PREDIS SRA Webinar
Nov 3rd 2022
ALAN WAREING (NNL)
This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.

Strategic Research Agenda Webinar - Agenda

10.00 – 10.10 Welcome / Introduction – Alan Wareing
10.10 – 10.30 Overview of PREDIS SRA development to date – Alan Wareing
10.30 – 10.45 Characterisation – Christophe Bruggeman
10.45 – 11.00 Treatment Processing – Federica Pancotti
11.00 – 11.15 Conditioning & Packaging – Kahina Hamadache
11.15 – 11.30 Waste Acceptance Criteria – Jose Luis Leganes Nieto

11.30 – 11.40 Break
11.40 – 11.50 Inventory – Alan Wareing
11.50 – 12.00 Technology Selection – Ernst Niederleithinger
12.00 – 12.10 Optimisation – Tim Schatz
12.10 – 12.30 Breakout room discussion – Breakout room leaders
12.30 – 12.45 Group feedback – Breakout room leaders

12.45 – 12.50 Close – Alan Wareing
SRA development to date

ALAN WAREING (NNL)
Initial SRA analysis – identifying themes & topics

<table>
<thead>
<tr>
<th>SRA Topic</th>
<th>Keywords</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste generation</td>
<td>Planning</td>
<td>Waste management strategy, waste hierarchy, waste routes, technology selection</td>
</tr>
<tr>
<td></td>
<td>Inventory</td>
<td>Sources and quantities of waste generated and in existing storage, future waste generation</td>
</tr>
<tr>
<td></td>
<td>Classification</td>
<td>Characteristics of wastes in order to sort, classify and identify waste types</td>
</tr>
<tr>
<td>Processing</td>
<td>Treatment</td>
<td>Pre-treatment and treatment to minimise waste quantities and volumes</td>
</tr>
<tr>
<td></td>
<td>Conditioning</td>
<td>Stabilise waste by conditioning</td>
</tr>
<tr>
<td></td>
<td>Packaging</td>
<td>Containers and packaging for future transport, storage and disposal</td>
</tr>
<tr>
<td>Storage &amp; Transport</td>
<td>Storage</td>
<td>Safe storage of wastes/packages including decay storage, interim storage and long-term storage</td>
</tr>
<tr>
<td></td>
<td>Transport</td>
<td>Transport of wastes between facilities at different stages of pre-disposal management</td>
</tr>
<tr>
<td>Disposability Assessment</td>
<td>Disposability</td>
<td>Suitability of wasteform for disposal, behaviour within a disposal environment, implications for treatment, conditioning and packaging</td>
</tr>
<tr>
<td></td>
<td>WAC</td>
<td>Parameters and metrics for waste acceptance</td>
</tr>
<tr>
<td>Cross-cutting</td>
<td>Characterisation</td>
<td>Characterisation of wastes throughout the lifetime of wastes/packages</td>
</tr>
<tr>
<td></td>
<td>Optimisation</td>
<td>Optimisation of the different phases of pre-disposal management</td>
</tr>
<tr>
<td></td>
<td>Quality &amp; Mgmt</td>
<td>Quality and management systems, records management and monitoring required throughout the lifetime of the wastes/packages</td>
</tr>
</tbody>
</table>

Methodology for identifying the SRA

Predisposal Management - Waste generation
Predisposal Management - Processing
Predisposal Management - Storage & Transport
Disposability Management - Disposability Assessment
Disposability Management - WAC
Way forward - Knowledge Management
Way forward - Stakeholder Engagement

This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.
This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.
This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.

---

SRA Development Timeline

<table>
<thead>
<tr>
<th>End User Engagement</th>
<th>Drafting</th>
<th>Wider Engagement</th>
<th>Drafting</th>
</tr>
</thead>
<tbody>
<tr>
<td>05/22</td>
<td>06/22</td>
<td>07/22</td>
<td>08/22</td>
</tr>
<tr>
<td>09/22</td>
<td>10/22</td>
<td>11/22</td>
<td>12/22</td>
</tr>
<tr>
<td>01/23</td>
<td>02/23</td>
<td>03/23</td>
<td></td>
</tr>
</tbody>
</table>

- **2nd Internal WS (Wider delivery partners) Survey expanded**
- **Focus Sessions to discuss ‘sub area’ details**
- **Begin composing chapters of 1st draft of updated SRA**
- **Draft EURAD position paper**
- **1st Draft of updated SRA**
- **Public Webinar**
- **Engage EURAD colleges IAEA WENRA**
- **Final Draft of updated SRA Submitted**

- **Rationalise Feedback and Reviews**
This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.

<table>
<thead>
<tr>
<th>Technical Topic</th>
<th>Priority Topics</th>
<th>Economic renewal &amp; growth</th>
<th>Protect citizens &amp; environment</th>
<th>Public trust &amp; confidence</th>
<th>Processes, products &amp; services</th>
<th>Improved performance</th>
<th>Contributes to competences and skills</th>
<th>Improve networks</th>
<th>Science quality and TRL</th>
<th>Innovation</th>
<th>Revenue, turnover</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory</td>
<td>5</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Understanding</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology Selection</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>Remote characterisation. Physico-chemical characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Hierarchy</td>
<td>2</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characterisation</td>
<td>1</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Processing</td>
<td>4</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conditioning &amp; Packaging</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deployment Options</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality &amp; Management Systems</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commission</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimisation</td>
<td>3</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Synergy between new and existing technologies</td>
<td></td>
</tr>
<tr>
<td>Secondary Waste Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R&amp;D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge Management</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stakeholder Engagement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Respondents by Organisation Type

- **Waste Management Operator**: 14
- **Waste Generator**: 2
- **Regulator**: 3
- **Research**: 1
- **TSO**: 1
- **Government**: 8
- **Other**: 1

This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.
This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.
Results and Emerging Priorities

Please select the five most important topics for R&D from the list below. (Rank your top five in order)

- Inventory
- Waste Acceptance Criteria
- Technology Selection
- Cost Estimating
- Funding
- Waste Hierarchy
- Characterisation
- Treatment Processing
- Conditioning & Packaging
- Storage
- Transport
- Deployment Options
- Quality & Management Systems
- Commissioning
- Optimisation
- Secondary Waste Management
- Management of R&D
- Knowledge Management
- Stakeholder Engagement

Focus group
PREDIS SRA: Characterisation

- Access to the properties of (nuclear) materials and radioactive waste
  - Conditioned/raw (primary) materials and waste streams
  - Different forms and shapes
  - In situ/Ex situ
  - Physical, chemical and radiological characteristics
- Destructive and Non-destructive methods
PREDIS SRA: Characterisation

- Sources:
  - SHARE SRA (D4.1) – thematic area 2
    - [https://share-h2020.eu/project-deliverables/](https://share-h2020.eu/project-deliverables/)
  - CHANCE D2.3
    - R&D requests in the field of conditioned radioactive waste characterization
  - MICADO [https://www.micado-project.eu/](https://www.micado-project.eu/)
  - EN-TRAP
  - PREDIS questionnaire and webinars

This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.
PREDIS SRA: Characterisation

- Waste classification
- Technology selection
- Isotope vector and scaling factor
- In situ characterization and segregation
  - Radiological characterisation challenges of (conditioned) radioactive waste (packages)
  - Non-radiological properties and inventory of radioactive waste
  - Developments or improvements of characterisation technology
- Digitalisation and data management
- Release/clearance methodology
- Competence development
- Quality control

This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.
PREDIS SRA: Characterisation

- Waste classification
  - Incorporating physico-chemical properties
  - Classification of legacy wastes → reduce uncertainties

- Technology selection
  - Fitness for purpose → increasing efficiency and harmonization of practices

- Isotope vector and scaling factor
  - Accounting for heterogeneity, changes over time and place, etc. → support of best practices and remove inconsistencies across waste streams and sites
  - Treatment of uncertainty/conservatism
  - For both radioactive and non-radioactive components → better inventory
  - Validation of computer calculations → benchmarking and quality management
PREDIS SRA: Characterisation

- In situ characterization and segregation
  - Remote, integrated and automated technologies → increase TRL and demonstrate maturity
  - Best practices for on-line characterization during remediation and clean-up (remaining underground structures)
  - Characterisation in accessible areas

- Radiological characterization challenges of (conditioned) radioactive waste (packages)
  - Development of new radiological and non-radiological characterisation approaches; non-destructive methods (as alternative to destructive techniques); analytical methods for specific nuclides; quick operative, reliable, robust, efficient and economic characterisation methods (e.g., in D&D projects, legacy waste inventory, etc.) → Improve safety, efficiency, economics, reduce uncertainty and conservatism
  - Share experience, knowledge and case studies (from more advanced programmes)
Radiological characterization challenges of (conditioned) radioactive waste (packages)

- (c’td)
- Sampling techniques, optimize sampling strategy (statistical approaches), assess uncertainty
- Characterisation of
  - Heterogeneous (metallic) wastes or containers
  - Solid organic waste (historic/legacy wastes)
  - Fissile material in waste drums
  - Large/dense (cemented) waste packages
- Mobile monitoring/characterization systems
- Increasing accuracy by combining different techniques
- Characterisation for security/safeguard purposes, e.g., related to transport of materials
PREDIS SRA: Characterisation

- Non-radiological properties and inventory of radioactive waste
  - Improving the understanding of the non-radiological properties and inventory of radioactive waste, e.g., presence of (toxic) chemical species and/or material characterisation inside a waste packages → Technology improvement, better inventory, demonstration of conformity
  - Non-destructive testing/characterization of physico-chemical content and properties, also during interim storage
  - Improved data and understanding of organic materials and complexants
  - Characterisation of ageing effects in cemented waste drums
  - Detection of gasses generation and outgassing monitoring

This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.
PREDIS SRA: Characterisation

- Developments or improvements of characterization technology → very topical
  - Coupling gamma spectrometry and tomography
  - Fast, cheap and straightforward methods for difficult to measure radionuclides (DTM), including in situ alpha and beta measurements (e.g., H-3, C-14, Ni-63)
  - Enhance the use of robotics including drones, submersible ROVs and sensors, allowing also the characterisation and/or sampling of difficult to access areas
  - Gamma camera technology
  - Alpha measurement on organic liquids (oils)
  - Graphite characterisation
  - Radiation-tolerant devices
  - Active neutron interrogation to measure fissile mass in high-level waste
  - Etc.
PREDIS SRA: Characterisation

- Digitalisation and data management
  - Digitalisation, modelling and simulation. Best practices and guidelines on the implementation of digital technologies to improve key tasks in the decommissioning. BIM and Digital Twins to add value and accelerate the decommissioning programmes
  - Characterisation data handling and uncertainty management
  - Improved interpretation of characterization results using AI or ML approaches
  - Evaluate regulatory implications of using advanced technologies → alignment and harmonization

- Release and clearance methodology
  - Characterisation for clearance/release of materials → best practices
  - Automated technologies for structures and land areas (final status surveys)
  - Sharing of experiences (e.g., with respect to difficult to measure items) and identification of regulatory differences regarding clearance criteria
PREDIS SRA: Characterisation

- **Competence development**
  - Implementation of educational and training programmes to ensure sufficient and skilled staff are available for the sector
  - (Improve access to) Facilities and infrastructures (e.g., equipped to measure large items)

- **Quality control**
  - Appropriate reference materials (standards)
  - Inter-comparison exercises/benchmarking
Treatment Processing

FEDERICA PANCOTTI (SOGIN)

This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.
Flexible decontamination and treatment processes

R&D:

• new technology to select the optimised solutions for decontamination with the main goal of reducing the amount of secondary waste.

• mobile or modular waste treatment facilities, that can be easily transported and adapted to the needs of a specific site and tasks, will give invaluable advantages in terms of flexibility for different quantities, dimensions, waste routes and regulatory requirements. They might support services as site operations run down at decommissioning sites and help to provide up-to-date and best-available technologies.

Strategic Studies:

• benchmarking for decontamination technologies

• To highlight the opportunities and challenges for shared solutions/facilities that can support less advanced/small programmes (in particular when small quantities of waste need to be treated).
Management of problematic waste

R&D:

• To enable waste routes for organic materials where currently not available. They mainly include the development of alternative thermal treatment technologies (considering also the issues related to the release of $^{14}$C).

• Solutions should be developed to passivate/inhibit corrosion of reactive metallic materials (including dust) to prevent or limit the hydrogen production.

• Challenges are present for the treatment of liquid waste with specific contaminants and hazardous and toxic materials (e.g. asbestos and PCBs). Knowledge Management and R&D activities are needed to enable waste routes, to provide solutions to remove specific contaminant from liquid waste (e.g. Cl, F, $^{14}$C, $^3$H, etc.) and to improve safety and reduce costs.

Strategic Studies:

• Graphite contains long-lived highly mobile radionuclides such as $^{14}$C, $^{36}$Cl and $^3$H that pose a challenge for conditioning and long-term sequestration of encapsulated graphite wastes. Strategic studies are needed to enable a generally accepted approach for graphite waste treatment/conditioning and disposal.
Recycling and reuse

Strategic Studies / KM / R&D:

• Benchmarking of technologies might help to identify technologies and approaches for recycling and reuse.
• Development of new technologies for recycling and reusing of materials will increase efficiency, reduce volume of waste to be disposed and reduce costs.
• Promote and facilitate the implementation of the recycling and reuse of materials. Applying the principles of circular economy to nuclear decommissioning and waste management will improve environmental sustainability and create opportunities at the international level for recycling.
• There is scope for much greater harmonisation in terms of clearance of materials for recycling and reuse, and application of good practices in recycling of released materials. The need for societal engagement for recycling was highlighted too.
New and emerging solutions

R&D:

• demonstration and industrialisation of lab scale solutions and technologies (e.g. thermal waste treatment processes like vitrification or hot isostatic pressing) might solve specific issues and optimise specific activities.

• IT tools and other emerging technologies to manage waste flows from production to disposal to enable optimisation (e.g. in data collection and integration).

Strategic Studies / R&D:

• A number of projects and studies have been launched worldwide to further develop nuclear energy technology in the near future (15–25 years) and beyond. For new fuel types and advanced reactors/fuel cycles some waste types will be either new or known to be problematic. Strategic Studies and R&D activities are needed to identify challenges and enable future waste routes.
Conditioning & Packaging

KAHINA HAMADACHE/MAXIME FOURNIER (CEA)
Conditioning & packaging

- **Conditioning & packaging (C&P)** refers to “all operations consisting of introducing the waste, possibly pre-treated, into a container where it can be blocked or incorporated into a matrix to form a waste package”

- PREDIS stakeholders identified C&P as the 3rd most important R&D topic to be addressed in the nuclear industry in the coming years, after waste characterisation and waste acceptance criteria.

- PREDIS stakeholders identified 3 main drivers related to C&P activities:
  - **society**: protection of citizens and the environment
  - professional **performance** of industry players: safe and efficient processes, products and services
  - **scientific excellence**: quality of science and increased development or optimisation of technologies

- The main subtopics to be addressed in the future R&D activities within EU are:
  - optimizing existing matrices,
  - developing new conditioning matrices,
  - studying the long term behavior of conditioning matrices,
  - further studies related to the containers performances and the improvement of the management of broken packages and secondary wastes.
For large volume of well-known radwaste, with identified routes

Matrix performances can be increased

Sharing best practices, enhancing interactions will help harmonize national strategies at the EU level

<table>
<thead>
<tr>
<th>Sub-area</th>
<th>Activities</th>
<th>Type of activity</th>
<th>Expected impacts</th>
<th>Urgency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimization of existing conditioning solutions</td>
<td>1. Optimize conditioning material properties: Waste loading, mechanical resistance, compatibility with the environment, long-term behavior,</td>
<td>R&amp;D</td>
<td>Meet WACs related to disposal facilities</td>
<td>Short/medium term</td>
</tr>
<tr>
<td></td>
<td>1. Increase waste loadings, mixing wastes</td>
<td>R&amp;D</td>
<td>Reduction of wastes for disposal</td>
<td>Long term</td>
</tr>
<tr>
<td></td>
<td>1. Exchange &amp; harmonization of best practices, interactions WMO/waste producers</td>
<td>KM</td>
<td>Exchange of knowledge on optimised solutions</td>
<td>Short / Medium term</td>
</tr>
</tbody>
</table>

This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.
Conditioning & packaging

Developing new conditioning solutions

- Increasing decommissioning projects across EU: the largest volume of radwaste is yet to come and routes to be identified
- Currently existing difficult or strategic wastes need sustainable routes
- Develop the use of innovative materials
- Opportunity to apply the principles of circular economy

<table>
<thead>
<tr>
<th>Sub-area</th>
<th>Activities</th>
<th>Type of activity</th>
<th>Expected impacts</th>
<th>Urgency</th>
</tr>
</thead>
<tbody>
<tr>
<td>New conditioning solutions for strategic waste addressing safety, technical and economic aspects</td>
<td>1. Development of innovative emerging solutions</td>
<td>R&amp;D / Strategic Studies</td>
<td>Identify routes for wastes that do not have existing routes</td>
<td>Short term</td>
</tr>
<tr>
<td>1. Use of recycled/innovative materials</td>
<td>R&amp;D Strategic Studies</td>
<td>Demonstrate - depends on the WACs in comparison with the raw material financial &amp; environmental impact</td>
<td>Medium term</td>
<td></td>
</tr>
</tbody>
</table>
### Conditioning & packaging

*Demonstrate long term behaviour of conditioning matrices*

- Safety demonstration of both optimized and new conditioning matrices will require **durability** demonstration and other R&D activities.
- Use of **simulation models** to understand long term stability and performance of matrices.

<table>
<thead>
<tr>
<th>Sub-area</th>
<th>Activities</th>
<th>Type of activity</th>
<th>Expected impacts</th>
<th>Urgency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long term behaviour and performances of existing and new conditioning matrices</td>
<td>1. Durability demonstration under irradiation condition (gamma and alpha)</td>
<td>R&amp;D</td>
<td>Demonstrate - depends on the WACs</td>
<td>Short term</td>
</tr>
<tr>
<td></td>
<td>1. Control hydrogen production</td>
<td>R&amp;D</td>
<td>Demonstrate - depends on the WACs</td>
<td>Short term</td>
</tr>
<tr>
<td></td>
<td>1. Fate of heavy metals</td>
<td>R&amp;D</td>
<td>Demonstrate - depends on the WACs</td>
<td>Medium term</td>
</tr>
<tr>
<td></td>
<td>1. Cements performances (pressure monitoring, compressive strength, stability...)</td>
<td>R&amp;D</td>
<td>Demonstrate - depends on the WACs</td>
<td>Short term</td>
</tr>
<tr>
<td></td>
<td>1. For all of above – simulation models</td>
<td>R&amp;D / Strategic Studies</td>
<td>Demonstrate to regulators behaviour/performance of waste form</td>
<td>Short term</td>
</tr>
</tbody>
</table>
## Conditioning & packaging

*Containers / Broken packages / Secondary wastes*

- Long term management of **packages** is to be assessed
- Improve the management of **secondary wastes**
- Bring guidance to improve the management of **broken packages**

<table>
<thead>
<tr>
<th>Sub-area</th>
<th>Activities</th>
<th>Type of activity</th>
<th>Expected impacts</th>
<th>Urgency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Containers</td>
<td>1. Use of reusable/recyclable/new types of materials</td>
<td>R&amp;D / Strategic Studies</td>
<td>Demonstrate to regulators behaviour and performance (containment and confinement capability)</td>
<td>Medium term</td>
</tr>
<tr>
<td></td>
<td>1. Long term behaviour</td>
<td>R&amp;D / Strategic Studies</td>
<td>Demonstrate long term behaviour/performance</td>
<td>Short term</td>
</tr>
<tr>
<td></td>
<td>1. Development of shock absorbers</td>
<td>R&amp;D</td>
<td>Exchange of knowledge on optimised solutions</td>
<td>Short term</td>
</tr>
<tr>
<td></td>
<td>1. Non-destructive control techniques</td>
<td>R&amp;D / Strategic Studies</td>
<td>Develop new or increase TRL of non-destructive control techniques</td>
<td>Short / Medium term</td>
</tr>
<tr>
<td></td>
<td>1. Simulation models to support understanding of stability/performance over long term.</td>
<td>R&amp;D / Strategic Studies</td>
<td>Demonstrate predictive capability of modelling</td>
<td>Short Term</td>
</tr>
<tr>
<td>Broken packages</td>
<td>1. Guidance to improve management of broken packages</td>
<td>KM</td>
<td>Exchange of best practices (criteria, re-pack)</td>
<td>Short term</td>
</tr>
<tr>
<td>Secondary waste</td>
<td>1. Reduce and simplify handling</td>
<td>R&amp;D</td>
<td>Handling optimization</td>
<td>Short term</td>
</tr>
</tbody>
</table>
Waste Acceptance Criteria

JOSE LUIS LEGANES NIETO (ENRESA)
PREDIS WAC in the PREDIS SRA

PREDIS WAC DEFINITION:

The selected parameters to be checked while taking over waste from the previous step of radioactive waste management (generation -> processing -> storage -> disposal)

Purpose of WAC: set the technical and administrative requirements for the acceptance of the radioactive waste, in all its forms, for its safe storage or final disposal.

- Final Disposal or Interim Storage of radioactive waste imply in advance developing and implementing actions that allow their acceptance in the planned repository.
- WAC are therefore required for the establishment of procedures of waste production that fulfill the acceptance process.
First Step: WAC Standpoint

WAC have always been a matter of discussion among countries and entities, which have been trying to harmonize or standardize their use. Country policy, kind of disposal/storage, waste classification, regulatory body, stakeholders, influence a lot on the final WAC to develop/apply.

Need to provide a good standpoint of the overall WAC implications to better facilitate their development from solid basis. Not trying to provide WAC themselves but to produce the capability of building a Waste Acceptance System from which WAC is a logic consequence.

To better identify future WAC research to develop it is first necessary to have the best image of the whole involved aspects and how they are related.
What we have and what we plan

- **Inventory**
  - Volume, mass, radionuclides, waste natures, …

- **Classification**
  - VLLW, LLW, ILW, HLW

- **Kind of Disposal/Interim Storage**
  - Trenches, Surface, Shallow, Deep

**WASTE ACCEPTANCE CRITERIA FOR**

Packages – Disposal Units – Casks – Large Items
What to consider in WAC development

- **Operational**
  - Administrative, Radiological Protection, Health Safety, Available Resources, …

- **Technical**
  - Engineering barriers, Total Volume, Geometry, …

- **Short – Mid Term analysis**
  - Structural, Release rate, Heat release,…

- **Long Term analysis**
  - Durability, Release rate, Heat Release, …
WAC Properties

- Generic
  - ID, Tracking, Code Nature, Weight, …
- Radiological
  - Dose rate, Isotopes, Activities, Activity Distribution, …
- Chemical
  - Toxicity, Pyrophoric, Leaching accelerators, Complexing agents,…
- Containment Capability
  - Leaching, diffusion, …
- Physical
  - Free liquids, Heat release, Volume optimization, …
- Mechanical
  - Compression, Traction, …
- Biological
  - Gas production, Degradation, …
This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.
Criteria themselves promote new research areas:

- New characterization approaches.
- Technology to accomplish criteria.
- Inventory improvements.
- Quality Management system.
- New Treatment processing.
- New Package conditioning.
WAC and SRA

- Actions in WAC specifically:
  - KM and SS for a suitable way to build a WA System.
  - SS to determine the fulfillment of WAC for non compliant packages or for new wasteforms.
  - SS to avoid excess of conservativeness in the establishment of some values in WAC.
  - Identify future R&D for SRA generally linked to:
    - Research could be promoted to decide whether a property is finally included in a WAC.
    - Established WAC could promote the development of new research.
WAC and SRA

- Specifically for WAC SRA is necessary to identify:
  - More realistic scenarios in the Safety Assessment of Disposal/Storage for avoiding excessive conservativeness.
  - Identify Chemicals to be considered, their involved processes and their influence on short-mid-long term in the disposal/storage.
  - Impact due to non radiological aspects, e.g. toxicity, how to build similar scenarios to the radiological ones that quantify the health risk.
  - Others?
Inventory

ALAN WAREING (NNL)
Inventory - Overview

• Need to demonstrate an appropriate level of knowledge of the inventory, including waste volumes; stock locations; radioisotope fingerprints/activity levels and the physicochemical properties.

• Large high-quality datasets required to be generated and managed. This includes consideration of:
  • Methods of collection, storage and assessment.
  • What data required to inform decision-making across the waste management lifecycle?
  • Making clear links between inventory and other key topics covered in this SRA, including Characterisation, Waste Acceptance Criteria, Waste Hierarchy, Treatment & Processing and Conditioning & Packaging.
Inventory – Key Topics

**Non-radiological, hazardous and chemotoxic materials**

- Need to understand inventory of chemically-aggressive and thermotoxic wastes
- Linked to characterisation, need to understand specific non-rad materials of interest – e.g. cellulose, nitrate, concrete, etc.
- Demonstrate that these wastes can meet the needs of differing regulations for both radiological and non-radiological aspects.

**Inventory – Legacy / Problematic wastes**

- Need to understand the form of legacy wastes and associated radioactivity (liquids present, materials promoting corrosion, gas generation etc.) to develop and validate processes for treatment, conditioning, packaging and disposal.
- ROUTES is looking at ‘challenging’ wastes and recently issued a report on this.
- Significant amount of work already being undertaken in this area and as such the gap is that of Knowledge Management and the sharing of best practice.
Inventory – Key Topics

Future Wastes

• Need to consider wastes arising from the use of new reactors and fuel types; e.g. new coolants that are activated etc. There is a need to convey to nuclear engineers to take into account waste produced.

• Advanced reactors/SMRs – need to understand the inventory of decommissioning wastes to inform strategies for treatment and disposal. Reactors will not be licensed unless wastes and their management are understood and strategy in place.

• Methodology/relevant good practice is needed across nation states, to allow designers/operators to understand what waste is being produced from these new technologies before the R&D and further investigation can commence.

Assessment, recording and management of data

• Need to understand the sensitivity of safety case calculations to uncertainty in inventory and hence effort required in gathering and recording inventory data. Levels of precision will be dependent on data need, and should inform the methods of data collection and storage such that effort to reduce uncertainty is placed where it is warranted.
### Common areas of interest - Inventory

<table>
<thead>
<tr>
<th>Sub-area</th>
<th>Activities</th>
<th>Type of Activity</th>
<th>Expected Outcome &amp; Impact</th>
<th>Urgency</th>
</tr>
</thead>
</table>
| Non-radiological, hazardous and chemotoxic materials | 1. Guidance on good practice in inventory development for these materials | Strategic Studies, KM | Meet regulations for non-rad/hazardous materials  
Knowledge of any effects on radionuclide/waste form/container/repository behaviour                                                                                                                                     | Short term – need to know now in order to make decisions on how to deal with the wastes |
| Legacy and problematic waste inventories          | 1. Knowledge management regarding existing studies                           | KM               | Understanding wastes that are not currently well characterised and are without identified waste routes                                                                                                                   | Short term                                                            |
| Future wastes and inventories (new fuels and advanced fuel cycles) | 1. Guidance on defining future wastes and inventories associated with new reactors/fuel cycles to inform development of a waste management plan. | Strategic Studies | Take full account of all wastes produced (and therefore to be dealt with)  
Understanding future wastes for disposal (implications for facilities)                                                                                                                                              | Short term                                                            |
| Assessment, recording and management of inventory data | 1. Accuracy, conservatisms, assumptions                                     | KM               | Reduction in uncertainty, removal of excessive conservatism that affects treatment/routing decisions  
Acquire right data to allow use of waste routes                                                                                                                                                                                                                 | Short term                                                            |
Technology Selection

CHRISTIAN KOPP AND ERNST NIEDERLEITHINGER (BAM)
Technology Selection

Assessing the potential technologies suitable for each category of waste, for the implementation phase, considering the cost-benefit ratio and availability of concepts and technologies.
Technologies (PREDIS):

1) Method or a set of methods to capture condition data from waste packages with the help of various sensor applications. (WP7)

   • Understanding the evolution of waste packages during the extended interim storage periods by store monitoring, package condition monitoring, modelling of thermophysical and chemical processes

2) Industrial mature treatment technologies (WP4-6)

   which are implemented to get to a point where waste is disposed of or stored
Areas of Interest identified:

1) Selection of technologies for (existing or future) waste streams where no WAC are present at the moment (no industrially mature waste disposal route available)

2) Comparison of technologies at different levels of maturity including cost-benefit ratio and availability with focus on NDT

3) Supporting innovation and reducing environmental impact of radioactive waste management

4) Further development of advanced technologies (geopolymers, ultra & nano filtration, selective sorption)
This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.

### Technology Selection

<table>
<thead>
<tr>
<th>Sub-area</th>
<th>Activities</th>
<th>Type of Activity</th>
<th>Expected Outcome &amp; Impact</th>
<th>Urgency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection of technologies for (existing or future) waste streams where no WAC are present at the moment (no industrially mature waste disposal route available)</td>
<td>1. Selection of proper treatment &amp; conditioning technologies for management of radioactive waste – supports case study development in 3.</td>
<td>Strategic Studies, Knowledge Management</td>
<td>Links to 3. Aids development of case studies and workflow</td>
<td>Short term</td>
</tr>
<tr>
<td></td>
<td>2. Definition of WAC criteria (link to WAC topic area)</td>
<td>R&amp;D</td>
<td>See WAC topic area</td>
<td>Short term</td>
</tr>
<tr>
<td></td>
<td>3. Review of technologies / develop case studies (PREDIS demonstrations)</td>
<td>Strategic Studies, KM, R&amp;D</td>
<td>Case studies accessible for WMOs.</td>
<td>Medium</td>
</tr>
</tbody>
</table>
### Technology Selection

<table>
<thead>
<tr>
<th>Sub-area</th>
<th>Activities</th>
<th>Type of Activity</th>
<th>Expected Outcome &amp; Impact</th>
<th>Urgency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Comparison of technologies at different levels of maturity including cost-benefit ratio and availability with focus on NDT</strong></td>
<td>1. Analysis of technologies in a new R&amp;D project</td>
<td>R&amp;D</td>
<td>Means of prioritisation of technologies for development</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>2. Selection of most suitable technology</td>
<td>Strategic Studies</td>
<td></td>
<td>Short</td>
</tr>
<tr>
<td></td>
<td>3. Link to case studies activity above</td>
<td>Strategic Studies</td>
<td></td>
<td>Short</td>
</tr>
</tbody>
</table>

This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.
## Technology Selection

<table>
<thead>
<tr>
<th>Sub-area</th>
<th>Activities</th>
<th>Type of Activity</th>
<th>Expected Outcome &amp; Impact</th>
<th>Urgency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supporting innovation and reducing environmental impact of radioactive waste management</td>
<td>1. Establish network of experts with focus on environmental issues</td>
<td>Strategic Studies</td>
<td>Expert group established</td>
<td>Short term</td>
</tr>
<tr>
<td></td>
<td>2. Consider environmental impact (LCA implementation)</td>
<td>Strategic Studies / KM</td>
<td>Improved understanding of environmental impact and costs</td>
<td>Short term</td>
</tr>
<tr>
<td></td>
<td>3. Consider societal impact and support development of accessible communication materials</td>
<td>Strategic Studies / KM</td>
<td>Support to national programmes on societal aspects and acceptance</td>
<td>Short term</td>
</tr>
</tbody>
</table>
# Technology Selection

<table>
<thead>
<tr>
<th>Sub-area</th>
<th>Activities</th>
<th>Type of Activity</th>
<th>Expected Outcome &amp; Impact</th>
<th>Urgency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Further development of advanced technologies (geopolymers, ultra &amp; nano filtration, selective sorption)</td>
<td>1. Literature study and survey about state-of-the-art. Implementation of work packages concerning these technologies in R&amp;D project</td>
<td>R&amp;D / KM</td>
<td>Scientific technology development – links to Treatment processing / Conditioning &amp; Packaging</td>
<td>Short term – Medium term</td>
</tr>
</tbody>
</table>
Optimisation

TIM SCHATZ (VTT)
Optimisation

Evaluating the potential for improving and optimising implementation phases taking account of both new and existing technologies, to improve costs and environmental impact while maintaining safety and accounting for potential risk scenarios.

- Optimisation is the process of obtaining the most suitable solution to a given problem.
- Optimisation should find the ‘best’ solution.
- In principle any step in the predisposal management of radioactive waste can be optimised over any or all of its attributes.
This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.
### Activities of Common Interest

<table>
<thead>
<tr>
<th>Optimisation Category</th>
<th>Sub-areas (activities)</th>
<th>Type(s) of Activity</th>
<th>Expected Outcome &amp; Impact</th>
<th>Urgency</th>
</tr>
</thead>
</table>
| **Design**            | 1. optimisation of waste characterisation & conditioning considerations versus repository design/sizing  
                       2. implementing new technologies with respect to existing techniques, infrastructure, etc.  
                       3. reducing costs | Strategic Studies: cost-benefit analyses, providing sound methods/tools for decision making  
                       Knowledge Management: learning from previous implementation efforts, knowledge transfer from more advanced programmes to earlier stage programmes | improved decision making  
                       more adaptive and flexible designs  
                       cost reductions | short-term (but can/will be ongoing throughout operational lifetimes) |
| **Performance**       | 1. heuristic evaluations over full life cycles to find global optimums for the entirety of predisposal radioactive waste management  
                       2. site modelling  
                       3. management of different variables and their interactions  
                       4. computational tools for formulating immobilisation matrices | Research & Development: developing ideas and tools for full life cycle evaluations, i.e., life cycle assessment (LCA) & design (LCD), new geoscience models, process models, numerical simulation, digital twins | improved underpinning for safety cases  
                       improved data management and process performance  
                       more economical, sustainable and environmentally friendly waste conditioning practices | short-term (but can/will be ongoing throughout operational lifetimes) |
| **System**            | 1. grout development  
                       2. package development  
                       3. better extraction of metals from mixed wastes  
                       4. better ILW&LLW separation  
                       5. upscaling of conditioning methods  
                       6. improved plasma torch lifetimes | Research & Development | more economical, sustainable and environmentally friendly waste treatment and processing practices | short-term (but can/will be ongoing throughout operational lifetimes) |
This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.

**SRA November Webinar Breakout sessions**

<table>
<thead>
<tr>
<th>Breakout Room 1</th>
<th>Lead</th>
<th>Notes/assistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakout Room 2</td>
<td>Maxime Fournier</td>
<td>Linda Fowler</td>
</tr>
<tr>
<td>Breakout Room 3</td>
<td>Lumir Nachmilner</td>
<td>Tim Schatz</td>
</tr>
</tbody>
</table>
SRA November Webinar Breakout sessions

- Virtual 3-4 Questions, the first general the next more specific, in each group 20 mins maximum discussion time
- Please state your name, country and organisation to help notetakers capture any points
- Will come back to share any discussion points
SRA November Webinar Breakout sessions

- Any general feedback on what you have heard about the SRA itself today?
- Anything major that has been missed from what has been presented?
- How best the PREDIS team can utilise this document?