REVISED VERSION – 19/07/2023

EURAD-2 public webinar #2

Towards EURAD-2

The Core Group

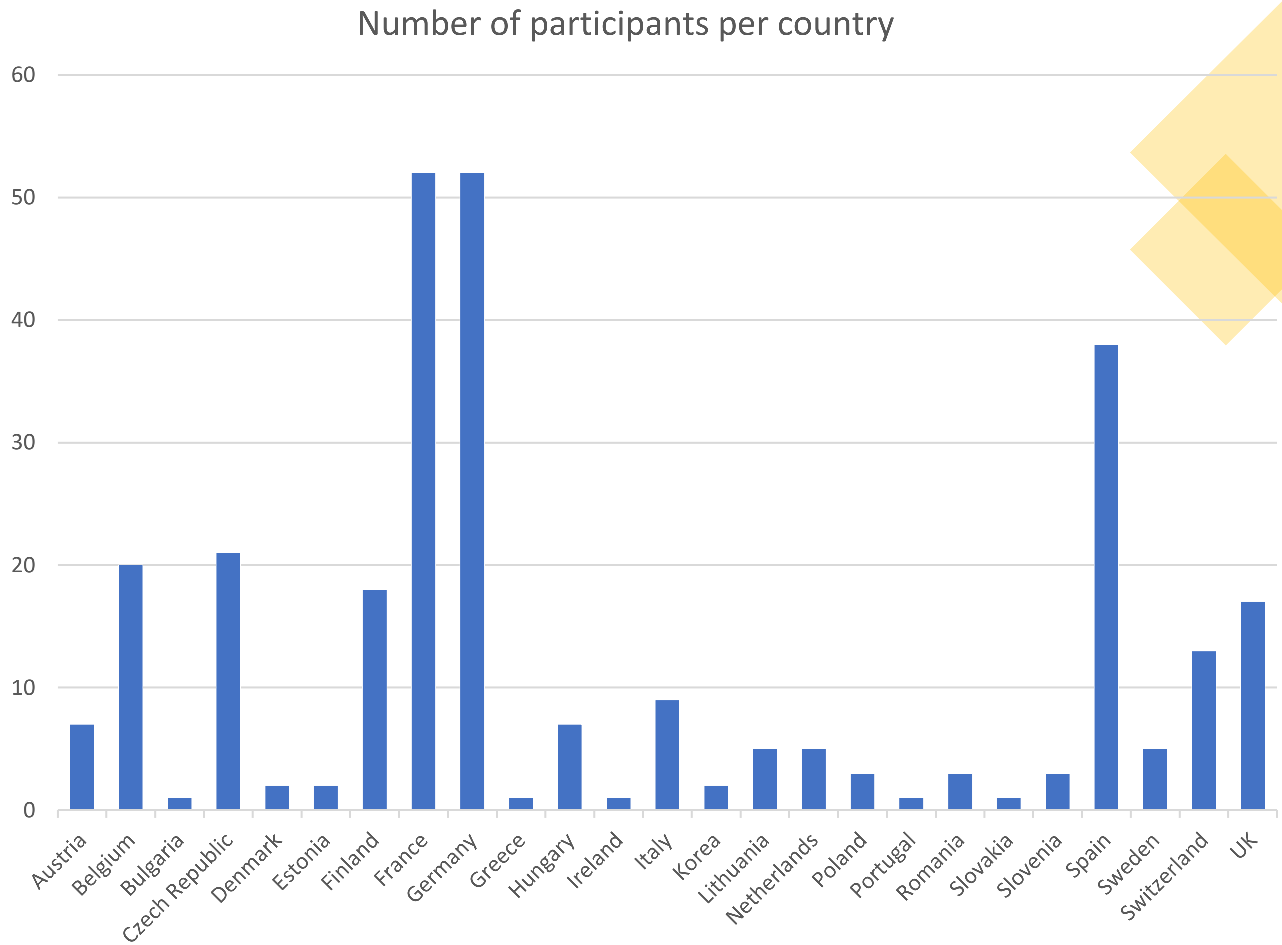
COORDINATOR	**Louise Théodon** (ANDRA – France)
Waste Management Organisations - WMO COLLEGE - via IGD-TP	**Ingo Blechschmidt** (NAGRA – Switzerland) **Astrid Göbel** (BGE – Germany)
Research Entities - RE COLLEGE - via EURAD-Science network; which also includes supply chains and companies	**Christophe Bruggeman** (SCK CEN – Belgium) **Lara Duro** (AMPHOS 21 – Spain)
Technical Support Organizations - TSO COLLEGE - via SITEX.Network; which also includes civil society and regulator views	**Erika Holt** (VTT – Finland) **Nadja Železnik** (EIMV – Slovenia)

Agenda

- 14.00-14.15 Introduction and objectives of the webinar
- 14.15-14.30 Process since EURAD-2 Focus Funnel in March
- 14.30-14.50 Governance
- 14.50-15.20 Knowledge Management Committee progress
- 15.20-16.00 WPs presentation (3 min per WP)
- 16.00-16.10 Break
- 16.10-16.50 WPs presentation (3 min per WP)
- 16.50-17.00 Next steps and conclusion

Foreword

- **371 participants registered from 28 countries**
- **No time for questions is planned – any questions can be sent to Core Group Coordinator (louise.theodon@andra.fr) or in the chat – they will be answered in the FAQ available online**



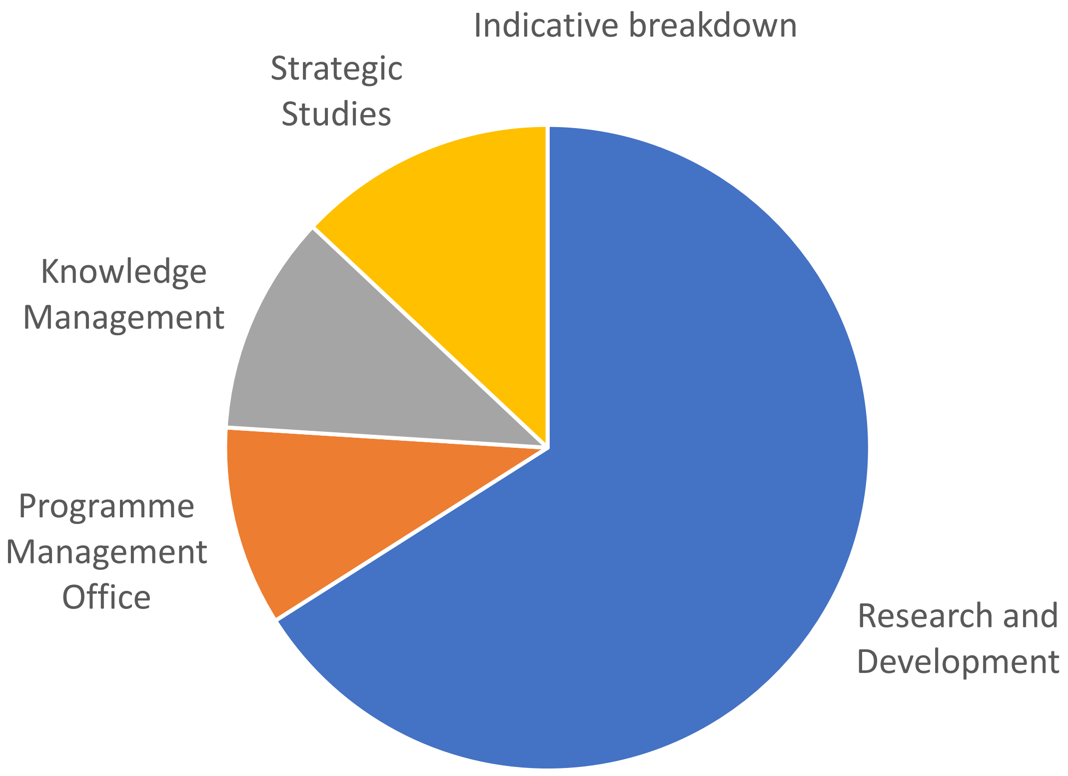
Background information

- Slides webinar 1 January 2023– first description of the development process
- FAQ – updated regularly based on questions received – organised by category
- Focus Funnel slides March 2023 – latest updates of the CG before webinar #2
- Summary Focus Funnel event – to find first information of technical scope
- CG communication – October 2022 – to understand the role of the CG
- CG communication – December 2022 – general progress information
- CG communication – May 2023 – to find contact info by WP Preparation Teams
- Guidance Associated Partners – for countries not funded by the EC
- Guidance Affiliated Entities – for institutes which are not Mandated Actors

Background information

- General principle of the Core Group : CG recommends / Colleges validate
- EC EURATOM Work Programme (published in March) prescribed different things
  - Co-funded partnership - 60 % funded by the EC in order to have 100 % funding for KM and StSt and 50% for R&D
  - Structure of the partnership remains – Beneficiaries / Affiliated Entities
  - Proposal to be submitted by November 8th
  - Content of the proposal is technical scope but also excellence, impact, governance, all financial and administrative information – limited number of pages so no detailed description of every single part of the WPs

Indicative breakdown based on EURAD-1 and PREDIS



- EC contribution estimated for the 5 years at 60 M € (total budget 100 M€)
- 10 % max for PMO

2 waves principle – 1st CG assumption (Nov 2022)

1st wave (60 %) = 36 M€

29 M €
- 25 M € R&D WP
- 4 M € StSt
- 4,2 M€ KM
- 3,6 M€ PMO

36,8 M€

+

2nd wave (40 %) = 24 M€

- 15 M€ R&D WP
- 3 M€ StSt
- 2,8 M€ KM
- 2,4 M€ PMO

23,2 M€

EURATOM Work Programme only secures 20 M € for the first 2 years of the programme

Key terminology

- **Affiliated Entity:** (previously referred during EURAD-1 as *Linked Third Parties*) can perform action tasks in the EURAD-2 programme and are allowed to charge costs directly to the grant (they receive EC funding). Therefore, they are subject to financial checks, reviews and audits. Contrary to Beneficiaries, they do not need a national level Mandate.
- **Associated Partners:** Associated Partners (previously referred during EURAD-1 and PREDIS as *International Partners*) can perform action tasks in the EURAD-2 programme. They do it without receiving any EU funding. Therefore, they are not subject to financial checks, reviews or audits. They do not have any voting rights in the General Assembly.
- **Beneficiaries:** organisations mandated by their national programme owners or governmental Ministries
- **Colleges** : refers to platforms that gather a number of organisations depending on their role in radioactive waste management, i.e EURADSCIENCE (for RE), SITEX.Network (for TSO) and IGD-TP (for WMO)
- **PMO (Programme Management Office):** in charge of scientific and technical coordination of the programme, as well as day-to-day management and communication activities. Members are selected by the Coordinator.
- **WP Preparation Teams**: refers to a group of 3 persons (one per College) who will be the main contacts for the development of the EURAD-2 workpackages

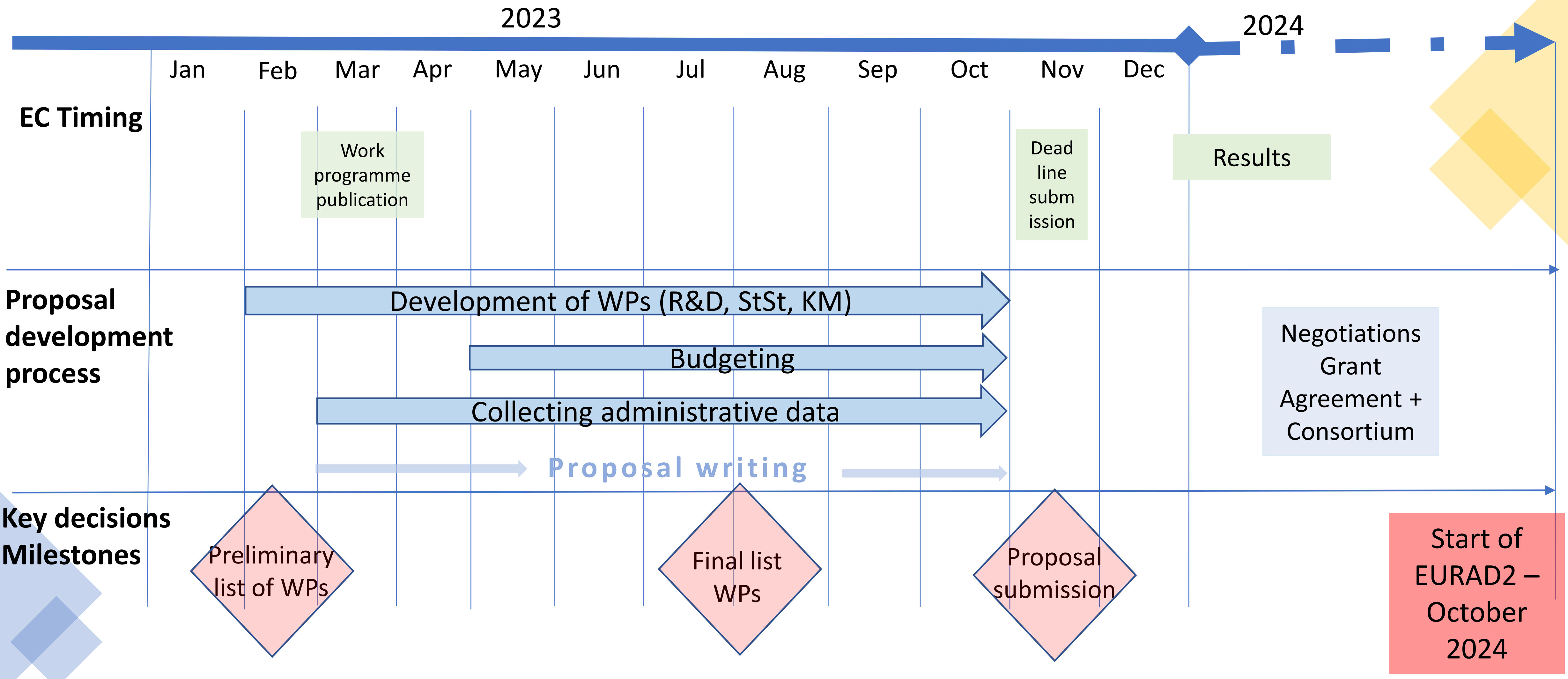
Objectives of the meeting – 1/2

- Share the latest progress of EURAD-2 Core Group
  - Last public meeting organised by the Core Group before the submission
- Give an overview of future work on Knowledge Management
- Give an overview of the potential technical work packages
  - To facilitate future exchanges with WP Preparation Teams and involvement in the WPs
- Clarify the next steps

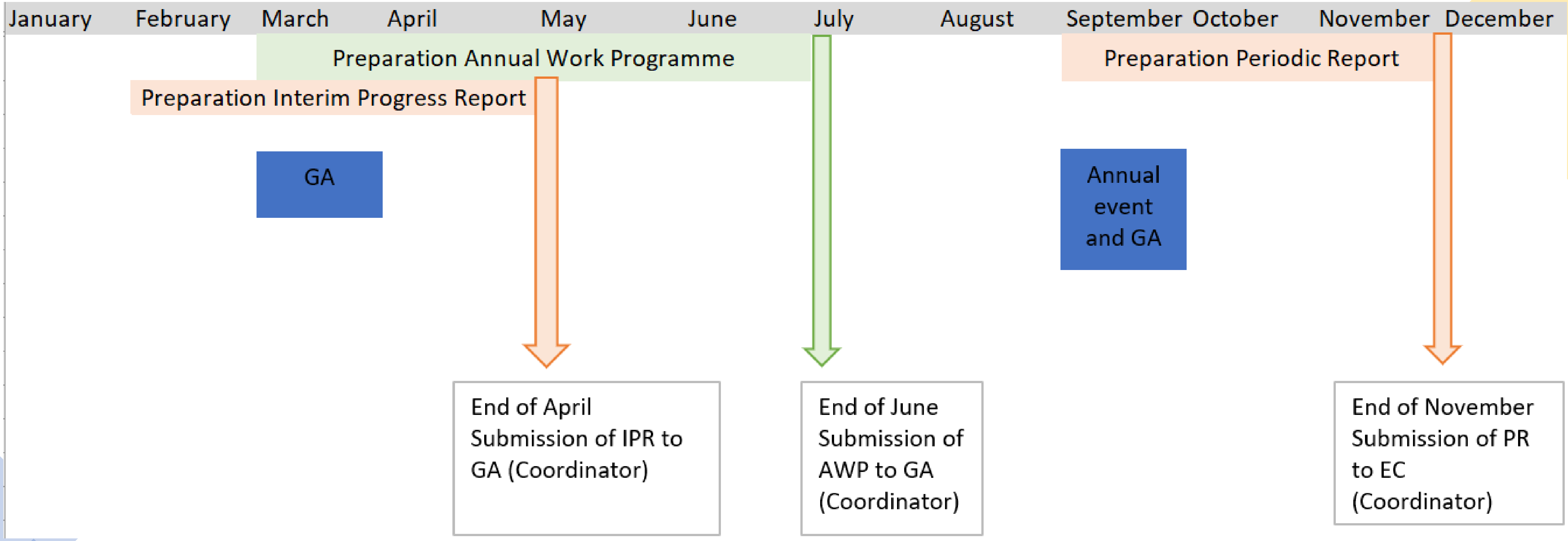
Objectives of the meeting – 2/2

- **The goal of the webinar is <u>not to :</u>**
    - Give opinion on the technical scope of the WPs
    - Discuss technical scope of KM
    - Pick WP leaders, build the consortium, define who is doing what, budgets

Moving forward EURAD-2 – Timeline – 1/2



Annual clock EURAD-2



Process since EURAD-2 Focus Funnel in March

Background information

- Core Group issued Template #1 in December 2022 and made a presentation on how to complete it during the Webinar #1 (January 2023)
- Colleges were asked to forward by the end of February their 15 top priorities
- Core Group made a recommendation of grouping WPs (common proposals / commonalities) in view of the Focus Funnel

Theme	Before grouping	After grouping for the FF
1 – Programme Management	7	6
2 – Predisposal	9	6
3 – EBS	22	11
4 – Geosciences	4	3
5 – Design optimisation	8	7
7 – Safety Case	4	3
Total	**54**	**36**

First identification of WPs

- CG made a first recommendation of WPs grouping to College, taking into consideration:
  - Audience discussions
  - Written feedback shared on post-its

Focus Funnel summary

- Colleges gave their positions on the grouping, identified interest and type of activity (R&D/StSt), appointed a key contact

19 WPs proposed for development of Template #2 – 3 members appointed for WP Preparation Teams + 1 Core Group observer

- Role of WP Preparation Team: work together to formulate WP scope, objectives and targets

Template #2 development – 1/2

- Guidance provided to WP Preparation Teams with checklist – ensure consistency between the different WPs and give guidelines especially on selection criteria of who will be in WPs
  - List of requirements: links with EURAD Vision, Roadmap, updated SRA ; European added-value, focused and manageable , …
  - Consider background documents : feedback Focus Funnel, Templates #1, Colleges' feedback
  - Reach out to the 3 Colleges – collective work to be approved by Colleges, collect list of interested parties
  - Submission of a draft version then final version

Guidance for WP Preparation Teams

Template #2 development – 2/2

- Set the evaluation criteria
  - Eligibility (links SRA, support from 5 Member States, minimum of 2 Colleges committed to be involved)
  - Prioritisation (inclusiveness, tangible results, complementary participation, added-value, equitable financing)
  - Balancing (positive participation, maintenance of independence, balanced programme)
- First screening done by the CG and feedback provided
  - General comments applicable to all WPs
  - Specific feedback per WP : strengths, suggestions, required

Prioritisation – 1/2

- Eligibility screening done by the Core Group
  - All 19 WPs considered eligible
- Colleges priorisation
  - Part A : Checking criteria (inclusiveness, complementary participation, added-value, equitable financing, tangible results, co-financing)
  - Part B: Defining priorities (Green/Yellow/Red)
    - Considering scope, duration, budget and outcomes
    - Green: yes / Yellow : yes with conditions / Red: no
  - Part C: Budgeting allowance
    - For yellow WPs, indication of EC contribution
    - Total of green and yellow WPs could not exceed 29 M € (see previous slide)

Prioritisation – 2/2

- Support of 2 Colleges necessary to be considered as a WP in EURAD-2
  - 2 or 3 « greens » = OK to proceed to Template #3
  - 2 or 3 « reds » = not OK to process to Template #3 – could be further developed for wave 2
  - All other scenarios = in iteration with the Colleges before final approval of the Colleges

All 19 WPs pitching today – no 2 or 3 « reds »

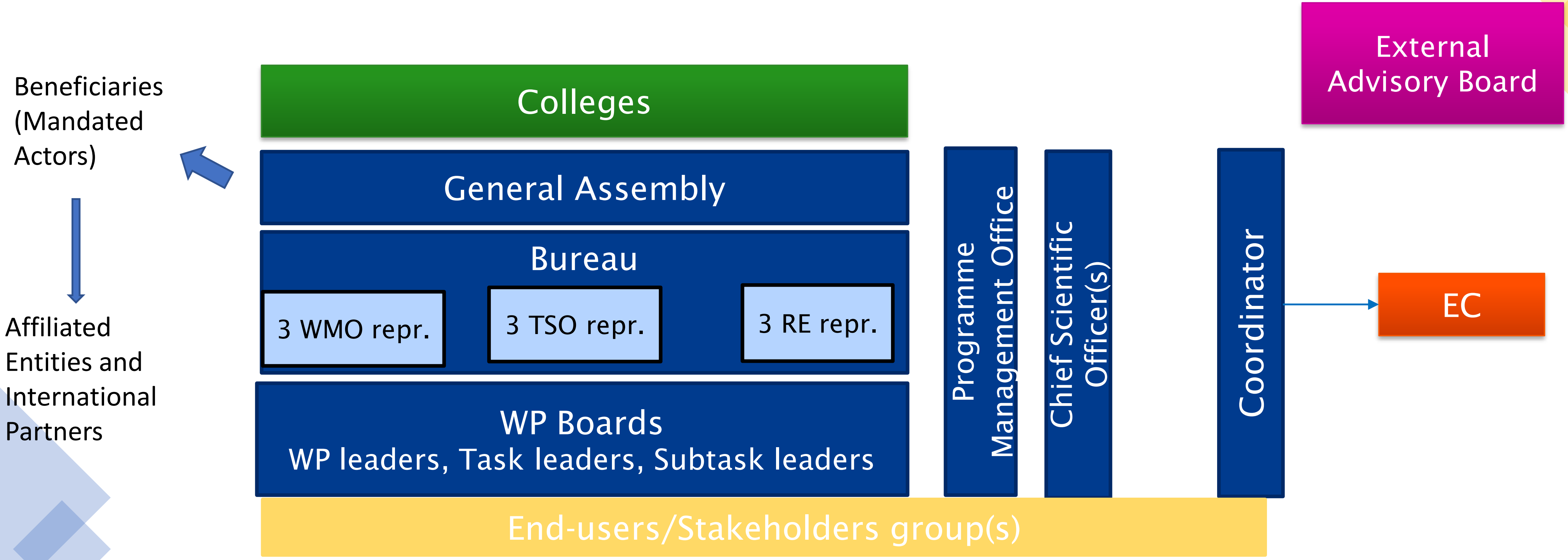
Governance

Make EURAD-2 more inclusive

- **No change in the general process of having Beneficiary / Affiliated Entities (previously LTP) – defined by the EURATOM Work Programme**
- **Improvement of communication to Affiliated Entities needed – to be considered by EURAD-2 Programme Management Office**
- Largest number of participants should not be the aim : participants should demonstrate qualification, excellence and experience
- Establishment of an alternative route to welcome more Affiliated Entities – see guidance

Governance

- **Agreed to keep the same general structure and take into considerations lessons learned from both EURAD and PREDIS and Colleges' feedback (position papers)**



Chief Scientific Officer

- Enforce **internally** the scientific leadership of the programme on aspects of science, technology and KM
- Paid role (subcontractor to Coordinator)
- Not a member of the Consortium or PMO, no direct link with the EC, reports to Coordinator
- **Could be more than 1 person depending on the credentials of the candidates and the scope of the WPs**
- Recommendation: EURAD-1 Bureau and PREDIS Management Team to propose names before May 2024 – to be approved by EC and EURAD-2 General Assembly

External Advisory Board

- Provide **external** expertise and balanced perspective, act as ambassadors of EURAD-2
- Not involved in the internal operations and feedback on the programme
- Paid role (subcontractor to Coordinator) – flat rate + travels
- Not members of the Consortium, reports to General Assembly
- Recommendation: EURAD-2 Bureau proposes names within the first 6 months, decision to be approved by EURAD-2 General Assembly

Inclusion of waste generators and regulators

- Waste generators
  - Not a new College – defined by EURATOM Work Programme
  - Participation as parties to the Consortium via an established College (most probably RE or WMO)
  - Encouraged to be active as end-users / stakeholders
  - Engagement via SNETP

- Regulators
  - Not a new College – defined by EURATOM Work Programme
  - Encouraged to be active as end-users / stakeholders
  - Engagement via TSO College and discussions with ENSREG
  - If Mandated, participate under the same conditions as other organisations – maintenance of independence is the issue of the regulatory authority itself

Inclusion of civil society

- Recommendation to focus more on wider dissemination / outreach

- Role of Nuclear Transparency Watch as representation of various NGOs is recognized – Other organisations representing civil society can be integrated in the programme (same participations rules – legal link to a Mandated Actor)

- Involvement through TSO College maintained

- Selection process of participants (i.e Civil society larger group) open and transparent as done in EURAD-1

Funding of activities – linked to governance

- CG recommends that Bureau member institutes gets funding for their direct contributions to strategic issues (like activities addressing a Strategic Research Agenda) but that no budget allocation is done directly to the platforms managing the Colleges' voices.

- CG recommends that some baseline portion of the WP leaders' effort for managing and coordinating the WP is financed at 100 %. For that matter, such costs (as person.months) will be integrate in the WP1 Programme Management Office, as portion % of the WP budget depending on the size/complexity.

Knowledge Management Committee (KMC)

Establishment of a KMC

- Role and boundaries:
  - Discuss with the Colleges the expectations how the KM activities should be established (priorities / type of activities)
  - Provide recommendations to Core Group, which then reports to Colleges for decision / approval
  - Members do not represent their individual, institute or country views
  - KMC is not a prefiguration of KM WP leaders – members will not necessarily have leadership role / commitment in EURAD-2 implementation (similar to Core Group)
- CG recommendation :
  - Mandatory KM Task for every R&D and Strategic Study WPs

EURAD-2

KNOWLEDGE MANAGEMENT PROGRAMME

KMC

Webinar, 11th July 2023

CONTENT

- Knowledge Management Committee (KMC)
- KMC Role and Output
- Position Paper
- Involvement of the EURAD-2 Community

KM definition *(IAEA, Safety Glossary 2018)*

"An integrated, systematic approach to identifying, managing and sharing an organization's knowledge and enabling groups of people to create new knowledge collectively to help in achieving the organization's objectives"

KMC MEMBERS

Knowledge Management Committee members are nominated by their colleges

Paul Carbol (EC JRC)

Waste Management Organisations, (WMO)

- Alexandru Tatomir (BGE)

Supported by:

- Anders Sjöland (SKB)

Research Entities (RE)

- Gunnar Buckau (KIT-PTKA)

Supported by:

- Alba Valls (Amphos21)
- Niels Belmans (SCK CEN)

Technical Support Organisations (TSO)

- Jitka Mikšová (SURO)

Supported by:

- Christophe Debayle (IRSN)
- Kateryna Fuzik (SSTC NRS)

KMC ROLE AND OUTPUT

KMC members are representatives of their respective College and do not represent the view of their institutes and/or countries

Role of KMC

- Manage the process for establishing the KM Programme in EURAD-2

Key steps

- Position paper – Engagement with the EURAD-2 community (mid July)
- KM Programme EURAD-2 – Draft Proposal draft (end September)
- KM Programme EURAD-2 – Final Proposal (end October)

POSITION PAPER

- Informing the EURAD-2 Community about the come-about of the KM Programme, including providing answers to following questions:
  - What should **stay the same** from EURAD and PREDIS?
  - What will **change** from EURAD and PREDIS?
  - What are the **priorities**?

Preparation of the KM position paper

Lessons learned (EURAD / PREDIS) → Needs → Questions answered → Position Paper

Through:

- KMC members exchange of experience
- Interaction with the Core Group
- Feedback - Interactions with Colleges

POSITION PAPER: LESSONS LEARNED

Lessons learned (EURAD / PREDIS)

SWOT analysis on KM in PREDIS and EURAD

Strengths

- The KM Programme provides for a harmonised understanding of objectives and implementation means for a community with many different organisations of different character and aims (including Mandated Actors and Associated Entities, but also a variety of End-Users).
- The KM Domain within the Roadmap and the SRA provides for transparency and acceptance of the KM Programme as a recognised part of the overall R&D Programme. It also provides a common understanding of the context of the programme and thus how the individual activities fit within the overall context.
- The KM Programme integrates all relevant actors and groups in a consistent manner.
- It provides for access to experts with different competence areas and experience from different levels and magnitudes of national waste management programmes.
- The organisation of the KM Programme within the well-defined overall context and the experience feed-back mechanisms results in needs and quality driven approach with high quality of the deliverables.
- The flexible budget with non-allocated resources enables learning-by-doing and rapid response to surveys and requests from the community, including the different End-Users.
- The flexible and pragmatic approach to administrative management of the knowledge and the KM Programme has proven effective, while using limited resources.
- There is a broad set of well-received communication (webinars, workshops, newsletters, end-users, stakeholders).
- Successful engagement and involvement of Users in the development of Guidance. This approach enhances transparency, acceptance and the use of the outcome.

Weaknesses

………

Threats

………..

POSITION PAPER: LESSONS LEARNED

Lessons learned (EURAD / PREDIS)

SWOT analysis on KM in PREDIS and EURAD

Strengths	Weaknesses
• Knowledge transfer (Training and mobility among others) • Progressive harmonization • Broad access + integration of wide set of experts • Needs and quality driven programme • Flexibility - non-allocated budget - learning-by-doing – rapid response to needs • Top-Down + Bottom-up approach to drafting: Positive example with involvement of Users in the development of Guidance.	• Relation to the MSs National Programmes unclear. • Difficulties to estimate human resource requirements for different activities. • Need for better interaction between the R&D and StSt WPs, involved partners, and the KM Programme activities. • Administrative challenges in engaging required external experts

Opportunities	Threats
• Better / more efficient strategy for, and structure of surveys. • Develop a long-term vision for the KM Programme. • Adapt interaction / communication tools towards the young generation and other interested communities.	• Lack of driving force in Early-Stage programmes, being beyond the influence of the KM Programme • Lack of interaction with End-Users may result in outcomes not matching the End-Users needs and interests. • The sustainability of the outcome beyond the implementation of EURAD and its successors remains uncertain.

POSITION PAPER

Needs

- KM needs were identified using following sources:
  - EC call: Euratom R&T programme 2023-2025
  - Mid-term review of EURAD
  - Position papers: WMO, TSO, RE
  - IGD-TP Vision 2040 – Strategic Research Agenda (SRA)
  - SITEX Network SRA
  - EURAD SRA+KM
  - PREDIS SRA+KM
  - KMC

POSITION PAPER

Questions addressed

1. The overall structure of the KM Programmes from EURAD and PREDIS will **remain** the same

The basic success stories of knowledge capture and transfer remains

Including ongoing improvements/additions in EURAD-2 with respect to:

- The technical/administrative management of knowledge and activities, balancing pragmatism and considerations for(post-EURAD) durable solutions.
- Links between R&D and StSt WPs and KM WPs through "Ambassadors/Task 2 leaders" and their participation in the executive body for the KM Programme.
- Guidance of Knowledge Capture efforts by scientists involved in R&D and StSt WPs in order to have a consistent structure of the SotA's, SoK's.
- Involvement of End-Users in the KM activities in order to promote visibility, acceptance and use of the outcome.
- ….

POSITION PAPER

Questions addressed

2. **Change** from EURAD-1 and PREDIS – New activities

- Introduce Feasibility Studies in order to elaborate upon implementation of new and innovative KM ideas.
- Broaden the KM activities to reach new target-groups/communities (for example knowledge transfer for the regulatory function)
- Integrate the knowledge capture with the knowledge transfer activities - Establish E-Learning tools from DI, SoK, SotA, ..
- Introduce a Topic on Support to Database Management.
- Support a sustainable network at a European level of experts, labs and technical installations that can be used by all European partners in support of their RWM programme needs.
- Extend Student Group activities by Career Development tracks (e.g. life-long mentoring).
- Use diverse social media for better out-reach.
- Support Communities of Practice.

POSITION PAPER

Questions addressed

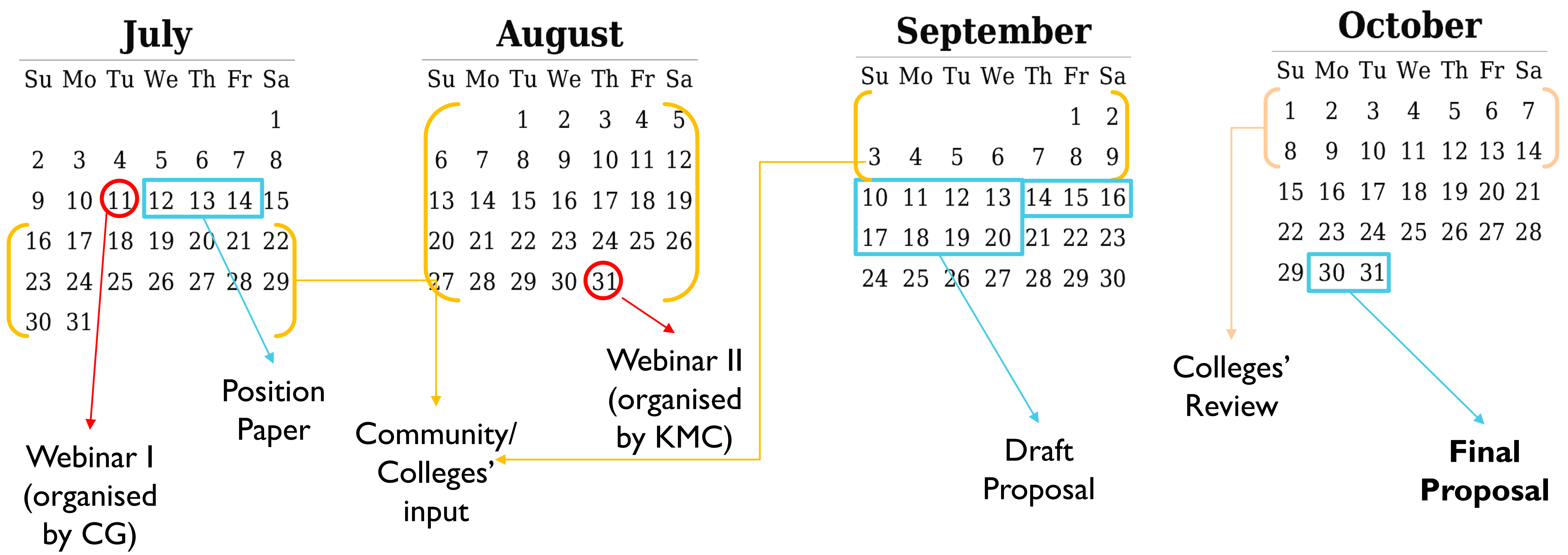
3. **Priorities**

KM programme continues along four main topics:

- i. **Knowledge capture** (establishing and updating Domain Insights and State-of Knowledge documents)
- ii. **Knowledge application** (guidance, sustainable network of labs, glossary, …)
- iii. **Knowledge transfer** (training courses, networking, CoP, students, mobility actions….)
- iv. **KM Programme administrative management** (strategic/operational KM decisions, management tools, wiki, social media…)

- ? Support to database management

INVOLVEMENT OF THE EURAD-2 COMMUNITY IN KM PROGRAMME



COLLEGE INPUT TO KMC

- 11 July - 9 September: Sent email to your College CG and KMC representatives
- 31 August: Comments during Webinar

THANK YOU FOR YOUR ATTENTION

WPs presentation

WPs presentation

Theme 1 – Programme Management

- ASTRA (WP1) – Alternatives RWM strategies – 3 min
- SURE (WP2) – Sustainability – 3 min
- FORSAFF (WP3) – WM for SMRs and future fuels – 3 min

Theme 2 – Pre-disposal

- ICARUS (WP5) – Waste characterisation – 3 min
- STREAM (WP6) – Treatment/Immobilisation – 3 min
- L'OPERA (WP7) – Long-term performance - 3 min
- SHIRE (WP8) – Graphite handling - 3 min

Theme 3 (first part) – Engineered Barrier Systems

- Spent fuel (WP9) – 3 min
- InCoMand (WP11) – Containers/Canisters - 3 min
- ANCHORS (WP12) – Bentonite/Buffers/Backfills - 3 min

ASTRA –**A**lternative RWM **STRA**tegies

Laure Prevot, Matija Simon, Marja Vuorio

Laure.PREVOT@egis-group.com / Matija.simon@eimv.si / marja.vuorio@covra.nl

Tailored Solutions, Innovation for Optimisation, Societal Engagement

Objective

- Analysis of readiness, feasibility and challenges of alternative RWM solutions needed by many countries, in particular SIMS, but also larger programmes to safely manage and dispose of their waste.

Impact – Added value

- Alternative RWM strategies need to be considered for waste types which do not currently have available WM routes or where WM routes could be optimised for challenging waste forms or where originally proposed/considered disposal solution in frame of national concept is updated. These include:
  - storage lifetime prolongation,
  - alternative WM solutions (including deep borehole disposal and internationally shared waste management solutions) and
  - disposal of waste bearing naturally occurring long-lived radionuclides (Depleted Uranium-DU, U, Th, Ra).
- ASTRA will contribute to identification of R&D needs and optimisation of national waste management programmes.

Scope – Overview of planned tasks

- Task 1: **Management/coordination**.
- Task 2: **Knowledge Management**
- Task 3: **RW long term storage** (situations in which waste is stored for periods that exceed the original design life of the containers and storage facilities, for example, owing to the disposal of the waste being delayed or postponed) for some specific inventories
- Task 4: **Deep borehole disposal (DBD) technological readiness level (TRL) and challenges**
- Task 5: **Alternative waste management solutions for SIMS**
- Task 6: Evaluation of **RWM strategies for the disposal of waste bearing naturally occurring long-lived radionuclide**s (Depleted uranium, U, Th, Ra)
- Task 7 : **Interaction with Civil Society (ICS)**

SuRE – Sustainability aspects in Radioactive waste management: General concept and practical measures for Environmental challenges

Abdesselam Abdelouas – RE

Hana Vojtechova – TSO

Gregor-Sönke Schneider – WMO

abdeloua@subatech.in2p3.fr / hana.vojtechova@suro.cz / Gregor-Soenke.Schneider@bge.de

1.1.4 safety, security, use of resources

1.5.1 Integrated waste management routes and strategic options

Objective

- Develop the concept of sustainability in the field of nuclear waste management, and identify specific challenges on environmental, economic and social dimensions. The aim is to develop appropriate technical and socio-technical approaches with a systemic analysis of inventory data of radioactive matter in European states for potential recycling, and identification of low CO_2 concrete for repository.

Impact – Added value

- The development of suitable concepts or practices which should combine technical aspects and non-technical questions to tackle sustainability challenges of nuclear waste disposal.

- Enhancing the concept of circular economy in the field of radioactive waste management (recycling of radioactive matter).

- Providing insights to anticipate the development of new low CO_2 concrete formulations.

Scope – Overview of planned tasks

- **Task 1**: Management/coordination of the WP
- **Task 2**: Knowledge Management (incl. training materials development and State-of-the-Art for R&D WPs, etc.)
- **Task 3**: Sustainability in radioactive waste management
- **Task 4**: Recycling of radioactive matters as specific sustainable application
- **Task 5**: CO_2-low concrete production as specific sustainable application

FORSAFF – Waste Management for SMRs and Future Fuels

Virginie Wasselin (Andra, WMO), Timothy Schatz (VTT, TSO), David García (Amphos 21, RE)

Observer: Nadja Železnik (EIMV)

Virginie.wasselin@andra.fr / Timothy.Schatz@vtt.fi / david.garcia@amphos21.com

Selected SRA drivers

- Tailored Solutions
- Innovation for Optimisation
- Societal Engagement

Objective

- Provide outcome guidance for stakeholders to make informed decisions on SMR and advanced reactor deployment and supplier options, with respect to nuclear waste management. In particular, understanding the disposability of wastes arising from proposed SMRs and advanced reactors (relative to the potency of the underpinning knowledgebase) and the reprocessing of SMR spent fuels will be critical to inform deployment decisions.

Impact – Added value

- Despite their many perceived advantages, the deployment of SMRs and advanced reactors will require meeting numerous challenges. One of the biggest challenges is the management of spent fuel and radioactive waste generated from their operation and decommissioning. This challenge involves not only disposal but includes the possible reprocessing of spent fuels as well.
- There are a large variety of designs, technologies, and potential applications for SMRs and advanced reactors which will have profound effects on waste management strategies and technical pre-disposal and disposal solutions.
- These impacts need to be fully considered in the decision-making processes for incorporating these reactors into energy production networks. Socio-technical aspects as public engagement and technology acceptance need to be also included in this WP to optimize the outcome of the technical work within the WP

Scope – Overview of planned tasks

Estimated Budget approx. → 1M€
Expected duration → 18M

- Task 1: Management/coordination of the WP (10%)
- Task 2: Knowledge Management (10%)
- Task 3: Waste Generation (30%)
  - Identify the full scope of waste generation (source terms, waste streams and inventories) relative to SMR and advanced reactor, operating conditions and fuel cycle options. Discussions with SMR/AR designers & fuel cycle industry will be integrated within this task, with the formation of an End-User group as a target to collect the maximum feedback from them. Additionally, energy production scenarios should be explored to evaluate future waste arisings.
- Task 4: Waste Management (including disposal and reprocessing options) (25%)
  - Assess predisposal (treatment, conditioning, storage, transport) approaches and development needs (and sharing thereof) in terms of anticipated waste generation across SMR and advanced reactor designs and operating conditions including characterisation methods and needs. Explore spent fuel reprocessing options in the backend of the fuel cycle for SMRs and advanced reactors. Examine disposal routes for SMR and advanced reactor wastes across a range of end-user needs considering conventional as well as more novel concepts (shared facilities, deep borehole disposal) as well as harmonization of waste schemes under IAEA and EC guidelines, disposability issues and evaluation of the SMR and advanced reactor waste within the existing waste acceptance criteria.
- Task 5: Policy and Regulatory Framework (5%)
  - Determine the need to adjust national policies and regulatory frameworks to support SMR and advanced reactor fuel cycle and waste management. We propose to include this task within the WP on a relatively low effort basis by taking full advantage of the work already performed by IAEA and others, i.e., ELSMOR project.
- Task 6: Stakeholder Engagement (20%)
  - Identify stakeholder perceptions and concerns related to SMR waste management and develop recommendations for transparent information exchange and dialogue. Foster the use of digital technologies for improving the communication with public.

ICARUS – Innovative ChARacterization techniques for large volUmeS (R&D) Pre-disposal (Theme 2)

Names of WP Preparation Team members:

- RE: POLIMI, Eros Mossini, eros.mossini@polimi.it
- TSO: NRG, Bas Janssen, b.janssen@nrg.eu
- WMO: ENRESA, José Luis Leganés Nieto, jlen@enresa.es
- CG observer: SCK CEN, Christophe Bruggeman, christophe.bruggeman@sckcen.be

Selected SRA drivers:

- Tailored Solutions
- Scientific Insight
- Innovation for Optimisation

Responses via questionnaire for contributing on template#2: 30

2023-07-06, questionnaire is still open for input:

https://forms.office.com/Pages/ResponsePage.aspx?id=K3EXCvNtXUKAjjCd8ope66lQLXfXzwJJj2QBqCOxZXpUM09CUEgzSjlFNk85SFFLUVNEMkQxWUdLSC4u

Objective

- New innovation, further development and optimization of techniques for characterizing WAC on large package scale use-case (LLW/ILW/mixed):
  - radiological,
  - physical and
  - chemical
- New NDA methods and prototypes for physical-chemical-radiological characterization of materials with complex geometry and composition.
- New DA methodologies for DTM radionuclides in complex matrices and improvement of Minimum Detectable Activity.
- New characterization methodologies for mixed/legacy wastes, DSRS and orphan sources.
- Validation of scaling factors methodology applied in industrial level decommissioning situations.
- Innovative sensors, integrated with NDT for real-time data detection and collection on drum metallic boxes and containers.

Impact – Added value

- There is need for **faster and more reliable characterization techniques** for classifying radioactive (incl. legacy/raw mixed) waste in **large volume packages** to reduce the volume of waste and to optimize the waste route. It is critical for the safe implementation of radioactive waste management programmes using destructive techniques (DT) on a laboratory scale and its correlation to non-destructive techniques (NDT).

- Identification of waste acceptance criteria and **best available characterization techniques** for large volume raw waste use-cases, **in industrial level decommissioning situations**.

- Use-case on optimization for operative industrial use in decommission/ operation process of NDT for **gamma activity distribution in complex large packages/components/buildings/soils** by collimation, segmentation, passive mass distribution techniques (e.g. by gamma tomography).

- Development of **sensitive radiochemical and radiometric/non-radiometric measuring** DT for determining long-lived Difficult To Measure (DTM) radionuclides critical for the safe implementation of national programmes in radioactive waste and environmental samples.

- Use-case to implement the **scaling factor approach and lower the uncertainties**. For the same use-case develop improvement of detection limits to meet all stringent requirements set by national regulators on these large volume packages.

- Implementation of **robust data management strategies** using efficient databases, coupled with cloud computing platforms, enabling scalable storage, real-time data processing, and long-term tracking of waste form characteristics. Linked with development of smart systems, e.g., **machine learning for anomaly detection** in large-scale data sets.

Scope – Overview of planned tasks

1. **WP management and coordination.**

2. Knowledge management, incl. SOTA.

3. NDT design for industrial implementation.
This task is intended to develop innovative operative passive/active NDT devices for large packages (metallic boxes, containers) characterization, to determine activity (e.g. Gamma, Alfa emitters), chemical (e.g. toxics, ASR) and physical (e.g. density, mass) and implementation of robust data management strategies for development of smart systems.

4. Design of DT for DTM radionuclides.
The aim is to develop simplified/quick DT in order to improve the detection limits and reduce the cost and time of current radiochemical analysis.

5. Scaling Factor optimization.
This task is created to investigate methods of improving the Scaling Factor Accuracy, trueness and precision and their impact~~s~~ on waste package activity and inventory determination.

6. Dissemination.

STREAM –
Sustainable Treatment and Immobilization of challenging waste

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☒**Pre-disposal (Theme 2)**

☒Engineered Barrier Systems (Theme 3)

Objective

Innovative and sustainable design, optimization and upscaling of treatments and conditioning materials for the predisposal of **problematic waste**

Solids (SIERs), organic (liquid and solid), metallic and legacy or failed wastes





Impact – Added value

Thermal treatments and alternative conditioning materials (e.g. geopolymers, phosphate binders low carbon binders such as CEM II-C/M, CEM VI, LC3) are not yet fully mature and need future studies on e.g. :

- the influence of the waste composition on the consolidation process of the conditioning matrix,
- the scale-up of their elaboration process
- the minimization and management of secondary waste

The impact of these novel treatment and/or conditioning routes to the safety case has to be demonstrated to allow their implementation by end users in the future.

➢ Reducing the environmental impact and **ensuring the availability of raw materials** in the context of the strongly evolving cement industry is becoming an increasing priority.

⇒ LCA and LCC analyses will enable and help the end users making choices on the materials.

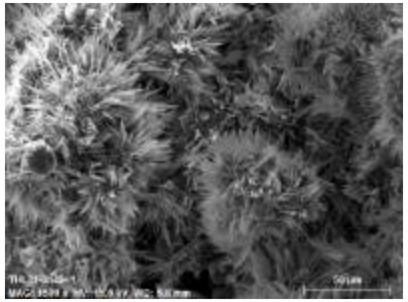
➢ Durability will be assessed in the WP7 "L'OPERA"

Scope – Overview of planned tasks

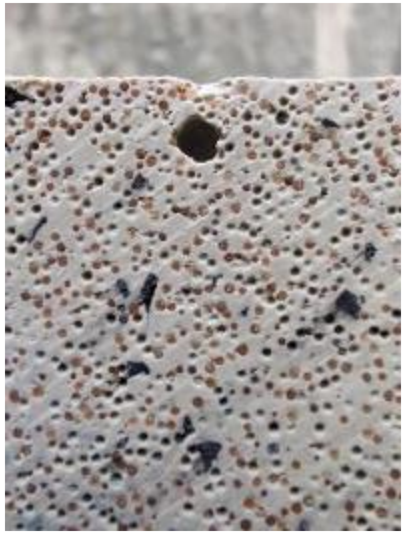
Task 1

- **Coordination**

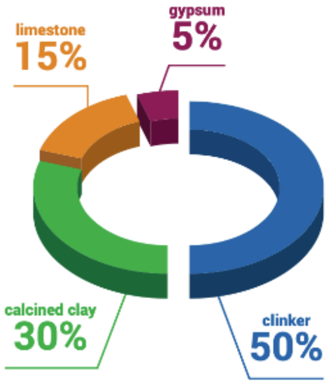
Task 2



K-struvite in magnesium phosphate binder

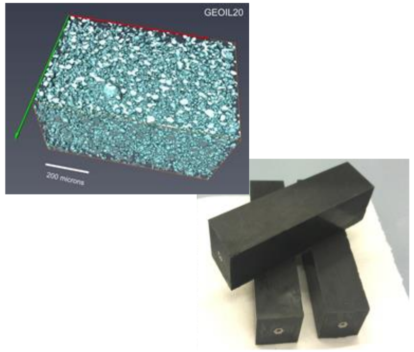


Encapsulation of ion exchange resins in a cement matrix



In-line mixing using a high shear mixer – STEMA platform

Cross-section of a geopolymer matrix embedding Mg-Zr cladding



Encapsulation of organic liquid waste using an alkali-activated binder

In-drum mixing - PREMICE platform

WP7 LOPERA
Long-term performance of waste matrices

Thierry Mennecart (SCK CEN), Maria Oksa (VTT), Denise Ricard (ANDRA)

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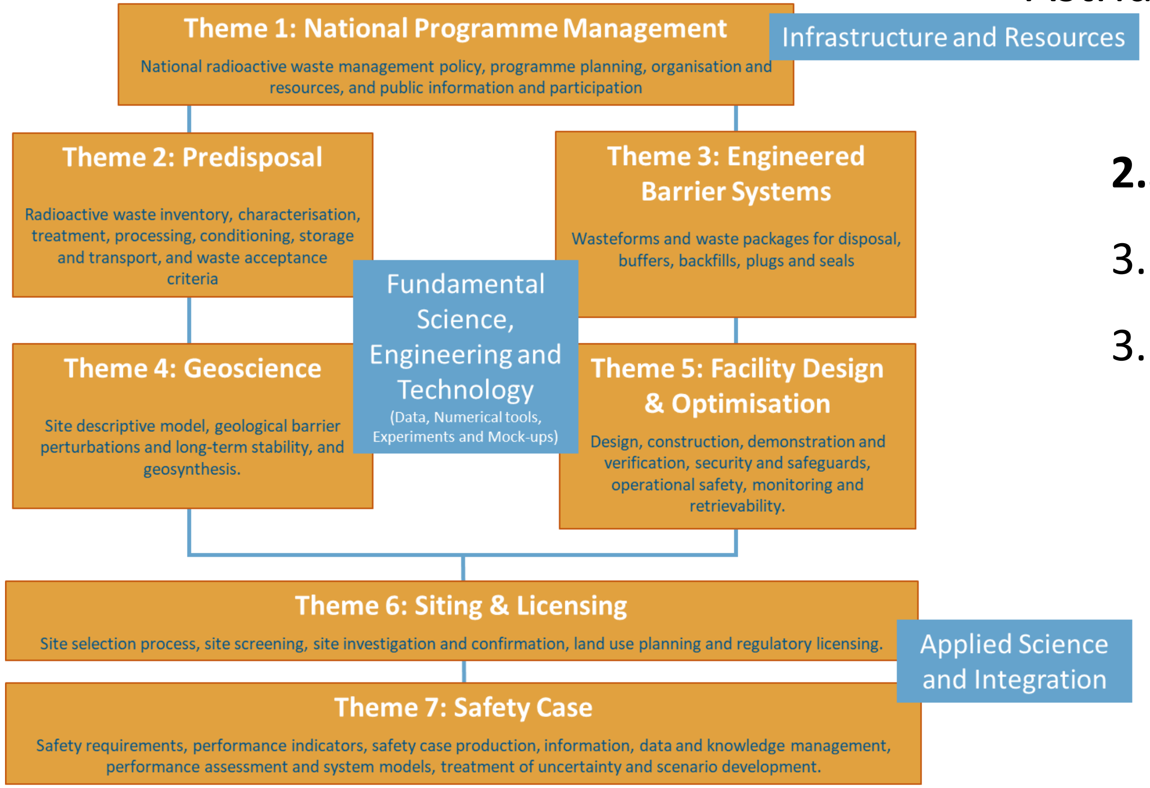
Astrid Göbel (BGE)



2.3.2 Optimisation of radioactive waste predisposal activities

3.1.3 Cemented LL-ILW

3.1.4 Other Wasteforms

Objective: Demonstrate long term behavior and durability of matrices and final wasteforms

Impact – Added value

- Increase the knowledge and understanding of matrices for the immobilization of Low and Intermediate Level Waste (LL-ILW):
  - Alternative matrices : geopolymers, organic-based materials (polymers and bitumen) and others such as magnesian cements
  - Historical matrices: bituminized wastes (some issues still require further understanding)

- Evaluation of the long-term performance of matrices for the immobilisation of Solid and Liquid Organic Waste.
  - Increase of the TRL of processes developed within previous/current European projects (e.g. PREDIS)
  - Investigate final wasteforms coming from innovative processes

- Long-term behaviour under disposal conditions
  - Degradation behaviour and its consequences on the performance of the wasteforms
    - Extrapolation to a few hundred years for surface disposal and to longer periods for geological disposal
  - Bituminized wastes (sludges and ions exchange resins encapsulation)
    - Thermal reactivity pressure induced by swelling of wastes

Scope – Overview of planned tasks

- Task 1: Management/coordination of the WP
- Task 2: Knowledge Management
    - Include training materials development and State-of-the-Art, etc.
- Task 3: Boundary conditions
    - Expected long-term conditions / radiation dose / dose rate, identification of the requirements/specifications and technical tests related to disposal facilities
- Task 4: Inventory of the conditioned materials and characterisation (physical and chemical characteristics)
- Task 5: Novel Matrices/wasteforms behaviour (performance, durability, long-term behaviour)
    - Evolution of matrices/wasteforms behaviour under ageing simulating disposal conditions (irradiation, leaching, coupled degradation, temperature variation…)
    - Effect of ageing on the performance of matrices/wasteforms (release of liquid immobilized wastes, matrices permeability, mechanical properties...)
    - Acquisition of degradation kinetic parameters
    - Upscaling for demonstration
- Task 6: Historical matrices behaviour
    - Long-lived behaviour of bituminized wastes (thermal reactivity and the effect of self-irradiation on thermal behaviour, water uptake swelling pressure that they exert in relation to their deformation …)
- Task 7: Implementation: Modelling for prediction of durability of materials and multiscale approach
    - Modelling approaches to predict long-term performance based in acquired experimental results by ageing the samples.

SHIRE – Safe Handling of IRradiated graphitE

StSt, theme 2: pre-disposal

Names of WP Preparation Team members:

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Selected SRA drivers:

- Implementation Safety
- Scientific Insight
- Innovation for Optimisation

Estimated budget: 1 M€

WP duration: 24 months

Objective

- **State-of-the-art** and **gap analysis** of non-conditioned irradiated graphite (i-graphite) storage and characterization, treatment, conditioning, and monitoring technologies for optimising the pre-disposal management and disposal of i-graphite.

Impact – Added value

- In the last decades, several projects have focused on i-graphite and useful data have been obtained. Still, there is **need for summarizing the outcomes** of such cutting-edge research activities to implement feasible waste routes for the disposal of i-graphite and tackle legacy waste accumulation.

- **State-of-the-art** and **gap analysis** for:
  - Setting the technical basis for defining the WAC for i-graphite storage and disposal.
  - The storage conditions and package monitoring technologies.
  - Physico-chemical-mechanical-radiological characterization, focus on Difficult To Measure radionuclides.
  - Treatment and conditioning methods, such as geopolymers and magnesium phosphate cements.

- **Case study**: i-graphite arisings from High Temperature Gas-Cooled Reactors.

- Needs for **future R&D** on i-graphite

Scope – Overview of planned tasks

- **Task 1: Management/coordination of the WP, 5%**
- **Task 2: Knowledge Management, 10%**
- **Task 3: Storage of non-conditioned i-graphite, 20%**
  - T3.1. Conditions and monitoring technologies
  - T3.2. Characterization of non-conditioned i-graphite
- **Task 4: Options for i-graphite management: Treatment, Conditioning, Recycle, Transport, Storage, Disposal and Recycle, 40%**
  - T4.1. Analysis of general WAC for various stages of i-graphite management
  - T4.2. State-of-the-art of the methods for various stages of i-graphite management
  - T4.3. Characterization needs for various stages of i-graphite management
- **Task 5: Study synthesis and definition of future R&D on i-graphite, 25%**
  - T5.1. GAP Analysis and needs synthesis
  - T5.2. Definition of future R&D on i-graphite
  - T5.3. Dissemination

WP9 - Release of safety relevant radionuclides from spent nuclear fuel under deep disposal conditions

RE: **Dirk Bosbach** (Jülich), d.bosbach@fz-juelich.de, **Michel Herm** (KIT), michel.herm@kit.edu

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Selected SRA drivers (boxes that were selected)

Implementation safety

Scientific insight

Knowledge management

Objective

- improved quantification and mechanistic understanding of the **release of safety relevant radionuclides** covering most representative types of spent nuclear fuel (SNF)
- **fuel evolution both prior and posterior to contact with ground water** to better predict the **radionuclide source term for post-closure safety assessment**
- built on previous collaborative European projects (FIRST nuclides, DISCO)

Impact – Added value

- **Integration of the spent fuel R&D community** by developing a coherent joint R&D program for an **improved quantification and mechanistic understanding** of the release of safety relevant radionuclides.
- **Closing knowledge gaps** outlined in for example the EURAD State of Knowledge Report Spent Nuclear Fuel Domain 3.1.1 (K. Spahiu 2021) and is built on the experiences gained in the FIRST Nuclides and DisCo projects.
- Clarify what approaches are overly pessimistic and what approaches need to be adjusted to better represent expected radionuclide release in the repository environment (optimisation)!)

Scope – Overview of planned tasks

- Task 1: Management/coordination of the WP, 10%
- Task 2: Knowledge Management (incl. training materials development and State-of-the-Art for R&D WPs, etc.), 10%
- **Task 3: IRF/FGR Performance of Spent Nuclear Fuel, 40%**
- **Task 4: Role of Grain Boundaries in Spent Fuel Corrosion, 20 %**
- **Task 5: Studies on Model Materials, 10 %**
- **Task 6: Mechanistic modelling, 10 %**

Innovative and new **Co**ntainer/canister materials under disposal field conditions: **Man**ufacturing feasibility and improved **D**urability

InCoManD (WP11)

RE: *Holger Völzke*, BAM, holger.voelzke@bam.de; *Andrea Cherkouk*, HZDR, a.cherkouk@hzdr.de

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EURAD SRA / Roadmap Themes

☒**Engineered Barrier Systems (Theme 3)**

☒Disposal facility design and optimization (Theme 5)

☒Safety Case (Theme 7)

EURAD SRA Topics

- 3.2.1 HLW and SF containers

- 3.2.3 Novel containers

- 3.4.1 EBS system

Objective

Innovative and new Container/canister materials under disposal field conditions: Manufacturing feasibility and improved Durability

→ **Innovative: solutions** (materials and/or processes) **never implemented or tested.**
→ **New: more traditional solutions** (materials and/or processes) **that need to be optimized, improved, tested in more realistic conditions…**
→ **Container and canister:** will be referred to as **"component"** for the sake of clarity.

- The WP **advances the state of the art* for HLW container/canister materials and their advanced manufacturing technologies** and **increases the fundamental scientific understanding of such components for performance assessment** under long-term deep geological disposal conditions.

*starting from the ConCorD project output and going beyond…

Impact – Added value

• Innovation and/or optimization of material solutions, including the assessment of the material durability (and analysis of the economical implications)
• Better description and understanding of material degradation mechanisms (pushing the state-of-the-art well beyond the current state by implementing as realistic as possible conditions)

⇒ **Better understanding on container/canister behavior will:**
- increase the confidence of life assessment and ensures long-term safety
- show to the stakeholders and society that the scientific community is continuously working hard for ensuring the best safety conditions of the final disposal.

• **Synergy through a cooperative project** involving several countries across Europe sharing a common goal

• Significant effort in **training new scientists**, in reporting the **SotA** in an easily accessible form, and to disseminate the results through peer-reviewed papers and during **lectures at the Master and Doctorate levels**.

Scope – Overview of planned tasks

WP divided into 7 tasks, defining 3 groups.

Group1: PM, KM, Prospectives

- Task 1 (10%): Management/coordination of the WP
- Task 2 (10%): Knowledge Management (training materials, summer school for young researchers, and SotA)
- Task 7 (~5 %): Preliminary considerations about the Life cycle costing/assessment (LCC/LCA) approaches, the availability of the raw materials, as well as of the impact of improved or new solutions on cell materials.

Group2: Material selection, component fabrication and durability

- Task 3 (~20%): (i) Identification of innovative HLW container materials or coatings, which includes ceramics, metals, and composites of those; improvement of recently defined alternative solutions;

(ii) Development of dedicated production routes

(rely on the use of a panel of elaboration processes and characterization/modelling techniques)

- Task 4 (~20%): (i) Evaluation of *in situ* durability of materials, identified in task 3, at laboratory scale and beyond and identification of the main processes and transients of interest (e.g., degradation of engineered barrier, intrusion of pore water from the surrounding host rock, gas generation, aerobic/anaerobic atmosphere, non-irradiating/irradiating environment, etc.); (ii) Development of *ad hoc* experiments to mimic accelerated field conditions (pH, temperature, irradiation…)

Scope – Overview of planned tasks

WP divided into 7 tasks, defining 3 groups.

Group3: Coupled stress-corrosion issues, modelling and understanding of transient effects

- Task 5 (~20%): For innovative or established materials, **(i)** assessment of the extent of joint mechanical-corrosion degradation modes and, **(ii)** measure of threshold stresses and comparison with levels under repository conditions, considering the possible role of defects. An approach coupling designed experiments and characterization tools combined with geochemical modelling will be implemented (to determine corrosion rates and mechanisms).
- Task 6 (~15%): **(i)** Development of modelling approaches related to the outcomes of tasks 3, 4, 5 to describe the physico-chemical, time-dependent transformations on the corrosion products; **(ii)** Development of modelling capabilities for capturing the main coupled interfacial processes influencing components long-term performance under deep geological disposal relevant conditions for the purpose of performance assessment.

ANCHORS -hydrAulic mechaNical CHemical evolution of bentOnite for barrieRs optimiSation

Names of WP Preparation Team members

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Selected SRA drivers (boxes that were selected)

Implementation safety

Scientific insight

Innovation for optimisation

Objective

- The objective of this WP is to increase the **optimisation potential of bentonite barrier systems**: buffer, backfill and seals**, Performance Assessment** and the Safety Case resilience
    1) **by qualifying the HM behaviour of various kind of bentonite types and mixtures** through laboratory experimental programme focused on heterogeneity and **chemical effects** at different scales and
    2) **by improving the numerical tools** that are necessary to carry out performance assessment of bentonite barriers in a **THMCG** repository environment.

Impact – Added value

- **Qualification of multiple bentonite types and mixtures** as alternative sealing materials in different repository concepts.
- **Investigate chemical effects** (e.g., alkaline and saline conditions) **on the HM behavior** of bentonite and bentonite-based mixtures and how it affects the disposal performance.
- **Study the consequence of bentonite and bentonite mixtures heterogeneities** in long term sealing performance under repository boundary conditions.
- **Improve THMCG constitutive models** related to the micro/macro interactions of the bentonite structure and the heterogeneity.
- **Investigate the effect of scale on bentonite testing**.
- Establishment of a comprehensive **database** containing THMCG material properties and representative numerical tests results for various kinds of bentonites and bentonite mixtures (**experimental benchmarking**).
- Elaboration of recommendations for better **quality control** of bentonite.

Scope – Overview of planned tasks

- **Task 1: Management/coordination of the WP, 10%.**
- **Task 2: Knowledge Management, 15%.**
- **Task 3: Lab testing, Multiscale experimental characterization of a wide range of bentonite types and bentonite-based mixtures**, **40%.**
  - Subtask 3.1 Micro scale testing/characterization, 20%.
  - Subtask 3.2 HMCG Laboratory testing/characterization, 20%.
- **Task 4: Bentonite Barrier modelling and Performance assessment, 30%.**
  - Subtask 4.1: Enhancement of existing constitutive models and numerical tools, 15%.
  - Subtask 4.2: Application to performance assessment cases, 15%.
- **Task 5 Social engagement, 5%.**

Break

WPs presentation

Theme 4 - Geoscience

- CLIMATE (WP14) - Climate change – 3 min
- RAMPEC (WP15) – Radionuclides – 3 min

Theme 5 - Disposal facility design and optimisation

- OPTI (WP13) – HLW repository optimisation - 3 min
- SUDOKU (WP16) – LL/ILW disposal optimisation - 3 min
- DITOCO2030 (WP17) – Digital twins - 3 min
- HERMES (WP18) – High-fidelity numerical simulations - 3 min
- CFSD (WP19) – Criticality safety - 3 min

Theme 7 – Safety Case

- DISTUC (WP20) – Thermodynamic database - 3 min
- NATAN (WP21) – Natural analogues - 3 min

CLIMATE – Impact of climate change on nuclear waste management

Aina Bruno (RE, Amphos 21), Veli-Matti Pulkkanen (TSO, VTT) Frederic Ego (WMO, Andra),

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CG observer: Astrid Göbel (BGE)

Selected SRA drivers

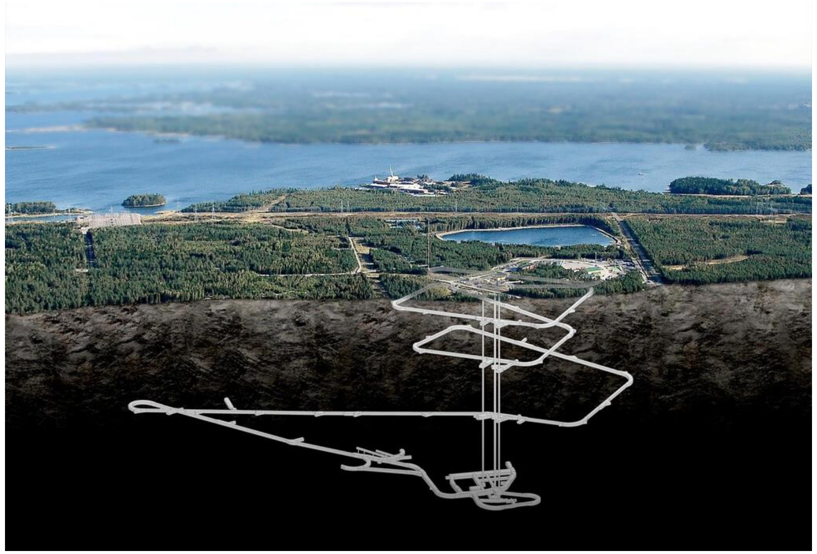
Implementation Safety

Societal Engagement

Knowledge Management

Objective

- Identify knowledge gaps and provide recommendations for future research needs of the impact of climate change on waste management facilities (predisposal, shallow, and near surface LLW, DGR LILW, HLW) during construction, operation and on post-closure site evolution.



Onkalo Project, POSIVA

Impact – Added value

- **Climate and its medium to long-term evolution is the main driver controlling:**
  - Thermal conditions; local and regional geomorphological evolution; weathering processes; changes in local and regional hydrogeological and hydrological contexts; changes in natural and anthropogenic ecosystems.

- **Climate change is increasing climate-related risks and the frequency and intensity of events (floods, landslides, snowstorms, tornadoes, etc.) that can:**
  - Affect the safety of all types of nuclear waste management facilities (from interim storage to waste repositories and preliminary storage) during construction, operation and post-closure ;
  - Pose serious risks for nuclear waste management facilities ;
  - Negatively impact public health and the environment.

- **Assessing the impacts of climate change is a new research topic in the nuclear waste management sector, although climate scenarios are considered in long-term safety assessments. Thus, the project will contribute to:**
  - The development of work on this subject at European level;
  - Identify gaps in knowledge;
  - Provide recommendations on future research needs on the impact of climate change on all types of nuclear waste management facilities and sites across Europe, in the short and long term.
  - Foster civil society’s confidence in radioactive waste management safety.

Scope – Overview of planned tasks

Estimated Budget approx. → 1M€
Expected duration → 24M

- **Task 1: Management/coordination of the WP (10%)**
- **Task 2: Knowledge Management (10%)**
- **Task 3: Strategic gap analysis (20%)**
  - Collection of current understandings and regulations in relation to climate impacts and climate risk assessment in the construction, operational, and post-closure phases of radioactive waste management facilities and sites.
- **Task 4: Construction and operational phase climate impacts (25%)**
  - Climate scenarios definitions. Selection and profiling of representative nuclear waste management facilities and sites in different climate zones across Europe. RWM facility data collection. Review of natural analogues relevant for the selected sites. Collection of physical hazard screening methods, and hazard identification. Evaluation of scoring methodologies. Assessment of climate modelling and risk assessment methodologies. Identification of needs and gaps for the selected construction and operational phases case studies, including using natural analogues. Feedback meetings with stakeholders.
- **Task 5: Post-closure climate impacts (25%)**
  - Climate scenarios definitions. Selection and profiling of representative nuclear waste management facilities and sites in different climate zones across Europe. RWM facility data collection. Review of natural analogues relevant for the selected sites. Collection of physical hazard screening methods, and hazard identification. Evaluation of scoring methodologies. Assessment of climate modelling and risk assessment methodologies. Identification of needs and gaps for the selected post-closure phase case studies, including using natural analogues. Feedback meetings with stakeholders.
- **Task 6: Interaction with Civil Society – Stakeholder engagement (10%)**
  - Interaction with Civil Society experts (also possibly outside nuclear field) on socio-technical challenges and associated uncertainties. Identify stakeholder perceptions and concerns related to impacts of climate change on nuclear waste management and develop recommendations for transparent information exchange and dialogue. Foster the use of digital technologies for improving the communication with public.

RAMPEC: Radionuclide mobility under perturbed conditions

RE: Marcus Altmaier (KIT, Germany), marcus.altmaier@kit.edu

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CG observer : Nadja Zeleznik (EIMV, Slovenia), nadja.zeleznik@eimv.si

R&D activity / 60 months / 5 M€ budget

Selected SRA drivers: Implementation Safety, Scientific Insight, Knowledge Management

Objective

- Improved understanding and prediction of disposal system chemistry and radionuclide mobility under perturbed conditions, based on new experimental studies and tailored modelling approaches up to the cell scale.

Impact – Added value

- RAMPEC will provide improved methods and approaches both regarding mechanistic modelling and modelling radionuclide migration on the cell scale.
- Use of existing data from previous projects (FUTURE, CORI, …) and targeted new experimental investigations.
- All RAMPEC Tasks aim for both scientific excellence and high relevance in the applied context - using coherent and forceful collaborations between the Tasks and Subtasks and within EURAD II.
- RAMPEC will allow for a broad international cooperation throughout Europe with excellent opportunities for education and training as well as sharing of resources and expertise.

Scope – Overview of planned tasks

- **Task 1 (5%)**: Management/coordination of the WP.
- **Task 2 (10%)**: Knowledge Management (including sorption database activity).
- **Task 3 (45%)**: Experimental program (specific Subtasks on (i) clay, (ii) granite, (iii) cement..
  - (Subtask 3.1): *Experimental studies in the clay system*. Perturbations to be investigated are limited to temperature ($T < 90°C$), complexing ligands, chemical plume and the saturation degree.
  - (Subtask 3.2): *Experimental studies in the granitic system*. Perturbations to be investigated are limited to the influence of secondary phases and changes in pore-water composition or pore structure (porosity).
  - (Subtask 3.3): *Experimental studies in the cement system*. Perturbations to be investigated are limited to ionic strength (sulphate, nitrate) and the impact of the saturation degree.
- **Task 4 (20%)**: Development of macroscopic/mechanistic models.
  - (Subtask 4.1): *Modelling - clay system*. (Subtask 4.2): *Modelling - granitic/crystalline rock system*.
  - (Subtask 4.3): *Modelling - cement system*.
- **Task 5 (20%)**: Upscaling of data and models Transfer to «cell» scale. Benchmarking of mechanistic models against simplified K_d approach.

OPTI - HLW Repository optimisation including closure

Valery Detilleux (valery.detilleux@belv.be)
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SRA drivers:

- Implementation Safety
- Innovation for Optimization
- Societal Engagement

Objective

- Develop a mutual understanding and provide recommendations about methodologies and further activities for design and optimization of specific HLW deep geological repository systems, structures and components (SSCs) and procedures.

Impact – Added value

- A mutual understanding about optimisation will be developed
- Networking about best practices for Optimisation strategies for EBS components and DGR processes
- Outcomes will help less advanced programmes in their earlier phases of repository development
- Transfer of knowledge from advanced to less developed programmes will be facilitated
- R&D needs about specific SSCs and procedures that could be optimized further will be identified

Scope – Overview of planned tasks

Task 1: Management/coordination of the WP

Task 2: Knowledge Management

Task 3: Building a mutual understanding about optimization approaches for waste disposal facilities and their management in RWM programmes and a safety cases. Baseline study oriented task.

Task 4: Key challenges regarding optimization of specific SSCs and procedures related to waste disposal facilities: identification & exchanges about their strategic and (socio-)technical aspects. Technically oriented task.

Task 5: Synthesis - Deliver joint proposals for further activities about area that need to be further optimized.

SUDOKU: Near-SUrface Disposal Optimization based on Knowledge and Understanding

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CG observer: Lara Duro, lara.duro@amphos21.com

SRA drivers: Innovation for Optimisation

Implementation Safety

Scientific insight

Objective

- Understanding the **behaviour and performances of** (i) **covers** and (ii) **cementitious barriers** of near-surface disposal facilities for short lived waste (ground level facilities) and ILW (shallow deep facilities) in view of **optimization** to ensure the **long-term safety of disposal facilities**.

Impact – Added value

- The SUDOKU approach is to combine the investigations on the multilayer cover with the durability of cementitious barriers to assess the **transfer properties of mobile radionuclides** (^{36}Cl, ^{14}C, ^{99}Tc..) in **damaged barriers** according to the chemo-mechanical evolution.
- The novelty of SUDOKU consists of:
  - evolution of hydraulic properties and durability of the cover with **on-site experiments**
  - experimental and modeling data about degradation of reinforced and unreinforced concretes in near surface disposal conditions
  - transport properties of mobile radionuclides in cracked and corroded reinforced cement-based materials.
- SUDOKU will provide understanding and assessing of the long-term integrity evolution of the multilayer cover under different climate change scenarios contributing to the optimization of this important barrier designed to seal the surface disposal facilities.
- The better characterization of the durability of the cover and the cementitious barriers achieved by the work proposed to be performed in SUDOKU will reduce the uncertainties and improve the safety assessments, in particular by taking into account the chemo-mechanical evolution of cement based materials in terms of radionuclide transfer parameters. The use of proven models in combination with **on-site and laboratory studies** will ensure the necessary reliability of the results and the determination of the **optimal EBS configuration** from the point of view of the safety of LLW/ILW disposal.

Scope – Overview of planned tasks

- Task 1: Management (coordination of the WP), 5%
- Task 2: Knowledge Management (incl. training materials development and State-of-the-Art for R&D WPs, layout, etc.), 10%
- Task 3: **Performance of multilayer covers**, 35%
  - Sub-task 3.1: Lab scale experiments on long-term interactions (different time-developing conceptual stages) affecting the mechanisms that control cover effectiveness
  - Sub-task 3.2: On-site experiments on an **existing** multilayer cover mock-up (including instrumentation systems)
- Task 4: **Chemo-mechanical evolution of reinforced and unreinforced cementitious barriers** and the **effect on the migration of mobile radionuclides**, 35%
  - Sub-task 4.1: Cementitious materials ageing and degradation - CMH evolution (*lab-scale and possible on-site experiments*)
  - Sub-task 4.2: The corrosion of steel reinforced materials (*lab-scale experiments*)
  - Sub-task 4.3: Effect of CMH evolution of cementitious materials and steel corrosion products on the migration of mobile radionuclides (*lab-scale experiments*)
- Task 5: **Modeling of the evolution of the EBS and its effect on radionuclide migration** on the basis of the experimental results obtained in Tasks 3 and 4, 15%

DITOCO2030 Next generation Digital Twins (DT) to support Optimisation (including communication of safety), Construction and Operation of surface and subsurface radioactive waste management facilities - moving into the next decade (2030)

WP preparation team

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Selected SRA drivers

- Scientific Insight
- Implementation Safety
- Innovation for Optimisation

Objective

To **lay-out the path** on how to **close the RD&D gap between the currently fragmented DT of individual disciplines**, **common data environments** and **decision-making platforms** that the radioactive waste management community needs in order to

i) optimize, construct, and safely operate the intermediate storage facilities as well as the surface and subsurface disposal facilities, and

ii) facilitate and improve the communication to all stakeholders, the general public and policy makers.

A digital twin in WP17 can be a virtual representation of an existing or future surface and subsurface radioactive waste management facility that can model the geometry, operations and coupled processes, is updated from real-time data, uses simulation, machine learning and reasoning to support their Optimization (including communication of safety), Construction and Operation.

Impact – Added value

It is **anticipated** that within EURAD-2 significant progress **to agree on what is needed from the individual disciplines in a DT** (*at what point in time and to what level of detail*), in order to use the DT for effective decision-making during the planning, construction, operation and maintenance of radioactive waste management facilities, and for interactions with stakeholders.

Development of a uniform markup language and an open standard for nuclear waste management.

i) identification and management of risks,

ii) performance assessment of safety margins,

iii) optimization of design configurations,

iv) calculation of costs to completion,

v) engagement improvement with stakeholders.

Scope – Overview of planned tasks

***Task 1** Management and coordination of the work package, including organisation of meetings.*

***Task 2** Effort allocated to the knowledge management, including documentation of the results.*

Task 3 **State of the art analysis** to record and document normative requirements and their implementation today

- Compilation and review of regulatory requirements
- Identification and comparison of potentially relevant international standards
- Compilation of use cases in which DT are already being used today (pre-existing definitions of DT)
- Outreach to other industries and other Horizon 2020 initiatives

Task 4 **Gap analysis** identifying the major challenges to close the RD&D gap between currently fragmented single discipline DT

- Clarify the needs and opportunities, assess drivers and barriers towards a standardized DT set objectives
- Capture the end-user needs and requirements on the final product in detailed descriptions of use-cases
- Compile ideas on how the envisioned DT supports the argumentation of a safety case, *the implementation and maintenance of the waste disposal facilities, including the generation of possible improvements,* and Stakeholders communication
- Develop qualitative and quantitative performance indicators to distinguish functional DT from dysfunctional ones in the long term
- Description of the human and technical competences required for the development, operation and maintenance of DT

Task 5 **Strategic recommendation** on the standardised design of DT, documented in a position paper

- Harmonisation of data collection/ processing
- Harmonisation of databases/information exchange
- Harmonisation of methods/workflows/processes with definition of data exchange requirements

Task 6 **Community engagement** with surveys, pluralistic workshops and webinars, including the documentation of results

HERMES: **H**igh fid**E**lity nume**R**ical si**M**ulations of strongly coupled processes for r**E**pository sy**S**tems and design optimisation with physical models and machine learning

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CG observer : Bruggeman Christophe (SCK CEN) christophe.bruggeman@sckcen.be

R&D activity / 48 months / 4 M€ budget

Selected SRA drivers: **Implementation Safety**, **Scientific Insight**, **Knowledge Innovation for Optimisation**

Objective

WP-HERMES aims at the development of high fidelity numerical models for simulations of strongly coupled THMC processes in repository nearfield, repository design optimization and interpretation of mock up experiments using a combination of physics based models and accelerated computing assisted with machine learning and artificial intelligence.

Impact – Added value

- Process-based numerical simulations for in-depth system understanding, analysis of experimental observations and their upscaling to the natural systems.
- The development of fully coupled THMC models and the use of surrogate models goes beyond traditional desktop studies based on application of standard simulation codes.
- The surrogate models supported by artificial intelligence concepts (machine learning, data driven models) will enable efficient repository conceptualization and design optimization in both advanced- and early-stage waste disposal programs.
- WP-HERMES will play a central role in facilitating collaboration between experimental work focused WPs and provide excellent opportunities for education and training, attracting students interested in developing cutting edge numerical tools.

Scope – Overview of planned tasks

- Task 1 (10 %): *Management/coordination of the WP*
- Task 2 (15%): *Knowledge Management*
  - Including open access models/codes hub and experimental/modelling data repository
- *Task 3 (30%): THMC-Process couplings and computational performance*
  - Definition and development of unified interfaces for process couplings
  - Forward and inverse modelling as well as sensitivity analysis
  - Dynamic integration of data into the models
- *Task 4 (20%): Surrogate models of individual phenomena*
  - Implementation of surrogate models and their benchmarking against physical models
- *Task 5 (25%) Tailored models for SA/PA and field scale mock-ups*
  - High fidelity models for repository near-field simulations

WP-19: CSFD
«Criticality Safety for Final Disposal»

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EURAD-2 Core Group Observer: A. Göbel (BGE, Germany)

Selected SRA drivers:

- Implementation safety
- Scientific Insight
- Innovation for Optimisation

Objective

- All organisations planning & designing deep geological disposal facilities, regardless of the stage of the programme, need to carry out **criticality safety assessments** for their concept(s) ↔ regulatory requirement(s).

- **The R&D work in WP-19 will address the challenge of doing post-closure criticality safety assessments for long time scales (orders of magnitude larger than in any other area of the fuel cycle).**

- Attain an improved shared understanding regarding the **methodological** validation, **experimental verification** and consolidated **technical basis** of criticality safety argumentation for final disposal of fissile wastes.

Impact – Added value

- **Enable/Support national programmes in ensuring post-closure criticality safety for their GDF concepts and inventories;**
- **Build, further develop and consolidate post-closure criticality safety case (argumentation).**

GDF Post-Closure Criticality Safety ensured through

Technical measures:

Design of final disposal containers & other technical barriers.

Administrative measures:

Research & develop methods and tools for deriving fissile mass limits per waste package and loading plans.

Post-Closure Criticality Safety Case

Evaluate performance of technical & admin. measures:

- **Develop methods to consolidate, validate and verify PCCS assessment methodology;**
- **Investigate & explore PCCS experimental needs.**

Consequence Assessments:

Develop methodology for post-closure criticality consequences assessments.

GDF optimisation

Investigate factors that influence the derivation of fissile material limits with a view to optimise waste package & barrier design.

PCCS communication to stakeholders

Develop an effective communication strategy to all relevant stakeholders (general public, national regulator, etc).

Scope – Overview of planned tasks

GDF Post-Closure Criticality Safety ensured through

Technical measures:

Design of final disposal containers & other technical barriers.

Administrative measures:

Deriving fissile mass limits per waste package & loading plans:

- **Task 5:** Development of PCCS methodology relevant to the derivation of spent fuel loading curves and fissile mass limits for ILW packages [18%]
- **Task 8:** Fissile waste records for PCCS assessments [10%]

Post-Closure Criticality Safety Case

Evaluate performance of technical & admin. measures

- **Task 3:** Validation of long-term evolution scenarios for post-closure criticality safety (PCCS) assessments [10%]
- **Task 4**: Verification of model implementation for PCCS assessments [12%]
- **Task 6:** Experimental basis for validation of depletion and criticality codes for PCCS [7%]

Consequence Assessments

- **Task 7:** Methodology for consequence assessment in the post-closure phase [13%]

GDF optimisation

PCCS-informed exploration of optimisation potential: **interplay between Task 5 & technical measures.**

PCCS communication to stakeholders

- **Task 9**: PCCS technical communication [10%]

WP coordination [10%] & **knowledge management** [10%]: Tasks 1 & 2

DITUSC: Development and Improvement of Quality Assured Thermodynamic Understanding for use in Nuclear Waste Disposal Safety Case

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[Lara Duro – Core Group observer]

Strategic Study / 18 months / 0.5 M€

Selected SRA drivers: Implementation Safety; Scientific Insight; Knowledge Management

Objective

- Quality assured thermodynamic understanding and data in support of the Nuclear Waste Disposal Safety Case, with special focus given to a transversal understanding, i.e. with all actors involved.

[This is not a review of existing studies to derive thermodynamic data (!)]

Impact – Added value

- Support present and future capabilities to perform reliable use of thermodynamic model calculations for the performance evaluation of various disposal configurations, for Safety Analyses and the development of the Safety Case.
- Improvement and consolidation of the knowledge to predict processes over long timescales in key fields for geological disposal of radioactive waste.
- White paper on the thermodynamic understanding for use in Nuclear Waste Disposal Safety Case:

  => State-of-the-art of systems considered within Tasks 3 to 7.

  => Definition of priorities and actions to fill-in limitations / gaps identified.
- Transversal understanding. Involvement of all actors:

  => Series of workshops with focus on individual Tasks.

  => Feed into state of knowledge and identification of gaps / limitations.

Scope – Overview of planned tasks

- **Task 1 (10%). Management/coordination of the WP.**
- **Task 2 (10%). Knowledge Management.**
- **Task 3 (15%). Thermodynamic data gaps.** Identification of data gaps within the NEA-TDB project and beyond, e.g., organics, zeolites, RN in relevant oxidation states / boundary conditions. Seek for synergies with on-going projects (NEA-TDB, ThermoChimie, THEREDA, etc.). Precise definition of the systems to be covered in the gap analysis will be completed in the next proposal step.
- **Task 4 (15%). Perturbed systems:** Thermodynamics in high saline systems (e.g., nitrate, chloride) and elevated T conditions (< 150 °C), including estimation methods.
- **Task 5 (15%). Thermodynamics of solid-solutions:** including clay or cement systems, zeolites, baryte, LDH, with emphasis on end-members incorporating anionic species / RN.
- **Task 6 (15%). Interplay of thermodynamics and kinetics:** including solid phases (transformation (am) → (cr)), redox phenomena, spent fuel dissolution, etc. Seek for synergies with on-going projects.
- **Task 7 (20%). Thermodynamics and safety case:** Integral assessment and documentation. *[Note: task to be implemented if participation of WMOs is confirmed]*

NATAN – Natural analogues and long-term evolution: upscaling towards relevant space and time scales

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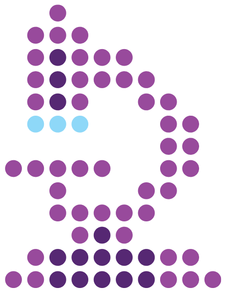
SRA·drivers·· (maximum·3)¶ ¤	☒Implementation·Safety¤	☐Tailored·Solutions¤	☒Scientific·Insight¤
	☐Innovation·for·Optimisation¤	☒Societal·Engagement¤	☐Knowledge·Management¤

Objective:

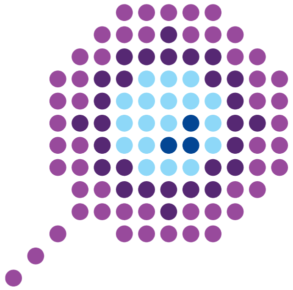
Using natural analogues (NA) to **upscale** laboratory based, URL-derived and instrumental data in space and time, **to test future scenarios** of **long-term evolution**, and **to build confidence** in and provide supporting arguments to the **safety case**

Impact – Added value



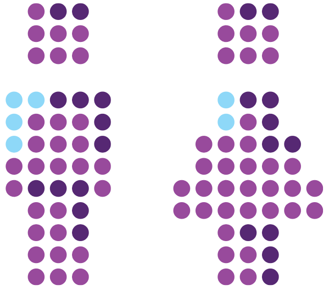
Science & Technology

State of the art analytical techniques with very low **detection limits** and novel **remotely sensed data** generate information with **higher precision** → sampling, field exploration & modelling



Safety Case

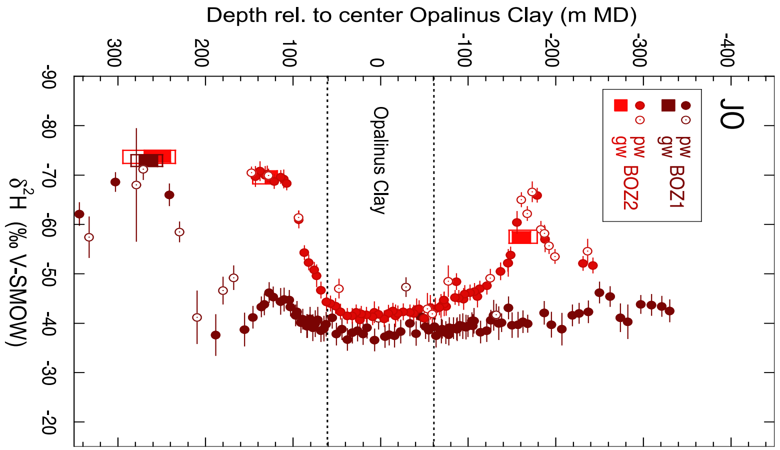
Building and/or **optimising** the **safety case** in different **disposal concepts.**



Societal engagement

Pluralistic dialogue to allow a better common understanding (between experts and **civil society**) about the meaning of the link between NA studies and safety case → visibility

Scope – Overview of planned tasks



Task 3 - Permafrost & geodynamics

S-T 3.1: Development of robust & generic **permafrost models** that are tested against data to assess the spatial distribution and type of permafrost.

S-T 3.2: Qualification of short-term observations on crustal movement (**satellite data**) and erosion for predictions.

S-T 3.3: Linking permafrost and geodynamic NA with flow, transport (Task 4).

Task 4 - Flow and transport

S-T 4.1: Constraints on flow and transport in host rocks and surrounding aquifers through **groundwater dating** and tracing of NA study cases in relevant geological settings.

S-T 4.2: **Radionuclide migration** analogue studies using state-of-the-art analytical techniques (SIMS/nano-SIMS, synchrotron and AMS).

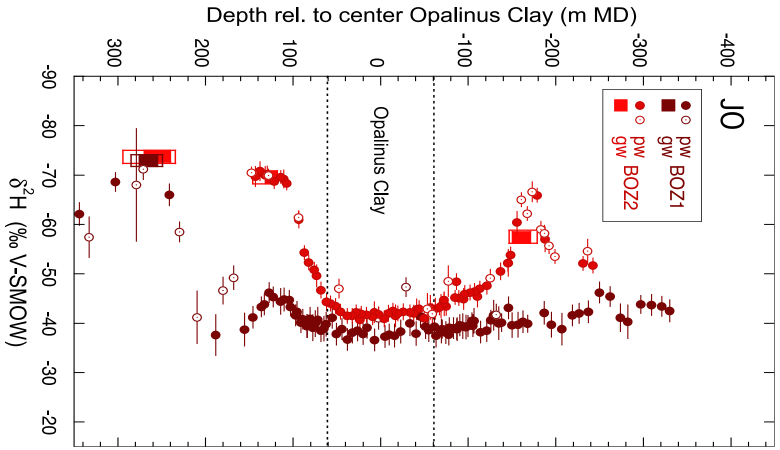
Task 5 - Corrosion

S-T 5.1: Constraints on corrosion behaviour of **copper** under anaerobic conditions & the role of, e.g., sulphide and cracking.

S-T 5.2: Constraints on corrosion behaviour of **steel** under anaerobic conditions, including cracking.

S-T 5.3: Constraints on microbiological and mineralogical processes at the **clay-metal interface.**

Scope – Overview of planned tasks



Task 3 - Permafrost & geodynamics

Possible sites: Palaeogene-Neogene outcrop and subcrop in southern North Sea basin; Fennoscandinavian shield; present-day arctic regions.

possible link with WP14 Climate change – StS

Task 4 - Flow and transport

Possible sites: clay-rich Mesozoic outcrop and subcrop in Alpine foreland; northern Apennines; Rupelian outcrop and subcrop in northwestern Europe; Ruprechtov and Oklo sites

possible link with WP15 Radionuclides and WP16 - ILW

Task 5 - Corrosion

Possible sites: Kiiruna, SE; Autun, FR; Nydam Mose, DK

possible link with WP11 Containers/canisters

Next steps and conclusion

How to get involved ?

- Register to your Colleges to have all information
- Contact the WP Preparation Teams

- Mandated Actors should provide mandate letters to Core Group Coordinator by 2 October 2023
- Affiliated Entities can check first list of previously mandated actors in the EURATOM Work Programme
- Associated Partners are welcome to participate to the WPs

[Guidance Affiliated Entities]

[Guidance Associated Partners]

Next steps

- Meeting with WP Preparation on Team 13 July 2023 to explain Template #3, best practices and tips, status of the WPs (green/yellow/red voting) etc…
- Development of Template #3 will be done by WP Preparation Teams during Summer together with budget
  - Two different status of WPs
    - Green ones – no major modification requested by the Colleges
    - Yellow ones – major modifications requested by the Colleges
- Final check for all WPs with Colleges is planned for end September – last comments integrated in October
- Core Group communication to be issued in the next two weeks with more detailed information on WPs and proposal development and schedule
- Slides will be available early next week on EURAD and PREDIS websites

Who to contact ?

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Thank you for your attention