WP3).
- Developing long-term roadmap
- Evaluate the impact of draft joint roadmap scenarios on SRA

ALLIANCE published its 3rd version of SRA and the final draft has been kept open for further consultation. The previous full version is the one released in 2014 after incorporation of more than 100 comments from a wide panel of stakeholders. The updated version, prepared for November 2019, is consistent with the radiation protection R&D challenges as expressed in the joint roadmap from CONCERT, alongside recommendations from the ALLIANCE External Scientific Advisory Board (ESAB) as reported in CONCERT D2.5.

The ALLIANCE has focused its research around three challenges:

1. To Predict Human and Wildlife Exposure in a Robust Way by Quantifying Key Processes that Influence Radionuclide Transfers and Exposure
2. To Determine Ecological Consequences under Realistic Exposure Conditions
3. To Improve Human and Environmental Protection by Integrating Radioecology

The updated SRA examines new drivers of the radioecology SRA since the 2014 publication and new research topics covered by the SRA, according to the needs expressed by the five topical roadmaps WGs - Marine radioecology, Human food chain modelling, Naturally Occurring Radioactive Materials (NORM) Radioecology, Transgenerational effects and species radiosensitivity, Atmospheric dispersion and transfer processes. To help the identification of new research lines and new drivers, ALLIANCE organised topical workshops addressing the different roadmap areas.

Task 2.3 (NERIS):

Key activities during year 5 were:

- The NERIS SRA to be updated by month 54.
- The list of priorities based on the updated SRA is prepared by month 42. Subject to extra funding, this is input to Joint Programming (WP3).
- Developing long-term roadmap
- Evaluate the impact of draft joint roadmap scenarios on SRA

NERIS published an updated version of its SRA in November 2019. The process of updating took into account comments and feedback collected from European and international stakeholders, as well as the other RP platforms in roundtable discussions on the SRA and the Roadmap. A dedicated meeting of the NERIS R&D Committee was organised during the ERPW 2019 in Stockholm in October 2019 to consider the stakeholder feedback.

The three main research areas are in the NERIS SRA are:

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

Task 2.4 (EURADOS)

Key activities during year 5 were:

- The EURADOS SRA to be updated by month 54.
- The list of priorities based on the updated SRA is prepared by month 54. Subject to extra funding, this is input to Joint Programming (WP3).
- Developing long-term roadmap
- Evaluate the impact of draft joint roadmap scenarios on SRA

The updated **EURADOS** SRA was sent for consultation during 2019 and finalized in January 2020. EURADOS has five main visions:

1. Updated dose concepts and quantities
2. Improved risk estimates deduced from epidemiological cohorts
3. Efficient dose assessment in case of radiation emergencies
4. Integrated personalized dosimetry in medical applications
5. Improved radiation protection of workers and the public

The previous SRA was published in 2014 as a EURADOS report. A new structure of the SRA was discussed and decided previously upon in the EURADOS Council meeting in June in Bologna. For each challenge of the existing SRA, an individual roadmap was developed. These individual roadmaps were combined and used as input for the joint CONCERT roadmap.

Task 2.5 EURAMED:

Key activities during year 5 were:

- The EURAMED SRA will be updated by month 54.
- The list of priorities based on the updated SRA is prepared by month 54. Subject to extra funding, this is input to Joint Programming (WP3).
- Developing long-term roadmap.
- Evaluate the impact of draft joint roadmap scenarios on SRA
- Organising meetings with stakeholders in the medical scientific community.

CONCERT Task 2.5 was about development of Research Agenda, roadmap and priorities for research with the medical scientific community. Since October 1st, 2017 **EURAMED** is a non-profit organisation registered in Austria. The first version of the EURAMED SRA was published in 2017 in Insights into Imaging journal. As the association was established and the SRA prepared only a couple of years ago, during three open consultations

over the last two years only very few points for optimization has been raised, and there was a Euratom call for the further development of medical RP roadmaps, EURAMED continued to use the 2017 SRA. There are five main research topics:

1. Measurement and quantification in the field of ionising radiation
2. Tissue reactions and biological radiation risk
3. Optimisation of radiation exposure and harmonisation of practices
4. Justification of the use of ionising radiation in medical practice
5. Infrastructure for quality assurance

Task 2.6 (SHARE):

Key activities during year 5 were:

- The list of priorities based on existing SRA is prepared by month 54. Subject to extra funding, this is input to Joint Programming (WP3). Organizing reflection groups with professionals and experts with expertise in social sciences and humanities applied in radiation protection-related topics.
- Meeting(s) of reflection groups interested in social sciences and humanities, with focus on ethics, risk perception and risk communication, and safety culture.
- Stakeholders in social sciences and humanities are consulted.
- Subject to extra funding, input to Joint Programming is provided by identifying joint research needs and priorities.

SHARE was established as an association in July 2019. SHARE SRA has been developed as part of the CONCERT Task 2.6 and build on the FP7 projects OPERRA. It was developed using a stakeholder consultation and dialogue approach. This process was initiated by social scientists at the annual RICOMET conferences (2015, 2016, 2017, 2018 and 2019), and the International Symposia on Ethics of Environmental Health (2014 and 2016) and included other dialogues with members of the radiological protection research platforms. In March 26, 2018, the SSH SRA was presented at the Society for Risk Analysis community and Science and Technology in order to collect input from broader SSH community.

There were two initial motivations in task 2.6: The first one was to stimulate an ethics of reflexivity on the interaction between nuclear science and society, the degree to which radiation protection research responds to social and ethical concerns and how this can be stimulated and enhanced. The second one was integration of social sciences and humanities in radiation protection research. These motivations include a broad spectrum of research topics. Specific focus has been laid on the responsibility of science with respect to the justification of the radiation risk, radiation risk communication, radiation risk perception, and radiation culture. The SHARE association was established in July 2019 with 24 members (institutions, universities). The first version of the SRA has been published in International Journal of Radiological Protection in 2019 (ANNEX 6). SHARE has identified six main areas for research:

1. Effect of social, psychological and economic aspects on radiation protection behavior and choices of different actors
2. Holistic approaches to governance of risk
3. Guiding principles for responsible research and innovation in radiation protection
4. Stakeholder engagement in radiation protection research, development, policy and practice
5. Risk communication
Radiation protection culture

Task 2.7

Key activities during year 5 were:

- Contacts with Art. 31 group and HERCA will continue and possibilities for joint activities searched. Feedback on long-term roadmap scenarios will be surveyed.
- The work for the identification of national level research needs will continue.
- Subject to extra funding, input to Joint Programming (WP3) is provided by identifying joint research needs and priorities.

Task 2.7 deals with communication of knowledge from research and innovation conducted within CONCERT and outside laying the scientific basis for the revised European Basic Safety Standards. Contacts with HERCA and Article 31 Group have been continued. CONCERT members have participated HERCA workshops and workshop series organised by RISKAUDIT, discussing the challenges related to BSS transposition and implementation (risk management). This Task provided important input to the Joint Roadmap (WP3) as the regulatory perspectives and impact on society were largely taken into account in the formulation of the exposure scenarios and game changers (research priorities) of the Joint Roadmap.

Milestones and Deliverables

MS 13 Annual SRA platform statements and the SRA update 2019 was due by M54. This milestone was reached along the submission of D2.13, whereby Annual SRA Statements and SRA updates were published.

D2.13 Updating the SRAs of MELODI, ALLIANCE, NERIS, EURADOS and EURAMED was due by end of November 2019 (M 54). The deliverable was submitted on 5th December 2019.

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WP3 - Priority research and Joint programming needs in the perspective of European Integration

Work carried out

The draft joint roadmap version submitted in 2017 as deliverable D3.4 served as a basis to collect feedback from the wider research community and other stakeholders until mid-2019. Stakeholder involvement along the course of the development of the joint roadmap is important, since the joint roadmap is meant to be a guide to plan research and develop radiation protection tools for the benefit of the society. We received strong support from WP5, notably from the task responsible for the organisation of the CONCERT Stakeholder group, to collect comments on the joint roadmap version 2017: Various meetings were organised the past years to collect the points of view of different types of stakeholders in the CONCERT stakeholder group.

We organised on 21-22 May 2019 a meeting of the working group CONCERT WP2-WP3, to discuss the comments received from these different stakeholders and end users, and to discuss which elements should be added to D3.4 to become a real joint roadmap. The Joint Roadmap was defined as a view of the research challenges in the context of existing and potential exposure scenarios, relevant from societal and radiation protection points of view.

On 8/10/2019, a first web meeting was held with the WP2-WP3 working group to agree on a new structure of the joint roadmap, and to define the actions for the different members of the WP2-WP3 working group within the different chapters. New elements in the second version of the joint roadmap are (1) how research can be of support in the different areas of radiation protection (principles, standards, practice), (2) planning research (3) priority setting, (4) resource identification, and (5) identification of the end users and stakeholders within the different research challenges, and (6) the game changers to enable priority setting and planning. Game changers are defined as research issues that, when successfully resolved, have the potential to impact substantially and strengthen the system and/or practice of radiation protection for man and/or the environment through 1) significantly improving the evidence base, 2) developing principles and recommendations, 3) developing standards based on the recommendations 4) improving practice. These game changers are strongly multidisciplinary, requiring input from the different research areas of the radiation protection research areas, demonstrating the “joint” character of the joint roadmap, needed to tackle the RP issues from the point of view of realistic or potential exposure scenarios. After the physical meeting on 16/10/2020 (at the ERPW 2019 in Stockholm) a series of virtual meetings were held on 7/1/2019, 26/11/2019, 6/12/2019 and 12/12/2019 to assess the progress and identify the actions to be carried out to finalise the deliverable. The work continued until the first week of January 2020, with submission of the joint roadmap on 8/1/2020. The deliverable was rejected and resubmitted on 10/2/2020. A meeting with the Stakeholder Group is planned 28/2/2020 in Paris, where the new version of the joint roadmap will be discussed. Other events in the pipeline are a WebEx meeting with OECD-NEA CRPPH, a presentation of the joint roadmap to the POMs prior to and during the final CONCERT meeting, and a presentation of the joint roadmap at the IRPA15 conference in Seoul in May 2020. We plan to publish the joint roadmap in a special issue of the IRPA15 conference, taking into account the comments received on D3.7.

Milestones and Deliverables

D3.7 Second joint roadmap: submitted M56; revised and re-submitted M57.

D3.6 If extra funding is available: Fifth Annual Joint Priority List submitted (M57)

WP4 - Organization and management of CONCERT open RTD Calls

Work carried out

During the fourth year of the EJP CONCERT, **Work package 4** was in charge of the follow-up of the nine research projects funded in the two CONCERT calls, three projects in the call 2016 and six projects in call 2017. For the scientific reporting, four different templates developed in WP4 were used: one midterm report and one final report for each call, adapted to the respective topics and conditions. The list of assessment indicators developed by WP4 was consulted for the development of the different scientific reporting templates.

The collection of the midterm scientific reports of all 9 projects was completed in March 2019 and the collection of all final scientific reports in February 2020. Projects that requested a prolongation will provide an updated final report latest on March 10, 2020.

WP4 is currently managing the final evaluation of the nine research projects funded by CONCERT. A panel of 5 international experts that already participated in the evaluation process of one or both CONCERT calls are currently reviewing the advancements and outcomes of the projects. The evaluation is based on two different steps: the remote evaluation of the scientific reports (midterm and final reports as well as available deliverables) and the presentations given by the projects representatives at the final meeting of the EJP CONCERT that the reviewers will attend. The participation of the panel in the CONCERT meeting will allow a direct exchange between the reviewers and the project representatives and will give the reviewers the possibility to direct questions to the teams of funded projects and to provide recommendations. The assessment reports on the follow-up (D4.3 and D4.6) of WP4 will contain the written reports on the evaluation given by the review panel. This final evaluation will provide the EJP CONCERT with an external feedback and analysis of the outcome, success and impact of the funded research projects.

WP4 will report on its work performed of the past years during the CONCERT meeting in March 2020 in Madrid and will provide support to the panel and its chair to present a first feedback on the assessment of the funded research projects the very last day of the meeting.

Milestones and Deliverables

MS23 Midterm evaluation of granted proposals from the 2nd call finished (M42) – The midterm reports of the second CONCERT calls are collected.

WP5 - Stakeholder involvement and communication in radiation protection research

Work carried out to date

CONCERT Work package 5 concerns stakeholder engagement activities; from the outset four main activities were envisaged: (i) Prepare a CONCERT stakeholder management strategy, (ii) establish a stakeholder panel, (iii) plan, launch and analyse a public facing survey, (iv) develop core information on radiation exposure and risk for the CONCERT web page. The CONCERT stakeholder group (task 5.2) continued its work in supporting the development of the Joint Roadmap for Radiation Protection Research by the European platforms. An important feature of this work has been a series of web meetings to discuss CONCERT projects, European Research Platform SRAs and the Joint platform Roadmap for European radiation protection research content (see the following table). It should be noted that the third meeting had to be cancelled due to too few participants. The

final meeting of the stakeholder group will be held on the 28th of February, 2020. It will be specifically dedicated to the presentation and discussion of the CONCERT joint roadmap.

Date	Topic	Roadmap challenges*	Invited projects	Invited platforms
19th February 2019 9.30-12.00	Social Sciences and Humanities	H	ENGAGE	SSH
16 April 2019 9.30-12.00	Dosimetry	D, E	PODIUM VERIDIC	EURADOS EURAMED
11th June 2019 9.30-12.00	Emergency & Recovery preparedness and response Legacy sites	F, G	CONFIDENCE, TERRITORIES, SHAMISEN- SINGS	NERIS, ALLIANCE
17th September 2019 9.30-12.30	Low dose effects	A-	LDLensRad LEU-TRACK SEPARATE	EURAMED, MELODI

WP5 supported the attendance of two scientists at ERPW2019, one providing insights into the modulation of tissue kinetics by low doses, the other to be a panel member for a discussion/consultation on the updated MELODI SRA. The WP also supported four speakers at other scientific meetings. .

Task 5.3 concerns development of stakeholder survey activities and the use of social media. In the current period, since the close of the survey for responses, an analysis has been undertaken and a draft report is available and under discussion within WP5 with a view to finalising in the near future. The analysis provides useful information on respondent's perception of radiation risks and their management. Additionally, the survey response provide insights into the information that respondents would find useful. Information on radiation exposure and risk has been developed and posted on the CONCERT website (<http://www.concert-h2020.eu/en/Stakeholders>). In addition to a Stakeholder landing page that integrates the information, sections covering 'What is ionising radiation?', Natural sources, artificial sources, health effects and radiation risks in context are available. The material draws on and integrates relevant resources available from trusted and credible sources elsewhere on the Internet. This information has been reviewed and minor modifications made in the reporting period.

Milestones and Deliverables

There were no deliverables and Milestones due between M49 and M57

WP6 - Access to infrastructures

Work carried out

The activities of the WP6 members have been concentrated on the organization and actions needed, in order to consolidate the ongoing steps of the four previous years. For that, the WP6 group has organized one meeting during this reporting period that was held in Stockholm, on October 16th 2019 during the 4th European Radiation Protection Week (ERPW).

As the group has to plan and write a big synthesis of the WP6 work for the next deliverable D6.6 "Publishing the web-Handbook including protocols issued from harmonization procedures" due for M60, numerous exchanges took place. To do this, we have created a detailed agenda with several key steps that have been achieved during this period. After the approval of the summary and the work to be done for the deliverable and for a potential scientific publication later, we have decided to identify a list of co-authors (internal and external

experts from the WP6 partners) who will be in charge to develop introductions for all the categories and subcategories of the webhandbook as they were defined (1) Exposure platforms: a) Low doses and low dose rates, b) Microbeams, c) Particular radiation qualities: ions, neutrons, alpha..., d) Internal contamination, e) Observatory sites, f) Metrology exposure platforms; 2) Databases, Sample banks & Cohorts: a) Databases, b) Sample banks, c) Cohorts; 3) Analytical platforms, Models & Tools: a) Analytical platforms, b) Models & Tools. This work has already been prepared with the help of three coordinators (one for each chapter). Also, a document with guidelines to help authors has been prepared. During the meeting, the discussion was focused on a revised agenda, and on new potential authors and chapters. The last step achieved for the period is the reception by the WP6 leader of all the first drafts of the introductions.

The publication of the classical monthly Bulletin: AIR² "Access to Infrastructures for Radiation protection Research" is now finished, with its last issue n°40 published in September. Efforts are now focused on special issues dedicated to the assessment of the CONCERT funded projects.

To implement our activities about dissemination an oral presentation entitled "Creation of video tutorials describing cytogenetic assays for dose exposure assessment" has been given during the ERPW in October. This talk was also supported by a poster and the possibility to see and discuss around the first MOOC (Massive Open Online Course) dedicated to cytogenetics: "The Dicentric Chromosome Assay". Moreover, a special session was managed by WP6 dedicated to "open access and sharing data". Finally a poster entitled "The STORE database; a platform for data and resource sharing in radiation biology, radioecology and epidemiology" was proposed.

To support activities related to "Harmonization, Practices and Protocols", three MOOCs are now available online:

- The Dicentric Chromosome Assay (<https://www.youtube.com/watch?v=ZG5ssFNI3Jc>)
- The Cytokinesis Block Micronucleus Assay (<https://www.youtube.com/watch?v=gc5uyTyHTrU>)
- The Premature Chromosome Condensation Assay (<https://www.youtube.com/watch?v=IECSDGTxOp0>)

Activities for establishing the strategy for facilitating access to infrastructures have been promoted through 2 actions, first by pushing infrastructures in the joint roadmap prepared by the WP2 and second, by constituting a pilot network of voluntarily partners with some infrastructures in order to answer to the EURATOM call NFRP-2019 2020 11 dedicated to education and training.

Milestones and Deliverables

There were no deliverables and Milestones due during this period.

WP7 - Education and training

Work carried out

Task 7.1 – Attracting and retaining students and junior scientists into the Radiation Protection research fields

Subtask 7.1.1 – Student travel grants

In order to further the policy of developing and maintaining expertise in the radiation protection research community, CONCERT is offering 10,000 € per year for travel awards to junior scientists. Support can be given for participation in a conference, a course or for an exchange visit to a laboratory, where this can be shown to be of value for increasing the applicant's involvement and knowledge/skills in current European research in radiation protection. There are four application deadlines per year: 31 March, 30 June, 31 September and 31

December. After each deadline a maximal sum of 2.500€ is paid out to the top applicants. The maximal level of support per applicant is 625€.

During this reporting period, there have been three application periods. The results were as follows:

- June 2019 4 grants
- September 2019 10 grants
- December 2019 12 grants

They were distributed among member States as follows:

- | | | | | | | | |
|------------|---|-----------|---|------------|---|----------|---|
| • Belgium | 6 | • Finland | 1 | • Poland | 1 | • Sweden | 3 |
| • Portugal | 1 | • Germany | 1 | • Spain | 1 | • UK | 5 |
| • Hungary | 2 | • Italy | 2 | • Bulgaria | 1 | • France | 2 |

The December 2019 call was the final for CONCERT.

Subtask 7.1.2 – Academic mobility in EU universities

This work was completed in November 2018

Task 7.2: Education and training as an essential part of dissemination and knowledge management within CONCERT

The purpose of this task is to promote E&T as an integral part of CONCERT-funded RTD projects, by requiring proposals to include evidence that due consideration has been given to the incorporation of graduate student involvement and the offering of new or specialist technologies as topics for E&T courses. The wording that was used for the two CONCERT calls was as follows:

“Education and training is an essential part of all activities within CONCERT. Proposals shall include a plan for integration of education and training into the research programme, with a description of the proposed activities. This must also give details of collaboration or involvement with academic departments, and of intended PhD thesis work, MSc project work, teaching seminars, ad hoc courses on the topics of the proposal, etc., where possible. The plan will be assessed as an essential part of the impact statement and will be considered within the evaluation procedure.”

A report on E&T activities such as student placement, courses seminars, workshops, etc. in the projects funded in the second CONCERT call in response to the requirement was completed and in June 2019 submitted as Deliverable D7.8

Task 7.3: Targeted E&T initiatives

During the time of CONCERT there have been five open calls for institutions to host short courses. The final call was held in the previous reporting period. The courses are all listed on the CONCERT page http://www.concert-h2020.eu/en/Concert_info/Education_Training. The final course will end on 29 May 2020.

Task 7.4: Coordination and collaboration on E&T policy and strategy

Subtask 7.4.1: Coordination and collaboration

A plenary session on education and training was organised and held 11:00 – 12:00 on Wednesday 16, at ERPW 2019 at Stockholm, Sweden. This was well attended and ended with a lively open discussion on the need for E&T to support the RP research community, and possible ways forward.

Subtask 7.4.2: Vocational training for experts foreseen in the new Euratom BSS directive

This subtask has been undertaken by Task 7.4 leader SCK-CEN and will be reported in D7.16 in month 60.

Task 7.5: European integration of junior scientist career development

A full morning session for early career researchers was organised by a committee appointed from UniPv, SU and NMBU, and held on Friday 18 October at ERPW 2019 in Stockholm. Plans were made to revive EU-RAYS (European Radiation Research Association for Young Scientists) with a more robust management similar to that of SWE-RAYS.

Milestones and Deliverables in current reporting period

- MS40** 5th Annual call for E&T initiatives (M51). Call text prepared and call announced M45
- MS45** 5th Annual meeting of interest groups (M54). Plenary session at ERPW reported T7.4.1 above M53
- D7.8** 2nd Report on E&T activities such as student placement, courses seminars, workshops, etc. in RTD Call 2, (M48). Delivered June 2019 (M49)

WP8 – Ethics

This work package sets out the 'ethics requirements' that the project must comply with.

WP9 - Research projects selected through CONCERT open calls

Work carried out

The objective of WP9 is to bring together RTD activities selected through two open calls for research projects organised along the CONCERT project. The nine different research tasks have been selected through the two transnational calls for proposals on “Radiation Protection Research in Europe” through the EJP CONCERT:

- Task 9.1 CONFIDENCE
- Task 9.2 LDLensRad
- Task 9.3 TERRITORIES
- Task 9.4 ENGAGE
- Task 9.5 LEU-TRACK
- Task 9.6 PODIUM
- Task 9.7 SEPARATE
- Task 9.8 SHAMISEN-SINGS
- Task 9.9 VERIDIC

BfS as leader of this WP will have the responsibility to follow up the progress of the different research projects.

Task 9.1 CONFIDENCE

First of January 2017, the CONFIDENCE (COping with uNcertainties For Improved modelling and DEcision making in Nuclear emergenCiEs) project started as Task 9.1 of CONCERT. The project focuses on identifying and reducing uncertainties in the release and post-release phases of an emergency. The latter includes the transition between the short-term post-release and recovery phases (e.g. the first year(s)). The following describes work performed between June 2019 and February 2020.

In SST 9.1.1, uncertainty propagation simulations have been carried out (subtask 9.1.1.2) for hypothetical accidental scenarios in Europe: the REM case study (two release scenarios, taking place at the Dutch power plant of Borssele, and two meteorological scenarios), the Western Norway case study (an accident occurring on a nuclear vessel in the Western Norway sea) and for the Fukushima accident. For each case study, the participants (seven for REM, two for Western Norway and six for Fukushima) used an ensemble of source terms and a meteorological ensemble and propagated them through atmospheric dispersion models. Ensemble

results provided by the different were compared. In the case of Fukushima, model-to-data comparisons were carried out by using graphical and statistical indicators designed to evaluate the quality of ensemble results. A special session at HARMO 19th conference in Bruges (3-6 June 2019) was organized to present these results. Within subtask 9.1.1.3.1, food chain propagation was carried out using one scenario of the REM case study. In this task, 50 outputs of atmospheric dispersion simulations were combined with different parameters of the food chain model, in order to take into account the uncertainties related to food chain parameters. Subtask 9.1.1.3.2 aimed at developing operational recommendations for the use of ensemble calculation in emergency response. In this task, two kinds of methods were investigated, whose goal was to reduce the computational time while keeping a good evaluation of the uncertainties. The first consisted of reducing the model run time for a single simulation, by means of numerical or physical simplifications. The second considered different ways of optimizing the number of simulations, by using clustering techniques (i.e. grouping together “similar” members of the ensemble to reduce their number) or sampling techniques (e.g. Monte Carlo methods). Some participants to the aforementioned propagation case studies applied these methods. Resulting gains in terms of computational time were assessed, along with the possible decrease in precision in the uncertainty estimate. Practical recommendations for the operational use of ensembles were then issued. The five reports describing the work carried out within these different tasks (three reports for the REM, Western Norway and Fukushima case, one for food chain propagation and one for operational recommendations) have been grouped within the deliverable D9.5.

In ST 9.1.2 measurement uncertainties of stationary and mobile monitoring systems were assessed, including the uncertainty due to iodine speciation in the monitoring of airborne radioactivity. Generally, the uncertainty budget was dominated by the detector environment (sites, vehicles) and by the uncertainty in interpolation but not by the measurement/detector uncertainty itself. Monitoring strategies were further developed to reduce the interpolation uncertainty by increasing the network density through deployment of mobile measurement systems. Data assimilation techniques, to combine modeling and monitoring data in the early phase, were successfully tested. A software for individualized dose calculation was developed, based on environmental monitoring input data and individual movement profiles through the contaminated area. Dose uncertainty was considered by an ensemble approach. The work on environmental monitoring and dose calculation was summarized in deliverable D9.7. Concerning individual dose measurements, a sensitivity analysis of thyroid doses was carried out for uncertainty evaluation. Dose measurements in personal objects (mobile phones, chip & SD cards) from external exposures were optimized in the low dose range and a methodology developed to estimate organ doses with uncertainties from these measurements (D9.10). The methodology behind the software for quick and efficient use in cancer risk assessment was published and summarized in D9.12. For application of the health risk assessment tool in the early phase, to aid decision making, tables of the different percentiles of the lifetime attributable risk per unit dose were generated, which can then be combined with prognostic dose data in a Monte Carlo approach to estimate the absolute number of expected excess cancer cases (and baseline cases) or the lifetime fractional risk, with uncertainties, in a given region of interest. This was realized for a simplified three age groups approach, for combined cancer outcomes and for females only (conservative approach), in order to limit the amount of information to be considered.

ST 9.1.3 produced three deliverable reports: (1) D9.15 — *An evaluation of process-based models and their application in food chain assessments*. This deliverable presented CONFIDENCE studies to evaluate a process-based soil-plant model for radiocaesium and also demonstrated how this model could be incorporated into the Food Chain and Dose Module for Terrestrial Pathways (FDMT), which is part of the European decision support system, JRODOS. The report additionally described the development of two process-based approaches for estimating the activity concentrations of Sr in crops. Finally, a summary of a consultation workshop held with end-users, to discuss the use of process-based models for soil-plant transfer and explore end-user reservations, was presented. (2) D9.16 – Evaluation of the importance of radioactive particles in radioecological models. For the first time, in this deliverable, a sub-model describing soil-plant transfer of radioactive (or ‘hot’) particle associated radionuclides was included into an established food chain model. It was demonstrated that in the

short-term after an accidental release there was little benefit in try to account for soil-plant transfer from radioactive particles in predictive models. However, in the longer-term failing to account for the behaviour of radioactive particles would likely underestimate radionuclide activity concentrations in crops (and hence animal products). Other potentially import processes associated with the deposition of radioactive particles which may need to be included into models to improve short-term predictions (e.g. deposition to and retention on plant surfaces) were highlighted. (3) D9.17 – *CONFIDENCE Overview of model improvements and future needs*. This report summarised all of the activities of ST 9.1.3 focussing on aspects not included in early deliverable reports (e.g. ¹³¹I interception and animal transfer studies, extrapolation approaches to predict radionuclide transfer when data are lacking, the establishment of a database of farm animal biological half-life values). A key element of the deliverable was the presentation of future research requirements with respect to the transfer of radionuclides in the human food chain, based on the activities of CONFIDENCE (ST 9.1.3), a consultation with end-users held in collaboration with the European Radioecology ALLIANCE, and a survey of Japanese scientist involved in post-Fukushima activities.

In ST 9.1.4, the second and last round of the Delphi study with stakeholders (SSST 9.1.4.2.2) was carried out between April and May 2019. A second questionnaire aimed at both creating a ranking of the most relevant issues and evaluating the uncertainties emerged during the stakeholders' panels, was designed. It was administered to the same sample than the 1st round providing feedback about the results of the first phase. As the first round, the questionnaire was translated to and administered in the language of each county or, alternatively, in English. The survey was available online in the WP4 dedicated webpage. In this study, the views of a sample of stakeholders from several European countries, concerning most important issues, objectives, challenges, and, additionally, about the uncertainties to be addressed during the transition phase of a nuclear emergency, have been conveyed. A prioritization that could be taken into account in the WP6 decision-making tool has been obtained. The deliverable D9.23 - *Prioritisation of preferences. Transnational stakeholder surveys results*, presents the results. The subtask 9.1.4.3, aimed to elaborate guidelines and recommendations to address and to improve the planning and the decision making process during the transition phase. The work has been based on the findings from the previous tasks, mainly, on the panel's results. Within this subtask, a categorisation of the uncertainties of concern, identified in the stakeholder's panels, was developed based in three dimensions: the first, referred to its location into the stages of the decision-making process; the second, based in six analytical categories, which framing the context of the decision situation and the sustainability goals to cover; and the third, according to the typology of the uncertainties and its relationship of knowledge with the actors and its influence regarding the own decision-making process. Based on the above classification, an exhaustive cross-country analysis of the results from stakeholders' panels has been carried out. At this end, an analysis grid was designed to extract the main findings and main uncertainties of each panel. A set of consolidated and structured results for each panel was the output. Finally, dedicated working groups, composed by the WP4 partners, were created to go in-depth into the different categories of uncertainties, extract general patterns at European level and to propose harmonised recommendations to deal with them. The deliverable D9.24 - *Guidelines and recommendations for decision making during the transition phase*, with the results of this work has been delayed to the M56, and, at the end of this reporting period, was under elaboration.

In ST 9.1.5, several national workshops have been carried out in subtask 9.1.5.3 and a report has been drafted, addressing uncertainties faced by the local actors and influence of emergency and post-emergency arrangements on their capacity to manage these uncertainties (D9.31). An additional workshop with international experts has been carried out in Bratislava (December 4, 2019) for subtask 9.1.5.4 to explore experts' interactions during nuclear emergencies and post-accident phases and their relations with the capacity of local actors to cope with uncertainties (D9.31). The workshop gathered 17 participants from 9 countries. Research conducted on social, ethical and communication aspects of uncertainty management has been finalised with recommendations for improved communication and stakeholder involvement related to uncertainties (D9.32) and guidelines on tools for communication of uncertainties (D9.29). Main results have

been presented and the final workshop of the CONFIDENCE project. Several scientific articles have been prepared, two of them are still in review process.

ST 9.1.6 further adapted and improved the MCDA software according to the feedback of the stakeholders and updates have been distributed in regular intervals, the last in December 2019. During the final workshop in Bratislava the third stakeholder exercise working with the MCDA tool was held. The results of all three workshops have been summarized into the report for deliverable D9.36 in which also the internal report with the title “The Various Meanings of Uncertainty”, that helped to better understand uncertainties, has been integrated. The indicators for robustness decision making were implemented into the JRodos system for demonstrating purposes and have been presented to and evaluated by the stakeholders during several workshops in 2019. The agent based system for modelling and simulating stakeholder decision making has been enhanced further by additional negotiation methods and multiple visualizations. Still the work focused on the understanding of the decision making process in European countries and the negotiation process between the decision makers. The latter one is documented in D9.35, completed in December 2019. Feedback in form of questionnaires filled by several CONFIDENCE members of different European countries has been evaluated and partly been integrated in the models. Also the announced joint work with WP1 lead to different visualisations methods of uncertainty maps which have been presented and evaluated in workshops of WP5.

ST 9.1.7 deals with education and training activities and dissemination of results. The training course under the task 9.1.7.1 “Use of uncertain information by decision makers at the various levels within the decision making process and its communication” was developed, prepared and conducted at VUJE, Trnava, Slovak Republic, 13-15 May, 2019 with 25 participants from 15 countries. The objective was to present guidance and recommendations for decision making in the post release and transition phase taking into account uncertain information. An objective of the course was focused on how to interpret, use and communicate uncertainties within the decision making process. Training the trainers and facilitators of national, regional and local workshops was one of the goals. The experience and very positive feedback on the training course developed and conducted in a very interactive and dynamic way influenced the preparation and development of the final CONFIDENCE dissemination workshop. The workshop under SST 9.1.7.2 “Do process-based models have a role in human food chain assessments” took place in September 9-11, 2019 in Madrid (CIEMAT) with a range of 40 stakeholders (industry, regulators, scientists and representatives from international organisations). The aim of this CONFIDENCE workshop was to discuss soil plant process-based models with a range of stakeholders to gain opinion on if stakeholders saw benefit in process-based model use and development. In part, this was motivated by the priority given to process based models by scientists (e.g. in the ALLIANCE SRA) versus a perceived lack of uptake of previously developed process-based models by end users. The CONFIDENCE course under SST 9.1.7.3 “Communication under uncertainty: Nuclear or radiological emergencies, radiation protection and other issues important to know for your (future) occupation” was designed to be applicable to a wide range of students and professionals, and to be adaptable according to the needs and background of the audience. The objective of the course was to build the capabilities, trust and confidence in radiation protection issues through engagement with the young generation via a series of lectures and round table discussions at crisis management, communication and media studies faculties. The set of courses have been prepared and conducted in Belgium (University of Antwerp, March 8, 2018), Spain (Universitat Pompeu Fabra, Barcelona , May 31, 2018 and University Polytechnica Catalonia (UPC), Barcelona, June 1, 2018), Italy (University of Milan, March 25 and April 16, 2019 and University of Milan-Bicocca, October 12, 2019), Norway (Norwegian University of Life Sciences, summer 2019) and Slovak Republic (Academy of Police Force in Bratislava, October 22 and 29, November 19, 2019) and NEA/IRPS (Nuclear Energy Agency International Radiological Protection School) held at Stockholm University in August 2018. The CONFIDENCE Dissemination Workshop took place in December 2-5, 2019 in Bratislava with participation of 88 experts. It was designed as an interactive and dynamic meeting focusing on the main achievements of the project. Results were communicated by oral presentations, posters, scenario-based facilitated discussions, working in groups, round table discussions and panel discussions. All materials from the CONFIDENCE dissemination workshop are available for downloading and use at the NERIS

Platform web page (web site: <https://eu-neris.net/home/newsletters/218-confidence-dissemination-workshop-coping-with-uncertainties-for-improved-modelling-and-decision-making-in-nuclear-emergencies-bratislava-slovak-republic-02-05-december-2019.html>). More than 30 articles on the CONFIDENCE project form a Special Issue of the Radioprotection journal (<http://www.radioprotection.org/>) will be published as Open Access. All work packages contributed to this special issue, therefore this is not mentioned separately. Many PhD students participated in the CONFIDENCE project and were successful in the finalisation of their Master and PhD degree thesis. As an example see the 'Science Slam' presentation of one of our PhD students: <https://bit.ly/2RvavNJ>. The education and training activities have been very successful and provided opportunity to build capabilities, trust and confidence in radiation protection issues, to strengthen capabilities of researchers, scientists and all stakeholders involved in the decision making and to disseminate the CONFIDENCE project outputs to wider community.

ST 9.1.8 deals with the operation of the CONFIDENCE project. The Management Board meets once per month to discuss the progress of the project, the next steps and initiate actions if necessary. This work package supported the coordinator and others in organising events, in particular the final dissemination workshop and the preparation of the special issue on CONFIDENCE. A final deliverable on the completion of the project was provided in December 2019.

Milestones and Deliverables

- D9.14** Published dataset on transfer in Mediterranean ecosystems (M46) (Delivered M46)
- D9.23** Prioritisation of preferences. Transnational stakeholder surveys results (M49) (Delivered M49)
- D9.30** Stakeholders' preferences and criteria for uncertainty management (M49) (Delivered M49)
- D9.7** Report on uncertainty reduction in external exposure assessment based on environmental monitoring data, including concept for identifying critically exposed groups (M51) (Delivered M52)
- D9.5** Guidelines for the use of ensemble calculations in an operational context, indicators to assess the quality of uncertainty modeling and ensemble calculations, and tools for ensemble calculation for use in emergency response (M53) (Delivered M54)
- D9.6** Software tool which allows the propagation of uncertainties to dose assessment models (in collaboration with Subtask 9.1.3) (M53) (Delivered M54)
- D9.10** Paper on external dosimetry using personal objects (M55) (Delivered M55)
- D9.12** Report on the risk assessment tool (M53) (Delivered M54)
- D9.15** An evaluation of process based models and their application in food chain assessments (M53) (Delivered M54)
- D9.16** Evaluation of the importance of hot particles in radioecological models (M53) (Delivered M53)
- D9.27** Paper on mental models associated to uncertainty management (M53) (Delivered M50)
- D9.28** Report on observational studies of emergency exercises (M53) (Delivered M48)
- D9.29** Guidelines on tools for communication of uncertainties (M53) (Delivered M53)
- D9.31** Report on international experts' dialogues (M53) (Delivered M54)
- D9.24** Guidelines and recommendations for decision making during the transition phase (M54) (Delivered M57)
- D9.32** Recommendations for improved communication and stakeholder involvement related to uncertainties (M54) (Delivered M54)
- D9.36** Report from stakeholder panels and workshops related to the application of the methods and tools developed in ST 9.1.6 (M54) (Delivered M55)
- D9.37** Visualisation approaches developed and tested in workshops and panels (M54) (Delivered M54)
- D9.17** CONFIDENCE: Overview of model improvements and future needs (M54) (Delivered M54)
- D9.39** Operating the CONFIDENCE project for 36 months (M55) (Delivered M55)

Task 9.2: LDLensRad

The EU CONCERT funded 'LDLensRad' project (Towards a full mechanistic understanding of low dose radiation induced cataracts) aims to bring together experts from across Europe to answer a number of key research questions on the topic of radiation effects on the lens.

During the current reporting period the focus has been on final generation and analysis of experimental data. The long-term imaging results can be summarized as follows: Significant effects of dose and dose rate have been identified in some models. However, for all models apart from the P2 *Ptch1*^{+/-}, P2 B6C3F1 wild type and *Ercc2*^{+/-}, all measured lens densities (19 mth post exposure) < 14.1% (which is 'clinically significant' in humans). Age and genetic background significantly contribute to cataract risk. In most mouse models: the effects of ageing and strain clearly outweigh the effect of IR dose or dose rate. For *Ptch1*^{+/-} P2 and *Ercc2*^{+/-} irradiated mice, the effect of age at irradiation is strongly influenced by genetic background. There are clear interaction effects (in dose, dose rate, age, strain and sex) so the impact of dose and dose rate is dependent on the status of these other factors.

Initial data on individual mechanistic endpoints is also being collated. The observed inverse dose rate response for DNA damage in the lens epithelium was published in late 2019 (Barnard et al., 2019).

The proliferation analyses completed to date in the PHE and HMGU mice indicate that IR reduces proliferation, with region of the lens epithelium (i.e, the nuclear or cortical areas), dose and dose rate all significantly involved. The morphology data indicate slow, but dynamic, development of opacities associated with radiation exposures of 0.5 - 2 Gy, 12 mth post exposure, with clear evidence of lens repair too, and gender and strain effects.

Regarding the NGS carried out at ENEA, initial analysis of miRNome identified miRNA indicative of a variety of well known radiation responses.

The lipidomic and proteomic work addressed the hypothesis that IR causes oxidative stress, leading to oxysterol formation from cholesterol and, ultimately, cataracts. Oxysterol levels were impacted with a trend of dose dependent increase, with differential responses in the lens nucleus and cortex.

Further analysis, including the in vitro work in support of the mouse studies on the additional endpoints, is ongoing.

Representatives of all partners and several Advisory Board (AB) members attended the Final Meeting (FM) 2019 organised in Rome on the 4th – 6th December 2019. In terms of scientific dissemination, over 50 poster and oral presentations have been given at national and international meetings to date and four peer-reviewed papers have now been published with two more submitted and a further ~10 expected. Of the project PhD students, Stephen Barnard "The effect(s) of dose and dose-rate of IR on early lens epithelial cell response and cataractogenesis" passed his viva in December 2019; Alice Uwineza: "Biological mechanisms underlying ionising radiation-induced cataracts" submitted in January 2020, and Daniel Pawliczek "Mechanism of cataract formation in mice exposed to moderate doses of ionizing radiation" is currently in progress, with submission expected before end June 2020.

The project AB members have been hugely important to the successful progression of the project to date. The most recent AB review, following presentation at the AM 2019, was very positive. For wider stakeholder engagement, the project ResearchGate site is well visited (<https://www.researchgate.net/project/LDLensRad-the-European-CONCERT-project-starting-in-2017-Towards-a-full-mechanistic-understanding-of-low-dose-radiation-induced-cataracts>). In addition, a final Stakeholder Dissemination meeting is being organized for March 2020, for public and scientific stakeholders (https://www.concert-h2020.eu/en/Events/HPRU_dissemination).

Overall, the project results can be summarized as follows: First of all, the partners have clearly demonstrated that both dose and dose rate of IR are important in terms of how the lens of the eye responds to the radiation. Importantly, doses as low as < 500 mGy, were found to cause quantifiable changes in the lens.

Further, our long-term studies clearly demonstrate that genetic background, age and sex are also involved in the response and, further, these factors influence each other. Taken together, the data also advance our understanding of how IR is involved in radiation cataract formation, though unanswered questions concerning mechanisms, latency and threshold still remain.

The LDLensRad data were obtained using animal and cellular models and human studies need to be carried out to better understand the mutual influence of these and other factors and, further, with the implication that the current radiation protection legislation and guidance might need to be reviewed in due course.

Milestones and Deliverables

The following Deliverables were submitted during this period:

- D9.40** Long term Scheimpflug imaging
- D9.41** Mouse stress/ communication studies
- D9.42** Mouse DNA damage studies
- D9.43** Mouse proliferation/ morphology studies
- D9.44** Mouse molecular studies
- D9.45** In vitro stress/ communication studies
- D9.46** In vitro DNA damage studies
- D9.47** In vitro proteomic, biochemical studies
- D9.48** Histopathological analysis
- D9.49** Behavioural analysis
- D9.50** Creation of statistical model
- D9.54** Progress summary and actions - year 3
- D9.57** Year 3 advisory panel report
- D9.58** Collation of manuscripts ready for submission

Task 9.3 TERRITORIES

The TERRITORIES project, led by IRSN, started on 01/01/2017 and finished on 31/01/2020, as it benefited of a one-month no cost extension. The final event was organised in Aix-en-Provence, 12-14/11/2019.

Subtask 9.3.1 (Quantifying variability and reducing uncertainties when characterizing exposure of humans and wildlife by making the best use of data from monitoring and of existing models), led by CIEMAT, targeted mechanistic fit-for-purpose knowledge for diagnosis and prognosis of the environmental behaviour of the radionuclides in different selected ecosystems.

A database (introduced in D9.59, delivered M50) has been created by PHE with data, from publically available information, or data created during the project. This database will be made publically available shortly.

D9.60 (delivered M50) concluded that sampling uncertainty is often the most important contributor to the total uncertainty of the measurement process, and TERRITORIES recommended that effort should be taken to explain and train laboratory staff in charge of performing sampling and monitoring campaigns in order to implement a method to quantify the sampling uncertainty.

D9.62 (delivered M47) provided methods and recommendations to calculate modelling uncertainties (including conceptual uncertainty, which is often not quantified), with examples also taken among the sites described in D9.59.

D9.61 (delivered M50) aimed to compare advantages and limits of process-based models compared to simpler ones for different context/scenarios and therefore proposed a method to quantify the improvement of the models, based in their accuracy and uncertainty. This method has been applied in all of the sites described in D9.59.

Subtask 9.3.2 (Reducing uncertainties when characterising exposure scenarios, accounting for human and wildlife behaviour, and integrating social and ethical considerations in the management of uncertainties), led by PHE, aimed to validate the added value of a realistic description of the exposure scenarios versus a generic scenario approach, and to integrate social and ethical considerations about uncertainties.

D9.63 (delivered M49) involved 7 partners (PHE, IRSN, BfS, DSA, SCK.CEN, STUK, University of Tartu) to look at variability in behaviour for most important exposure pathways with state-of-the-art reviews, associating 2 case studies related to Chernobyl deposits (human populations in a Belarus village, and reindeers in Norway).

D9.64 (delivered M49) delivered a proof of concept, illustrating the potential of socio-technical integration research (STIR) to enhance reflexive awareness among technical and social scientists of the uncertainties that accompany radiation protection research, specifically in the processes of modelling and dose and risk assessment. These uncertainties are of a technical nature but are bound up with various 'non-technical' considerations – economic, social, ethical, psychological, etc.

Subtask 9.3.3 (Stakeholder engagement for a better management of uncertainty in risk assessment and decision-making processes including remediation strategies), led by CEPN, and co-led by NRPA (new name DSA), developed methods for a holistic management of uncertainties associated with remediation (dose reduction, socio-economic cost, generated waste amount etc.) and for an integrated decision-making process. The work included structured dialogues with stakeholders (by means of panels or use of a serious game) to investigate how uncertainty management comes into play in decision making processes for existing exposure situations (D9.66, D9.67, D9.68, D9.69, all of them delivered M49), and a review and case studies (D9.70, delivered M49) on how to perform socio-economic analysis (WP3).

Based on the output of this work within subtask 9.3.3, but also done in the whole project, a series of recommendations have been proposed to manage two types of existing exposure situations, NORM sites and the long term situation after nuclear accidents. These recommendations address co-constructed monitoring, radioecological modelling, dose assessment tools (populations and biota), rehabilitation of living conditions, socio-economic aspects of remediation, etc. Outputs were discussed with a wide audience during the Final Event in Aix en Provence (12-14 November 2019) and final versions have been delivered at the end of the project.

Subtask 9.3.4 (Strategic and integrated communication, education and training), led by University of Tartu aimed to share with a wide audience (stakeholders and decision-makers, young scientists, students) the methodological approach and novel guidance documents developed. D9.76 (delivered M54) described the output of the workshop held in Oxford in March 2019 (audience: 100 people, including one third of students and early career professionals or post-doc). The website and blog have been continuously updated.

Milestones and Deliverables

All milestones have been reached and all deliverables have been delivered.

Task 9.4 ENGAGE

The ENGAGE project (“ENhancinG stAkeholder participation in the GovernancE of radiological risks for improved radiation protection and informed decision-making”) reviews why, when and how stakeholders – including wider publics - are involved in radiological protection. It addresses three radiation protection contexts: medical exposure to ionising radiation, emergency preparedness, response and post-accident exposures and exposure to indoor radon.

For task 9.4.1 (rationales and frameworks for stakeholder engagement) activities included the analysis of *rationales and frameworks for stakeholder engagement* based on document analysis and interviews with representatives of different international and national stakeholders. The results on rationales and frameworks for stakeholder engagement were analysed field by field as well as from a transversal view and reported in deliverables D9.85 and D9.86.

For task 9.4.2, the work on case studies of stakeholder engagement in practice in three investigated fields has been carried out and reported in deliverables. Case studies were selected to cover a broad range of participation practices, and attention was given to both formal and informal participation. In total, 15 national case studies of stakeholder engagement in practice have been developed and reported in deliverables D9.89, D9.90 and D9.91 and two journal articles. A special session on stakeholder engagement and a workshop have been organised by ENGAGE partners as part of the RICOMET 2019 international conference (1-3 July 2019).

For T9.4.3 The final report presenting the findings of the case studies on RP culture as well as a first set of recommendations (D9.87) have been elaborated, based on the results of the workshop organised in Athens (13-15 February 2019) These recommendations have been used to prepare the final ENGAGE report (D9.94).

For T9.4.4, the final project workshop has been organised in Bratislava (11-13 September 2019) (D9.88) and the final project recommendations (D9.94) were developed and discussed during the workshop with all participants. The report on knowledge base have been finalised and published (D9.92). The operation of the project has been reported in D9.93. Several dissemination activities have been undertaken: session on formal and informal participation hosted by ENGAGE at RICOMET 2019 (July 1-3, 2019, Barcelona), reporting on the ENGAGE project and/or its results: European Radiation Protection Week 2019 (Stockholm, Sweden, 14-18 October 2019), IAEA workshop on Communication and stakeholder involvement in Radon issues (4-6 June, 2019, Belgrade, Serbia), EANM’19 Congress, (October 12-16, 2019, Barcelona, Spain), Radon Risk Communication Workshop (Potsdam, 8-10 October 2019). Two scientific articles have been published, and a special issue of Radioprotection Journal with ENGAGE project outcomes (Open Access) is under development (May 2020), regular information sent to the ENGAGE stakeholder group.

A one month delay has been requested and approved for the organisation of the final workshop. A one month extension of the ENGAGE project has been requested and agreed for the finalisation of the ENGAGE project report with recommendations for stakeholder engagement (D9.94) and the operation of the ENGAGE project (D9.93). All other activities planned for the project were implemented and finished in time.

Milestones and Deliverables

- D9.83** Preliminary report on case studies (M46)
- D9.84** Stakeholder Workshop (M46)
- D9.85** Report on rationales and frameworks for stakeholder engagement in radiation protection in the medical field (part 1), nuclear emergency and recovery preparedness and response (part 2) and indoor radon exposure (part3) (M48)
- D9.86** Report on stakeholder engagement in radiation protection: transversal issues and specifics of different exposure situations (M50)
- D9.87** Final report on case studies, including recommendations and guidelines on building and enhancing radiation protection culture (M50)

- D9.88** Dissemination workshop (M52)
- D9.89** Report on venues, challenges, opportunities and recommendations for stakeholder engagement in the medical field (M52)
- D9.90** Report on venues, challenges, opportunities and recommendations for stakeholder engagement in emergency and recovery preparedness and response (M52)
- D9.91** Report on venues, challenges, opportunities and recommendations for stakeholder engagement in relation to indoor radon exposure (M52)
- D9.92** Knowledge base report (M55)
- D9.93** Operation of the ENGAGE project (M55)
- D9.94** Final report of the ENGAGE project (M55)

Milestones:

- Radiation protection culture workshop Athens (EEAE, 12 February 2019),
- Final project workshop: Bratislava 11-13 September 2019,
- Draft Report on stakeholder engagement in radiation protection: transversal issues and specifics of different exposure situations (M48),
- Drafts:
 - Report on venues, challenges, opportunities and recommendations for stakeholder engagement in the medical field (M50),
 - Report on venues, challenges, opportunities and recommendations for stakeholder engagement in emergency and recovery preparedness and response (M50),
 - Report on venues, challenges, opportunities and recommendations for stakeholder engagement in relation to indoor radon exposure (M50),
- Draft Final report on case studies, including recommendations and guidelines on building and enhancing radiation protection culture (M46),
- Draft Knowledge base report (M46),
- Draft Final report of the ENGAGE project (M52).

Task 9.5 LEU-TRACK

Within SST9.5.1.1 a Skype meeting was held in September 2019 to discuss the status of the project and deliverables. The most important achievements within LEU-TRACK were presented by the coordinator during the ERPW2019 in Stockholm in the frame of the extended CONCERT Executive Board meeting (14 October, 2019). LEU-TRACK final meeting was held in Munich, organized by HMGU on 4-5 December, 2019. During this meeting it was discussed the status of the deliverables still to be submitted, planned remaining experiments to be finished and publications to be prepared from project results.

During M49-57 five out of the six deliverables were submitted (D9.95-9.98 and D9.100). D9.99 dealing with project final report was re-scheduled for M 30 (March 2020) since the project was also extended for M30. Three out of the 4 proposed milestones for this period have been reached, one, deposition of data is in progress.

Within SST9.5.1.2, scientific results related to the project we represented at various domestic and international meetings. The most important LEU-TRACK related meeting was the satellite meeting “The role of extracellular vesicles in mediating ionizing radiation-induced bystander and systemic effects” organized jointly with SEPATE during the ICRR2019 in Manchester, UK, 25 August 2019. Four LEU-TRACK-related oral presentations were held. The great interest for this event was reflected in the number of attendees, which was approx. 200. Altogether one peer reviewed article and 15 communications at scientific meetings were completed during the first period of the project.

Within SST9.5.1.3 the most important educational and training event was the training course organized by PHE “Essential on Radiation Leukemogenesis” on 20-23 January 2020. During this event theoretical presentations and practical demonstrations were held by PHE colleagues and invited speakers, the number of attendees was 12, two young scientists from LEU-TRACK consortium members also participated at this event.

Within SST9.5.2.1, 2 and 3; animal treatment, sample collection and distribution among partners was finished and long-term follow up of the animals to monitor the influence of EVs on leukemogenesis was continued. At present the number of treated animals available for long-term follow-up is 761, which are being followed either until they become terminally ill or reach the age of 24 months, when mice are euthanized and investigated for signs of leukaemia or other diseases. At the time of this report, approx. 50% of the mice have been euthanized. So far, 9.8% of mice treated with 3 Gy TBI, 10% of mice treated with 3 Gy+3 Gy EV and 16% of mice treated with 3 Gy+0 Gy EV have developed AML. Until now, 1 mouse irradiated with 0.1 Gy had AML (1.1%) and no AML case was detected in solely EV treated or control mice. Nevertheless, other haematological malignancies are suspected based on the BM phenotype, which need to be confirmed by histology. Apart of haematological malignancies, a panel of other malignancies increased in irradiated and/or EV-treated mice, such as eye and liver tumours.

Within SST9.5.2.4 regarding analysis of EV phenotype, most EVs expressed integrins typical for mesenchymal stem cells (MSCs) (CD29 and CD44) (CD29 positivity 30.5%, 34.46% and 13.86%, while CD44 positivity 42.07%, 47.06% and 24.71% within vesicles from 0 Gy, 0.1 Gy and 3 Gy samples, respectively), thus MSCs seem to release the most EVs into the BM microenvironment. Decreasing of MSC-derived EVs after irradiation was consistent with the reduction of live MSC pool in the BM. Nevertheless, despite of shrinking subpopulations, certain surviving progenitor cells seemed to release more EVs after irradiation than in control (0 Gy) mice. Ratio of erythroid progenitor-derived EVs increased almost 8-times, Gr-1 positive EVs (released by granulocyte progenitors) increased 4.55 times after 3 Gy irradiation compared to the 0 Gy samples.

Within SST9.5.2.5 regarding analysis of bone marrow-derived EV miRNA cargo, analysis of the 0.1 Gy group revealed 4 significantly upregulated miRNAs with fold changes ranging from 8 to 13-fold. Pathway analysis of the top ten most significant up and downregulated miRNAs from the 0.1 Gy dose showed that the most relevant miRNAs regulated by the low dose target genes involved in endocytosis, cell cycle, MAPK signalling, ubiquitin-mediated proteolysis, leukocyte transendothelial migration, regulation of actin cytoskeleton and adherens junction. BM EVs from 3 Gy irradiated mice showed 20 miRNAs significantly regulated, out of which only 2 were downregulated. When comparing both doses, four different miRNAs were found to be statistically relevant in 0.1 Gy and 3 Gy: mmu-miR-761, mmu-miR-129-5p, mmu-miR-669g, and mmu-miR-34b-5p. Therefore, the 0.1 Gy response seems to be conserved in 3 Gy. All miRNAs have a higher fold change at 3 Gy when compared to 0.1Gy, suggesting a dose-dependent upregulation, rather than an on/off mechanism of upregulation. For miRNA analysis from plasma EVs received from NNK, miRNA sequencing analysis were outsourced to Arraystar (USA, <http://www.arraystar.com/>) due to the low concentrations obtained that didn't meet the nCounter technology minimum requirements. Next-generation sequencing was performed. Differentially expressed analysis showed two miRNAs to be the highest upregulated miRNAs in both doses. The top ten differentially expressed downregulated miRNAs showed that common downregulated miRNAs are present at both doses.

Within SST9.5.2.6 regarding proteomic analysis of bone marrow- and serum-derived EVs the total numbers of identified proteins were 310 and 2103 in serum- and BM-derived EVs. In the serum-derived EVs from mice treated with 0.1 Gy or 3 Gy TBI 91 and 106 proteins were deregulated, respectively. In the BM-derived EVs, 148 and 152 proteins were deregulated at 0.1 Gy or 3 Gy TBI, respectively. The majority of deregulated proteins in both EV types were involved in defence or stress responses or responses to a stimulus. In both EV types and at both IR doses there were 15 common differentially regulated proteins representing proteins responding to stress or stimulus or participating in the cellular defence.

Within SST9.5.3. 1, 2 and 3 phenotypical changes in the bone marrow subpopulations of EV-treated mice were analysed 24 hours or 3 months after treatment. Phenotypical changes after EV treatment in the different cellular subpopulations in the BM were very similar to direct IR effects both acutely (24 hours after EV injection) and in the long term (3 months after EV injection). Mostly affected cell populations included: 1) haematopoietic stem cells, the number of which decreased dose-dependently in the directly irradiated and EV-recipient mice both 24 and 3 months after the treatment; 2) lymphoid progenitors, the number of which decreased only after the high dose irradiation and treatment with EVs isolated from high dose irradiated mice; 3) granulocyte progenitors, where long-term decrease in the cell pool was more pronounced than the acute one. The rate of EV uptake in the BM and major EV acceptor cells was analysed. BM-derived EVs were fluorescently labelled and co-cultured with BM single cell suspensions. EV uptake was evaluated by FC. Both irradiation of acceptor cells and EVs increased EV uptake in certain BM subpopulations but irradiation of acceptor cells had a stronger effect. Changes in apoptotic rate, proliferation index and DNA damage of EV-treated spleen cells were analysed. The proportion of apoptotic cells in the spleens of leukaemic mice increased compared to non-leukaemic controls, DNA damage was slightly reduced, while the proportion of proliferating cells was not altered. Hematoxylin-eosin staining indicated more compact spleen morphology of the leukaemic mice. Changes in the oxidative status and antioxidant system in the spleen of mice treated with EVs was investigated. Mice exposed to EVs derived from the BM of high-dose irradiated animals showed changes similar to those found in directly irradiated counterparts, namely reduced expression of antioxidant enzymes (superoxide dismutase and catalase) and a tendency to lower SOD activity and higher concentration of oxidized proteins.

Within SST9.5.4 the aim is to identify radiation-related and leukaemia-risk associated biomarkers in human leukaemia patients subjected to irradiation. Patients with leukaemia (AML, ALL) were conditioned for stem cell transplantation at the Department of Radiotherapy, GUF, and blood samples were collected from 11 leukaemic patients before (d0) and after TBI with 2 x 2 Gy (d1) while 11 healthy donors served as controls. An ultracentrifugation protocol was established for EV isolation and EVs yielded typical EV markers (CD9, CD81 and TSG-101). The suitability of these particles for proteomic analyses to be performed at HMGU was confirmed. At HMGU, the proteomics analysis was done as described for the murine samples. Altogether, 255 proteins were identified. A clustering in principal component analysis was observed for healthy controls but not for patients. The analysis of the 27 deregulated proteins identified in serum-EVs from leukemic patients (d0-EVs) compared to healthy controls revealed a tight cluster of interacting proteins belonging to protein categories “defence response”, “response to stress” and “response to stimulus”. Similarly, the protein abundances in patient EVs 24 h after irradiation (d1-EV) were compared with EVs of the same patient before irradiation (d0-EV). Thirty-seven (37) deregulated proteins were found in the serum EVs of at least three out of five patients. The deregulated proteins were mainly plasma proteases, serum amyloids and glycoproteins, representing similar protein categories as before (“cellular defence”, “stress response” or “response to stimulus”). Due to a very low yield of miRNA that did not allow nCounter analyses, EV RNA was recovered from patients/donor serum samples by an miRNeasy Mini Kit (QIAGEN) and sent to a company (Arraystar, Rockville, USA) for next generation sequencing based miRNA analyses. All samples passed quality control and the miRNA profile analysis is currently being performed.

Milestones and Deliverables

Milestones:

Distribution of murine samples for total-body and bone marrow irradiated animals - completed
Collection of plasma from leukaemia patients and distribution of isolated EVs to partners - completed
Deposition of raw data generated by the project in publicly accessible database – in progress
Final meeting - completed

The following deliverables were submitted:

- D9.95** Evaluating radiation effects on EV phenotype and cargo – delivered
- D9.96** Evaluating leukaemia risk in irradiated +/- EV treated animals – delivered
- D9.97** Evaluating major cellular and molecular mechanisms mediated by irradiated EVs – delivered
- D9.98** Identification of human EV-related leukaemia markers and radiation exposure markers – delivered
- D9.100** Report on LEU-TRACK related dissemination and training activities – delivered

Task 9.6 PODIUM

The objective of PODIUM is to improve occupational dosimetry by an innovative approach: the development of an online dosimetry application based on computer simulations without the use of physical dosimeters. Occupational doses will be assessed based on the use of modern technology such as personal tracking devices, flexible individualised phantoms and scanning of geometry set-up. Because of the limited time frame, we will simultaneously use an intermediate approach with pre-calculated fluence to dose conversion coefficients for phantoms of different statures and postures. We will apply and validate the methodology for two situations where improvements in dosimetry are urgently needed: neutron workplaces and interventional radiology.

ST9.6.1: Dose simulations input: staff movement monitoring and radiation field mapping

The indoor positioning system (IPS) for PODIUM must be able to recognize the presence of a human body (or more than one) in a workplace, identify its posture and measure with accuracy the position of relevant human joints in 3 Dimensions. In the previous periodic report has been described a solution based on the use of a single sensor. Subsequently, a solution based in a multi-sensor proposal has been developed and tested with two sensors. For the interventional radiology workplaces this also comprises the calibration of the system to refer the skeletons' positions to a world reference point placed at the C-Arm isocentre. The system is able to provide with isolated 3D data belonging to the main worker. The main worker is identified at the beginning of the intervention as the one who raises one of their hands over the head.

In the case of radiology, the technical parameters of the x-ray beam shall be obtained from the Radiation Dose Structured Report (RDSR) files; new format files (DoseWise system) have been investigated. As regards the radiation look-up tables approach, the radiation field lookup table includes the data used for characterizing the field in the so-called scatter sphere and ray tracing approach. Several simulations with MCNPx 2.70 transport code have been carried out to store relevant data in a series of scatter fluence files corresponding to a fixed set of input source parameters, which include machine parameters (kVp, primary and secondary projections, filtration, focal spot position relatively to the patient body etc.) and types of patient body. Each scatter fluence file contains the energy spectrum of the photon fluence found on a sphere centered in the focal spot of the C-Arm.

The radiation field lookup table containing the scatter fluence files have been integrated in a dedicated software named IPP_SE, which is run directly by PODIUM's web-application.

ST9.6.2: Dose simulations using computational phantoms and Monte Carlo methods

Firstly, a library of pre-calculated fluence to dose conversion coefficients is provided (a) for phantoms having reference statures and non-reference postures and (b) for phantoms having various statures. This library of dose conversion coefficients can be used as a first approach of the fast, online dosimetry application for workers in realistic workplaces. The numerical data of the conversion coefficients were uploaded in the STORE database and can be found at [DOI:10.20348/STOREDB/1156](https://doi.org/10.20348/STOREDB/1156).

Secondly, two fast MC systems (MCGPU-IR and PENELOPE/penEasy) have been developed for its application in hospitals for interventional radiology procedures. The two tested codes provided acceptable results in simulation times that can be lower than 20 s (CPU/GPU use time) per simulated irradiation event. It is worth

mentioning that one of the main advantages of MCGPU-IR is the calculation of the effective dose, E , which cannot be measured directly because physical detectors can only determine the operational quantities. This code requires much lower computing time to calculate E than to calculate $H_p(10)$.

ST9.6.3: Development of the Dosimetry online Calculation Application

The goal of WP3 was to develop a user-friendly application that combines all the developments made within the PODIUM project and allows non-specialist users to assess and follow up staff doses. A set of requirements was listed for this so-called Dosimetry online Calculation Application (DCA). The technical modules for staff tracking and dose calculation were developed as external modules by the PODIUM partners. However, they had to be connected with the DCA.

Users work with the DCA by logging in to a user-friendly web application. Each user has its predefined roles. The whole process flow is implemented in a logic and easy to follow way. First room, radiation source and worker data have to be inserted in the database. Then a procedure can be defined and created. Once connection with the locally installed tracking system is made, the procedure can be started. After finishing the procedure the tracking file is uploaded automatically by the tracking system. The RDSR file containing the radiation source data has to be uploaded manually because direct communication with the C arm is not yet possible. Then the dose can be calculated with the dose calculation method of interest by connecting with the locally or remotely installed dose calculation system. Finally, the radiation protection expert and workers can consult the calculated doses. The DCA was already successfully tested in clinical practice. The first tests were always partial because the DCA was still under development. However, it proves the feasibility of the PODIUM approach.

ST9.6.4 Assessment and validation of the online dosimetry application in hospitals

Work on the clinical validation continued and intensified during the period. The measurement continued and two more clinical validations were performed at the Swedish hospital. During these treatments, several dose meters were used by the operator, which gave the opportunity to compare simulated values in several positions on the body. Validation was challenged by low dose levels and the use of radiation shielding. The validation also included testing of the two camera systems during a clinical case.

At the Irish Hospital, IPS equipment was installed in two operating rooms, one endovascular suite and one room where cardiovascular treatments were performed. A special technical solution for extracting data from one of the X-ray machines was necessary, as it was not easily available. The recruitment of patients and operators was successful and approximately five suitable procedures from both rooms were recorded for validation.

On both validation sites, significant work was done on manual processing of collected data. The data from the X-ray machine must be handled but also data from IPS needed manual work. The simulations were performed for most of the mapped treatments. Various simulation methods as well as lookup table method were applied for these cases. The results from the calculations differed in some cases. These findings provided input into the understanding of calculating difficulties for these type treatments. Substantial difference between calculated and measured could also be seen. This requires a detailed analysis.

The effective calculations of dose and organ dose still need to be developed and validated. So far, only the quantity $H_p(10)$ has been used in both measurements and calculations. That is, the phantoms to be used that simulate the operator in the calculations have not yet been fully evaluated.

However, the validation in the clinical setting provided valuable information and identified several problems that must be addressed when calculating radiation doses to staff this environment. We can also identify important issues that must be solved in order to make it possible in the future to adequately determine organ doses for staff without involving measurements of radiation.

ST9.6.5: Assessment and validation of the online dosimetry application in mixed neutron-gamma workplace fields

Work on the characterization of the PHE simulated workplace field continued: using the DIAMON instrument for spectrometry and further innovative modelling to set up the effective dose rate map for the facility. When combined with people tracking using the Kinect, it was demonstrated that effective doses as low as 1 μSv could be estimated, a factor of 100 better than could be achieved using personal dosimeters to estimate $H_p(10)$.

The SCK•CEN field was characterized using survey instruments, Bonner spheres and the DIAMON. The MCNP model of the field was set up in parallel to this and the source term optimized with reference to the spectrometry results. Personal dosimeters were evaluated using long exposures to be compared against MCNP calculated reference values determined for each face of a slab phantom, with the distribution across the face also being calculated. Tracking using the Kinect demonstrated that the technology could track staff moving in this real workplace. Additional neutron conversion coefficients were calculated for this field because the geometry indicated that there would be a strong component of the field incident on a person from low angles. These conversion coefficients were required to generate the effective dose map.

Studies were performed to evaluate the advances required for real time effective dose modelling in anthropomorphic phantoms. These concluded that the issues with effective dose calculation in distributed energy neutron fields remain unresolved and that computational advances are required. However, the effective dose rate map method developed in PODIUM has proved that effective dose can be estimated without real time modelling.

ST9.6.6: Dissemination of the project results

The exploitation was finalized to include the roadmap on how consortium partners intend to use project results in future activities, in further research and development and possible product marketing strategies. The document defines all the important details about the exploitation of the results of the project, the impact in the relevant research and development fields and the individual strategies of the project partners. The plan also includes a modern strategic tool, the business model canvas, used for PODIUM applications and the BFMULO Matrix implemented for each exploitable result and for each partner.

Another activity performed during the last 6 months of the project is the organizations and the conduct a workshop jointly organized with European ALARA network (EAN). The main objective of the workshop was to emphasize and to discuss the ALARA principle and to present the advantages of online dosimetry systems in routine practice.

The joint workshop was held in the Congress Center of the National Centre for Scientific Research “Demokritos” and in the facilities of the Greek Atomic Energy Commission in Athens, Greece. On the 26th November 2019 the results of the PODIUM project were presented while from the 27th to the 28th of November the 19th European ALARA Network presented the “Innovative ALARA Tools”. The workshop was divided into 4 sessions, where the objectives, methodology, results and future work of each work package were presented and discussed. The total number of participants registered to PODIUM workshop was 49 but finally 45 of them participated.

The main outcome of the workshop is that the feasibility study by PODIUM over two years has been a success. The technology is now available for tracking people to be monitored, calculating doses in a fast way (using a look-up table approach/dose mapping or Monte Carlo calculation). Detailed and personalised phantoms are also available. Some limitations and challenges that remain were presented. Future work plans were described along with how PODIUM fits in with the TRL (Technology Readiness Levels) defined by H2020. Overall the conclusions of the project are very promising.

Milestones and Deliverables

The following deliverables were submitted in the reporting period (M49-M57):

- D9.111** Report summarizing the feasibility of the methods, and the accuracy of personal dosimetry in the real workplace (M49).
- D9.112** Criteria for the approval of online dosimetry as legal dosimetry system (M49).
- D9.113** Report from the feasibility study performed in two hospitals (M53).
- D9.114** Report summarizing the experimental and clinical findings when using the online dosimetry application (M54).
- D9.115** Workshop (M54)
- D9.116** Fluence to dose conversion coefficients for reference phantoms and postures other than standing for photons and neutrons (M55).
- D9.117** Fluence to dose conversion coefficients for non-reference phantoms for photons and neutrons (M55).
- D9.118** User-friendly online application + manual (M55)
- D9.119** Report summarizing the computational developments needed to realize full online dosimetry using simulation of voxel phantoms in the workplace. (M55)
- D9.120** Exploitation plan (M55)
- D9.121** Final report (M55)

Task 9.7 SEPARATE

SEPARATE: “Systemic Effects of Partial-body Exposure to Low Radiation Doses” is an interdisciplinary project, combining in vivo irradiation, molecular/cellular biology, omics and bioinformatics to investigate how partial body irradiation (PBI) may have significant implications regarding systemic consequences and human health at low and intermediate doses of ionizing radiation. At the time of this report, almost all set objectives have been achieved.

In WP1, led by ENEA, after establishment of experimental measurements to ensure that the out-of-field effects under study were not the result of photons crossing the lead shield or deflected in the cap through the irradiated tissues, irradiations of all mouse groups were completed and samples distributed to partners.

In WP2, led by HMGU, by means of omics analyses we demonstrated that in-field and out-of-field irradiation cause nearly identical modifications in non-coding RNAs, proteome and metabolome at 15 days post-irradiation, especially after irradiation with 2 Gy. Through miRNome analysis based on NGS, we in fact observed changes in miRNAs in out-of-field hippocampus and heart 15 days after PBI with 2 Gy of X-rays that were also detected in corresponding tissue of whole body irradiated (WBI) mice. Similarly, proteomic and metabolomic profiles indicated that both WBI and PBI (2.0 Gy) induce similar effects 2 weeks after irradiation in the hippocampus. In contrast to hippocampus, the heart shows no similarities between WBI and PBI at the metabolic level (2 weeks and 6 months), although the proteomic and metabolomic responses of both WBI and PBI clearly differ from the sham-irradiated control. The impact of out-of-field irradiation on hippocampal neurogenesis was also evaluated and results clearly demonstrate that PBI causes progressive defects in the dynamic transition among neural stages in the dentate gyrus, and these defects are nearly identical to those induced by WBI. Alterations, mainly involving the stem cell compartment and self-renewal, point to a complex disturbance in the control of progression of neural stem cells into neurons by PBI. Irradiation with 0.1 Gy did not affect hippocampal neurogenesis in WBI or PBI groups. According to pathway analysis predicted by the significantly altered miRNAs in common after PBI or WBI, the impact of out-of-field irradiation on heart was focused on the evaluation of changes in the expression levels of genes and proteins related to radio-induced fibrosis. Results again showed high similarity in the expression of fibrosis hallmarks (fibronectin and collagen deposition) after WBI and PBI.

In WP3, led by OBU, the extraction and characterization of exosomes from 24 hour and 15 days post control, 2Gy WBI and PBI organs and plasma was completed and several relevant functional assays *in vitro* were performed in recipient mouse embryonic fibroblasts (MEFs) after incubation with exosomes from CN, PBI and WBI mice. Results demonstrate reduction of MEF cells viability, increase of DNA damage, induction of rapid calcium fluxes and production of ROS and NO in recipient MEF cells. The highest γ H2AX foci levels were observed in MEF cells treated with both WBI and PBI brain exosomes compared to CN, while plasma exosomes affect MEF cell DNA to a larger extent, compared to mouse organs, as shown by amount of DNA in comet tail and total chromosome aberrations. Exosomes from 15 days post IR mouse organs also induced DNA damage as shown with comet assays. However, overall DNA damage was lower compared to 24 hrs post IR samples, as there was no significant change in γ H2AX foci levels or chromosomal aberrations for all organ treatments in MEF cells. Exosomes from WBI, PBI and CN organs were also analyzed in terms of proteome. Proteomic analysis shows that the cargo of exosomes from different organs (whole brain, liver, heart) reflects primarily the main components of the organ in question. In the brain, the exosomal proteins belong mainly to compartments only found in the brain such as myelin sheaths, synapses or axons. In the liver, many exosomal proteins belong to the category of cytochrome P450 proteins (CYPs) and in the heart to the mitochondrial proteins. Changes in the miRNA cargo of plasma exosomes from 24 hrs post WBI and PBI mice with 2 Gy of X-rays were also analyzed by NGS and compared with controls. All miRNAs differentially expressed were up-regulated, regardless of irradiation condition; however, a higher level of differentially expressed miRNAs was found after WBI (n= 57) compared with PBI (n=13). Of note, 5 common miRNAs (miR-99a, 200a-3p, 200a, 182-5p and 182) were detected in exosomes from 2 Gy PBI and WBI samples, but not in exosomes from controls. Further investigations will be necessary to understand exosomes' role in mediating out-of-field effects. Finally, the involvement of exosomes in the propagation of radiation signaling through *in vivo* functional assays is an ongoing step. Exosomes (1.2×10^9) derived from 2Gy-PBI or 2 Gy-WBI plasma/organs, were intracranially injected in the brain of non-irradiated recipient neonatal mice and their cell internalization was demonstrated by fluorescence microscopy. We are now optimizing the experimental protocol to evaluate a possible apoptotic response in the exosome-injected brains.

Communication within the project was excellent. The consortium has met in person at: the Kick-off meeting (Rome, March 2018), the 1st Annual meeting (Dublin, December 2018), the Member Board Meeting (Rome, May 2019) and the Final Meeting will take place in Rome, 20-21 February 2020. Also, at the international meetings (i.e. ICRR2019 and ERPW2018 and 2019), the SEPARATE partners met & discussed the results and future planning. Administratively, all steps have been handled smoothly.

Milestones and Deliverables

The project has fully achieved the milestones for the period. The following deliverables were submitted in the reporting period (M49-M57):

- | | |
|---------------|---|
| D9.126 | Data set on proteomic and metabolomic changes in control, irradiated and shielded tissues |
| D9.127 | Data set on NGS-based miRNomes analysis in control, irradiated and shielded tissues |
| D9.128 | Report on the status of publications and manuscripts |
| D9.129 | Final report of the SEPARATE project |

Task 9.8 SHAMISEN-SINGS

SHAMISEN-SINGS, built upon the recommendations of the EC-OPERRA funded SHAMISEN project, aims to enhance Citizen Participation in preparedness for and recovery from a radiation accident through novel tools and APPs to support data collection on radiation measurements, health and well-being indicators.

The specific objectives are to:

- 1) Interact with stakeholders to assess their needs, and their interest in contributing to dose and health assessment, and evaluate how new technologies could best fulfil these needs. Consider lessons from current issues in Fukushima related to lifting evacuation orders and medical care for vulnerable population;
- 2) Review existing APPs for citizen-based dose measurements, and establish minimum standards of quality;
- 3) Review existing APPs/systems to monitor health and develop a core protocol for a citizen-based study on health, social, and psychological consequences of a radiation accident;
- 4) Build upon existing tools to develop the concept/guidelines for one or more APPs that could be used for:
 - monitor radiation to empower affected population and to contribute to radiation assessment of an accident's consequence, including visualisation of radiation conditions;
 - log behavioural and health information to be used, with appropriate ethics and informed consent, for citizen science studies.
 - provide a channel for practical information, professional support and dialogue.
- 5) Assess the ethical challenges and implications of both the APPs and citizen science activities through a consensus workshop.

The project started in month 29 of CONCERT. The progress between June 2020 and February 2020 (M49-57) is presented below:

Subtask 9.8.1. Stakeholders' needs

Work on this WP has been completed. The results were presented at the international conferences and meetings. A book chapter, that includes partial results, has been sent to be considered for publishing in a book (with an invitation to some participants of the ISEEH2018 conference in Budweis, Czech Republic) in October 2019. The article on the WP1 results is under preparation (expected to be submitted in April – May 2020).

Subtask 9.8.2 - Citizen participation in radiation measurements

Work in ST 9.8.2 has been completed – except for preparation of video tutorials that would be complementary to infographics for dose measurements for general public and the SHAMISEN SINGS Recommendations on apps use described in the manual or booklet (for the reference, see subtask 9.8.4). The draft versions of infographics are published in five languages in ResearchGate and distributed by mail for gathering any feedbacks from stakeholders (including general public) and to be discussed at the final stakeholder meeting in the 9th of March 2020.

Infographics: “How to measure radiation with your mobile phone”: in [English](#), [French](#), [Spanish](#), [Russian](#) and [Japanese](#) (versions for discussion at the final SHAMISEN SINGS meeting).

Subtask 9.8.3 – Citizen Participation in health and well-being monitoring

The task has been completed within the SHAMISEN SINGS project. Due to its complexity and relatively short time of the project live, finally the prototype was not possible to develop. Instead, we developed the Recommendations of its further development. Moreover, our colleagues from FMU (Fukushima, Japan) and leaders of this WP3 in the SHAMISEN SINGS project got a national grant to work further and develop with a support from the Japanese grant in the next 2 years. The summary of recommendations of the SHAMISEN

SINGS project on apps development and use are included in the final SHAMISEN SINGS booklet (for the reference see next subtask).

Subtask 9.8.4 Concept and specifications of App(s) and/or tools

The logistic and organization of this subtask had to be revised as one of the originally foreseen partners, which was to lead this subtask, moved to an institute in Luxemburg. Work was taken over by ISGlobal, with collaboration with ISS and some contribution from FMU and IRSN. An van Nieuwenhuyse, who was initially going to lead this subtask, has been collaborated as an expert.

Final results of the SHAMISEN SINGS project are represented in the booklet which will be published under CC license, in a pdf format to be download and printed in the end of March 2020.

This booklet contains:

- 1) Recommendations on dose measurements for three types of stakeholders (apps developers; users – general public and third users of the gathered information – local authorities);
- 2) Recommendations for health and welfare indicators apps development and use;
- 3) General data management plan, and
- 4) Ethical issues related.

The draft version the booklet is published in ReserachGate and distributed by mail for gathering any feedbacks from stakeholders (including general public) and to be discussed at the final stakeholder meeting in the 9th of March 2020:

[The SHAMISEN SINGS booklet \(version for discussion\)](#) “*Mobile apps for monitoring radiation doses, health and welfare in the context of a nuclear or radiological accident: Guidelines and recommendations for users, developers and public authorities*”.

The results of the projects are therefore recommendations for apps and a tool-kit. However, colleagues from FMU obtained a national grant to develop apps on health and welfare after a nuclear accident based on the SHAMISEN SINGS recommendations and criteria during the next two years.

Subtask 9.8.5 Coordination and Dissemination

Work in ST9.8.5 during their reporting period consisted in the organisation of meetings and conference calls, coordination of work between work packages and the setup of the SHAMISEN SINGS website and share point.

In terms of dissemination, the following scientific communications were presented by SHAMISEN SINGS Consortium members at international and national conferences during the reporting period:

- Ohba, T. et al. (February 2020). *Citizen science to monitor health and well-being after a nuclear accident*. The 1st Workshop of the Research Center for Radiation Disaster Medical Science, Hiroshima, Japan (oral).
- Fattibene, P. (November 2019). *An analysis of commercial apps to turn smart devices in radiation detectors for citizens' use (SHAMISEN-SINGS)*. International conference, ALARA network workshop, Athens, Greece.
- Ohba et al. (October, 2019). *Adaptation of an EU-initiated mobile phone application interface for interactive support*. ERPW, Stockholm, Sweden. (oral)
- Fattibene, P., Della Monaca S., Brescianini, S., De Angelis, C., Nuccetelli, C., Bottolier Depois, JF, Trompier, F., Barquinero, JF, Chumak, V., Liutsko, L., Cardis, E. (October 2019). *Correct use of apps for self-made measurements of radiation: proposal of recommendations for citizens, developers and authorities*. ERPW, Stockholm, Sweden (oral)
- Fattibene, P., De Angelis, C., Della Monaca S., Nuccetelli, C., Bottolier Depois, JF, Trompier, F., Barquinero, JF, Chumak, V., Liutsko, L., Cardis, E. (October 2019). *An analysis of commercial radiation measurement mobile apps for citizens use*. ERPW, Stockholm, Sweden (poster)
- Liutsko et al. (October, 2019). *SHAMISEN SINGS project – Benefits & challenges by using apps for dose and health monitoring after a nuclear accident*. ERPW, Stockholm, Sweden. (oral)

- Fattibene, P., Brescianini, S., De Angelis, C., Della Monaca, S., Nuccetelli, C. (October 2019). Radiazioni e partecipazione: dal citizen empowerment alla citizen science. National conference AIRP, Perugia, Italy.
- Cardis, E. & Oughton, D.H. (2019, August). *Shamisen and Shamisen Sings: Psycho-social impact of the Chernobyl and Fukushima accidents: Lessons learnt, recommendations and role of citizen-science*. ICRR, Manchester (invited keynote).
- Liutsko, L., Tanigawa, K., Ohba, T., Goto, A., Lyamzina, Y., Fattibene, P., Della Monaca, S., Novikava, N., Chumak, V., Maître, M., Croüail, P., Schneider, T., Tomkiv, Y., Oughton, D., Charron, S., Pirard, Ph., Sarukhan, A., & Cardis, E.; SHAMISEN SINGS Consortium (July, 2019). *Individual differences in preferences on mobile APPS for dose and health measurements in case of a nuclear accident*. ISSID2019, Italy: Florence (poster)
- Cardis, E. et al. (July, 2019). *SHAMISEN and SHAMISEN-SINGS – lessons learned and recommendations*. RICOMET, Barcelona, Spain (oral)
- Oughton, D., Ess, C., Tomkiv, Y., Fattibene, P., Della Monaca, S., Schneider, T., Liutsko, L., Chumak, V., Barquinero, J. F., Cardis, E. (2019, June). *Ethical challenges and implications of dosimetry and health APPs – results of a consensus workshop*. RICOMET, Barcelona, Spain (oral)
- Ohba, T., Lyamzina, Y., Goto, A., Murakami, M., Nakano, H., Kuroda, Y., Miyazaki, M., Kumagai, A., Ohira, T., Liutsko, L., Sarukhan, A., Tanigawa, K., & Cardis, E. (July, 2019). *Development of a mobile phone application for interactive supports of returned residents in a nuclear accident*. International conference RICOMET, Barcelona, Spain (oral)
- Brescianini, S & Fattiben, P. *An Economic Analysis of citizens' engagement in ionizing radiation measurements*. International conference RICOMET, Barcelona, Spain (poster)
- Liutsko, L., Ohba, T., Goto, A., Lyamzina, Y., Tanigawa, K., Fattibene, P., Della Monaca, S., Novikava, N., Chumak, V., Maître, M., Croüail, P., Schneider, T., Tomkiv, Y., Oughton, D., Charron, S., Pirard, Ph., Sarukhan, A. & Cardis, E.; SHAMISEN SINGS Consortium. (July, 2019). *Radiation protection culture in practice: Insights from people's behaviour in areas contaminated by the Chernobyl and Fukushima accidents*. International conference RICOMET, Barcelona, Spain (oral)
- Fattibene, P., De Angelis, C., Della Monaca, S., Nuccetelli, C., Bottollier-Depois, J.F., Trompier, F., Barquinero, J.F., Chumak, V., Liutsko, L., Cardis, E. (July 2019). *An analysis of commercial radiation measurement mobile apps for citizens' use*. International conference RICOMET, Barcelona, Spain. (oral)

A presentation of the SHAMISEN SINGS project and work in progress was also made in the RICOMET2019 workshop session and stakeholders meeting for feedback in July, 2nd, 2019.

During the report period, we had a Consortium meeting for reporting of progress of work and planning the pendent tasks during the ERPW2019, 14th of October 2019 in Stockholm, Sweden. Several work meetings on tasks of WP4 were taken at ISS, Italy, Rome in January 2020 with filming the material for the videotutorial and a discussion of the Russian version of the infographics with general public (university students of the 1-2 year on Medicine department in Minsk, Belarus, February 2020). The Final Consortium meeting will be held in 10th of March, just after the meeting with international stakeholders at ISGlobal (9th of March 2020), participants of which will come from EU, Belarus, Ukraine and Japan.

Milestones and Deliverables

D9.134	Consensus workshop report on ethical issues – submitted (M49)
D9.136	Guidelines/concept for dose measurement apps and tools– submitted (M52)
D9.137	Preparation of core protocol for an APP to collect information on health and welfare – submitted (M52)
D9.138	Concept/guidelines for apps and tools for dose measurement and health and well-being monitoring – submitted (M54)
D9.139	Tutorials for apps and tools, including database management plan – submitted (M54)
D9.140	If feasible, Prototype APP for health and welfare monitoring, diet, space-time distribution – submitted (M54)

Task 9.9 VERIDIC

VERIDIC project officially started on 1st February 2018 (CONCERT M33).. During the past 9 months (June 2019 until February 2020 (M49-57)), the following activities were performed:

Two projects meetings were organised, in Limerick, Ireland, on 24th October 2019, and in Athens, Greece, on 25th November 2019.

The project was presented in two sessions of the European Radiation Protection Week (ERPW2019) in Stockholm, Sweden, between 14th and 17th October; at the Euclid-workshop in Luxemburg City, Luxemburg, on 9th December 2019 and at a SFRP-day in Paris, France, on 4th February.

Task 9.9.1 Harmonisation of skin dose reporting

Two papers presenting the task results are being drafted. No new activities were performed during the reporting period. The task was already complete.

Task 9.9.2 Commissioning and quality control protocol for skin dose calculation software

Within subtask 9.9.2.1, Angular and dose rate response of thermoluminescent dosimeters were tested during the previous reporting period. . Results were analysed. They confirmed that the energy dependence of the TLDs should be considered in assessment of the dose measurement uncertainty and appropriate corrections should be applied. A report summarising the results of the subtask (deliverable 9.142) was written. It includes a review of uncertainty associated with skin dose measurements using quality control dosimeters, TLDs and gafchromic films

Within subtask 9.9.2.2, the acceptance test protocol for the accuracy of skin dose calculation (SDC) software previously developed was refined. It was used as a basis to define a quality control protocol, which is a shortened version. As part of subtask 9.9.2.3, the acceptance protocol was tested on three additional angiography systems (GE, Philips and Siemens). In addition, 3 clinical procedures, intended to represent more realistic conditions, were repeated on an anthropomorphic phantom on each of the tested angiographic systems (task 9.9.2.4) Canon angiography system already tested. Solid-state dosimeters (multimeters), gafchromic films and thermoluminescent dosimeters were used.

Measurement results were compared with calculations of skin dose estimates and skin dose maps performed with up to 8 SDC software products, depending on the system compatibility. A report summarising the results of subtask 9.9.2.2, 9.9.2.3 and 9.9.2.4 (deliverable 9.143) was written. It includes the description of the acceptance and quality control testing protocols.

Task 9.9.3 Investigation of skin dose determinants and optimisation of medical practice

Within subtask 9.9.3.1, the data collection of RDSR/dose reports and medical data of high-dose cardiac procedures was completed. 13 hospitals from 8 European countries, including more than 20 angiography units, are included. 534 PCI, 219 CTO and 209 TAVI procedures were collected. Univariate and multivariate statistical analysis of data samples was performed within subtask 9.9.3.2. The common clinical factors having an influence on the skin dose and on the dose indicators was determined. Moreover, reference levels were determined for each type of procedures. A report summarising the results of subtask 9.9.3.1 and 9.9.3.2 (deliverable 9.144) was written.

Milestones and Deliverables

All milestones and deliverables planned were achieved and delivered on time (31/01/2020).

D9.142 Dosimeter calibration and measurement uncertainties in IC (task 9.9.2.1)

D9.143 Acceptance and Quality control protocol; accuracy of the tested SDC software tools (tasks 9.9.2.2, 3 and 4)

D9.144 Collected procedures and recommendation for dose optimisation (tasks 9.9.3.1 and 2)