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Roadmap for a Joint Programme on Radioactive Waste Management and Disposal

Work Package 5

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PU	Public	X

PP	Restricted to other programme participants (including the	
RE	Restricted to a group specified by the partners of the JOPRAD project	
CO	Confidential, only for partners of the JOPRAD project	

Extract from the EJP Founding Documents V0.5 (7th May 2018) that are under development, as a follow up of the JOPRAD project.

A **Roadmap**, with clear objectives, linking the EuroJoint Programme activities (as listed in the SRA) to milestones typical of different phases of a radioactive waste management (RWM) programme has been developed (focussed on those planning for disposal). The Roadmap relates to Joint Programme Founding Documents (and was not addressed by the preparatory work carried out in the EC JOPRAD project). It draws from the IAEA work (see, [IAEA Planning and Design Considerations for Geological Repository Programmes of Radioactive Waste](#)). The IAEA definitions of recognised phases of a waste disposal programme (and their associated major objectives) are used to provide the Roadmap framework:

- Phase 0: Policy, framework and programme establishment*;
- Phase 1: Site evaluation and site selection;
- Phase 2: Site characterisation;
- Phase 3: Facility construction;
- Phase 4: Facility operation and closure;
- Phase 5: Post-closure.

**Note that Phase 0 was not covered by IAEA-TECDOC-1755, but added to recognise the needs of Members States who are in the process of establishing a waste management programme.*

For each of the phases above, the Joint Programme Roadmap explains how aspects related to disposal facility design, and safety case development (and supporting safety analyses) span across all phases, including Phase 0. The Roadmap elaborates further on the how the emphasis of work on each of these differs and changes through successive Phases.

The Roadmap demonstrates the totality of scope of the Joint Programme and its relevance to waste management and disposal programmes at different stages of maturity. The Roadmap effectively provides a framework upon which to organise the scientific priorities of the SRA, enabling users and programmes to ‘click-in’, and to access existing knowledge and active work or future plans. It also provides a framework for future periodic assessment of the Joint Programme, and to evaluate future priorities and new work packages as new knowledge is acquired or as new needs are identified.

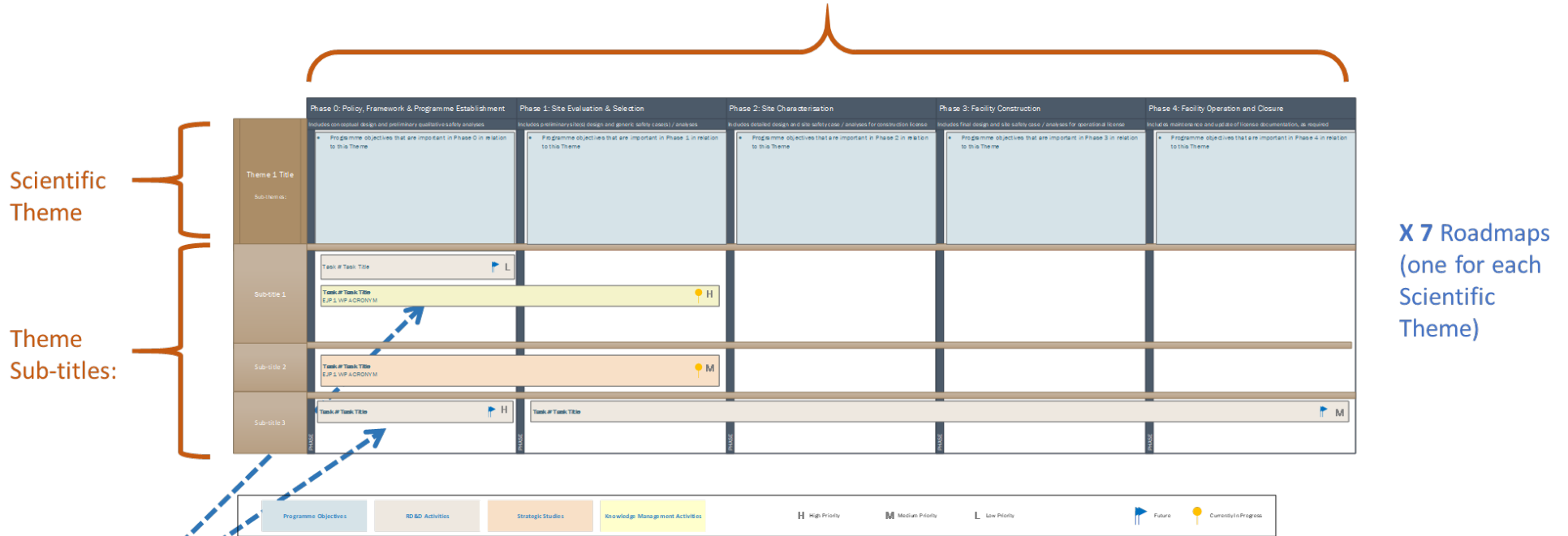
The Roadmap comprises 7 tables:

- A theme-specific table showing how identified activities of the Joint Programme SRA relate to different Phases of implementation and typical Waste Management Programme objectives for each theme ([blue boxes](#)). The SRA tasks are flagged (I) to illustrate those being addressed in-part or in-full by scope of active projects EC-funded projects, including those of the Joint Programme. Tasks that will be addressed in future work of the Joint programme are flagged also (II). RD&D, Knowledge Management and Strategic Studies are each colour differently also - ***once KM Work Package descriptions available we can colour code those that are active Vs. those for the future. Please note that roadmap diagrams are still draft and work-in-progress as WPs develop.*

The Roadmap tables will be used throughout the Joint Programme as a tool to support managing the SRA in reviewing progress, updating on how new work should be prioritised (importance and urgency) and communicating the completed, ongoing and future work activities to those interested in our work.





Roadmap Overview: Map of Joint Programme Tasks (as prioritised by EC JOPRAD project) for each Scientific Theme mapped to Typical Phases of a Waste Management Programme



Waste Management Programme Phases of Implementation (0-4): Top line corresponds to IAEA Phases, second line describes the design and safety case emphasis in each Phase
















- Tasks are assigned across phases and sub-theme for where they are most relevant
- Tasks show EC-funded work by yellow marker, inc. name of the Horizon H2020 project or EJP1 work package
- Tasks are colour coded to show if they are predominantly an RD&D, Strategic Study, or KM activity
- Tasks identified by the JP as a priority for future work are indicated with double blue flag and marked H/M/L



Roadmap Theme 1: JP Priorities and Activities of Common Interest that relate to Managing implementation and oversight of a radioactive waste management programme

	Phase 0: Policy, Framework & Programme Establishment	Phase 1: Site Evaluation & Selection	Phase 2: Site Characterisation	Phase 3: Facility Construction	Phase 4: Facility Operation and Closure
<p>Theme 1 Managing implementation and oversight of a radioactive waste management programme</p> <p>Sub-themes:</p>	<p>Includes conceptual design and preliminary qualitative safety analyses</p> <ul style="list-style-type: none"> Establishment of national regulatory and legal framework for radioactive waste management licensing framework, including criteria and standards for issuing authorisations for disposal facilities - See IAEA INFORC/546. Develop clear roles and responsibilities for authorities, implementers and supporting technical / non-technical organisations including the private sector and how to maintain and / or secure resources to deliver their remit with respect to radioactive waste management, including disposal. Establishment of national funding (and cost estimation) scheme and timescales (indicative plan or schedule) for radioactive waste management, including disposal. 	<p>Includes preliminary site(s) design and generic safety case(s) / analyses</p> <ul style="list-style-type: none"> Competence development and maintenance to support the short and medium-term activities of the national radioactive waste management programme (including disposal) specific to each phase Develop and maintain information and knowledge management systems. Development and maintenances of stakeholder engagement strategy to support key decision making processes during the various phases 			
Programme planning	<p>J3.11 Pre-licencing management  L</p> <p>How to establish and implement a radioactive waste management RD&D programme EJP1 WP KM  H</p>				
Organisation	<p>J3.15 Training and competence maintenance of skills and expertise to support safe radioactive waste management and disposal</p>				
Resources	<p>J3.15 EU research infrastructure  H</p>	<p>J3.14 Information management</p>			<p> M</p>

Programme Objectives	RD&D Activities	Strategic Studies	Knowledge Management Activities	H High Priority	M Medium Priority	L Low Priority	 Future	 Currently In Progress
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Roadmap Theme 2: JP Priorities and Activities of Common Interest that relate to Radioactive waste characterisation, processing and storage (Pre-disposal activities), and source term understanding for disposal

	Phase 0: Policy, Framework & Programme Establishment	Phase 1: Site Evaluation & Selection	Phase 2: Site Characterisation	Phase 3: Facility Construction	Phase 4: Facility Operation and Closure
<p>Theme 2 Radioactive waste characterisation, processing and storage (Pre-disposal activities), and source term understanding for disposal</p>	<p>Includes conceptual design and preliminary qualitative safety analyses</p> <ul style="list-style-type: none"> Develop, and maintain national waste inventory (characterization, documentation of waste being produced and estimates for future arisings). Provide input to evaluation of disposal options (waste inventory for planning purposes and to scope preliminary design options and safety analyses). Develop guidance for waste treatment (preliminary waste acceptance criteria) for the different waste disposal routes. Where necessary, develop new waste treatment methods and input to the development of the corresponding waste treatment facilities. 	<p>Includes preliminary site(s) design and generic safety case(s) / analyses</p> <ul style="list-style-type: none"> Adjust waste treatment guidance (preliminary waste acceptance criteria) according to new findings, taking results from site evaluation into account (optimization for safety and other issues (incl. cost)). Refine radionuclide source term treatment and understanding of waste package performance to account for understanding of a prospective/ selected site. Provide inventory and source term understanding for construction license. 	<p>Includes detailed design and site safety case / analyses for construction license</p>	<p>Includes final design and site safety case / analyses for operational license</p> <ul style="list-style-type: none"> Transform waste treatment guidance into draft waste acceptance criteria and adjust them according to detailed repository layout (optimization for safety and other issues (incl. cost)). Provide inventory and source term understanding) for operational license. 	<p>Includes maintenance and update of license documentation, as required</p> <ul style="list-style-type: none"> Organize logistics (delivery of waste to repository) and enforce compliance of waste accepted for disposal with waste acceptance criteria in force Ensure compliance with safeguards Maintain national waste inventory and maintain detailed documentation on wastes emplaced in the repository Modify waste acceptance criteria when appropriate to take optimization for safety and other issues (incl. cost)) into account. Provide detailed information (incl. documentation) for closure license.
<p>Waste handling, characterisation, treatment and packaging</p>	<p>1.2.4 Management of damaged waste packages H2020 Project DISCO</p> <p>3.7 Links between waste producers & implementers</p> <p>J1.1.3 Novel conditioning methods for problematic wastes. H2020 Project THERAMIN  H</p> <p>Waste management routes across Europe EJP1 WP ROUTES  H</p>	<p>J1.1.7 Improved understanding of the nature and quantities of the likely chemotoxic component of common decommissioning wastes.  M</p> <p>J1.1.2 Technology for characterisation & segregation of historical wastes. H2020 Projects CHANCE, INSIDER & THERAMIN  M</p> <p>J1.1.8 Optimisation of novel waste treatment techniques. EJP1 Project SFC  M</p>			
<p>Interim storage</p>	<p>3.10 Long-term storage for disused seals radioactive sources</p> <p>2.4.5 Operational lifespan of interim storage</p>				
<p>Transportation between facilities</p>					
<p>Radionuclide inventory and source term</p>	<p>3.6 Methodologies applied to refine inventory</p> <p>3.5 Inventory collation</p> <p>J1.1.1 Inventory data and uncertainty treatment. EJP1 WP SFC</p> <p>J1.1.10 Quantification of fissile content of spent fuels.  L</p>	<p>J1.2.2 Improved understanding of the performance of the final waste package (including the waste form) during prolonged storage prior to its transport and disposal.  H</p> <p>J1.1.9 Improved understanding of radionuclide release from wasteforms other than spent fuel.  H</p> <p>J1.1.4 Improved understanding of radionuclide release from spent fuel, inc. fire and impact. H2020 Project DISCO & EJP1 WP SFC  H</p> <p>J1.1.5 Demonstration of geopolymer performance in representative disposal conditions.  M</p> <p>J1.1.6 Fourth generation (Gen(IV)) wastes  L</p>	<p>1.4.2 Improved understanding of the generation and release of radioactive trace gases and bulk gases from wasteforms and waste packages.  H</p>		
<p>Waste acceptance criteria</p>			<p>2.1.6 Waste acceptance criteria  M</p>		

Programme Objectives
RD&D Activities
Strategic Studies
Knowledge Management Activities
H High Priority
M Medium Priority
L Low Priority
 Future
 Currently In Progress

Roadmap Theme 3: JP Priorities and Activities of Common Interest that relate to Engineered barrier system (EBS) properties, function and long-term performance

	Phase 0: Policy, Framework & Programme Establishment	Phase 1: Site Evaluation & Selection	Phase 2: Site Characterisation	Phase 3: Facility Construction	Phase 4: Facility Operation and Closure
<p>Theme 3 Engineered barrier system (EBS) properties, function and long-term performance</p> <p>Sub-themes:</p>	<p>Includes conceptual design and preliminary qualitative safety analyses</p> <ul style="list-style-type: none"> Based upon first ideas of the geological possibilities and taking disposal inventory waste characteristics into account, develop possible broad EBS concepts for evaluation by safety and facility design Assess these broad options with respect to: <ul style="list-style-type: none"> contribution of the EBS to long-term safety compatibility of EBS components with one another and other repository materials technical feasibility and technology readiness cost 	<p>Includes preliminary site(s) design and generic safety case(s) / analyses</p> <ul style="list-style-type: none"> For the sites evaluated / eventually selected and for the wastes to be disposed, develop different EBS concepts in co-operation with safety and facility design Assess these concepts in co-operation with safety and facility design with respect to: <ul style="list-style-type: none"> contribution of the EBS to long-term safety of repository system reliability of EBS performance technical feasibility and technology readiness cost Adapt selected variants to site conditions and increase understanding of EBS performance (and reliability of the assessment method) 	<p>Includes detailed design and site safety case / analyses for construction license</p> <ul style="list-style-type: none"> For the site selected, optimize the EBS concepts chosen in co-operation with long-term safety, geology, and facility design Increase the level of understanding (incl. predictability of evolution) of the EBS For those components needed during construction, get industrial production ready (manufacturing, transport, emplacement and quality assurance). For those components needed later (operation, closure), continue development with respect to their later industrialization. If necessary, make demonstration experiments / prototypes (to demonstrate understanding and/or industrial feasibility) 	<p>Includes final design and site safety case / analyses for operational license</p> <ul style="list-style-type: none"> Implement components according to plan (manufacturing, transport, emplacement and quality assurance) For those components needed later (operation, closure), get industrial production ready If necessary, prepare/ continue demonstration experiments / prototypes for (long-term) monitoring Where deemed necessary or useful, continue optimization and increase understanding 	<p>Includes maintenance and update of license documentation, as required</p> <ul style="list-style-type: none"> Implement components according to plan (manufacturing, transport, emplacement and quality assurance) Monitoring of EBS performance (partially in dedicated experiments/ prototypes) Where deemed necessary or useful, continue optimization and increase understanding Provide input to closure and implement components for closure according to plan
Spent Fuel and high-level waste disposal canisters		J1.2.3 Developing alternative HLW and Spent Fuel container material options and improved demonstration of their long-term performance.			
Containers for long-lived intermediate and low level wastes					
Clay-based backfills, plugs and seals	1.3.1 Use of clay-based materials in a geological disposal facility H2020 Project BEACON	J1.3.1 Characterised bentonite / clay-based material evolution under specific conditions to provide data on hydro-mechanical, thermal and chemical behaviour. H2020 Project BEACON & EJP1 WP HITEC			
		1.3.4 Low pH cement understanding			
Cementitious-based backfills, plugs and seals		J1.3.3 Improved quantification and understanding of cement-based material evolution to improve long-term modelling and assessments. (P) CEBAMA			
		J1.3.4 Improved understanding of low pH cements. H2020 Project CEBAMA			
Salt backfills		J1.3.6 Improved understanding of a salt backfill.			
EBS system understanding	J1.3.8 Identify co-disposal interactions of importance to long-term safety.	J1.2.1 Improved understanding of the interactions occurring at interfaces between waste packages and different barriers in the disposal facility.		J2.2.2 Improved understanding of plugs and seals	
		J1.3.7 Improved description of the spatial and temporal evolution of transformations affecting the porous media and degrading materials in the near-field of HLW and ILW disposal systems.			
		J1.3.2 Improved chemical and microbial data to better quantify gas generation and the consequences of microbial processes.			
		J1.3.5 Improved understanding of the impacts of different metallic and cementitious component phenomena on near-field evolution via improved models. H2020 Project THERAMIN			
		J1.4.4 Improved understanding of gas reactivity in the EBS.			



























Programme Objectives	RD&D Activities	Strategic Studies	Knowledge Management Activities	H High Priority	M Medium Priority	L Low Priority	Future	Currently In Progress
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Roadmap Theme 4: JP Priorities and Activities of Common Interest that relate to Geoscience to understand rock properties, radionuclide transport and long-term geological evolution

	Phase 0: Policy, Framework & Programme Establishment	Phase 1: Site Evaluation & Selection	Phase 2: Site Characterisation	Phase 3: Facility Construction	Phase 4: Facility Operation and Closure
<p>Theme 4 Geoscience to understand rock properties, radionuclide transport and long-term geological evolution</p> <p>Sub-themes:</p>	<p>Includes conceptual design and preliminary qualitative safety analyses</p> <ul style="list-style-type: none"> Compile available geological information and use information to screen the country for regions with sufficient geological long-term stability and - within these regions - for geological formations at appropriate depth (minimum depth for protection from surface effects, maximum depth to ensure feasibility of construction) with acceptable barrier performance and acceptable rock mechanical properties for construction. Implement necessary studies to increase geological information as far as needed to start site evaluation 	<p>Includes preliminary site(s) design and generic safety case(s) / analyses</p> <ul style="list-style-type: none"> Refine geological information (incl. focused geological investigations) as input to and in parallel to site evaluation and site selection. Develop and refine understanding of long-term evolution, incl. development of modelling capabilities Develop / refine understanding of radionuclide behaviour within the geological barrier. That includes experimental work and development of modelling capabilities Provide information to assess compatibility of waste, EBS and geological environment (repository-induced effects) Provide geological and hydraulic data sets for repository design and safety assessment, also as input to siting license if needed 	<p>Includes detailed design and site safety case / analyses for construction license</p> <ul style="list-style-type: none"> Develop site characterization program (based on requirements for EBS design, facility design, safety assessment and general geological understanding) and organize / conduct measurements (in situ, lab work). Implement monitoring devices (baseline measurements, start of long-term monitoring) Analyze data and develop geological synthesis (incl. corresponding reports) that includes geological data sets for EBS design, facility design and safety assessment also as part of documentation for construction license 	<p>Includes final design and site safety case / analyses for operational license</p> <ul style="list-style-type: none"> Geological characterization of underground excavations in parallel to construction of the facility. Implement new monitoring devices / long-term experiments underground to confirm key geological information Continue with long-term monitoring Periodic re-evaluation of geological understanding and data-bases based on new information from facility construction and monitoring Maintain an overview on new findings in science Provide information and documentation for operation license 	<p>Includes maintenance and update of license documentation, as required</p> <ul style="list-style-type: none"> Continue with long-term monitoring (incl. measurements underground) Geological characterization of newly constructed disposal rooms. Periodic re-evaluation of geological understanding and data-bases based on new information from facility construction and monitoring Maintain an overview on new findings in science Provide information / documentation for periodic safety evaluations
Long-term stability (uplift, erosion and tectonics)		J.2 Development of site evolution models, and how to manage data as it is obtained during the site characterisation phase			
Perturbations (gas, temperature and chemistry)		J1.4.4 Improved understanding of gas reactivity in the EBS and different host rocks. EJP1 WP Gas ● H		J1.5.3 Quantification of long-term entrapment of key radionuclides in solid phases to inform reactive transport models. ▶ M	
		J1.4.1 To increase understanding of gas migration in different host rocks. EJP1 WP Gas ● H		J1.4.3 Develop and implement two-phase flow numerical codes to increase gas transient representation at the disposal scale. ▶ M	
	J1.4.2 Improved understanding of the generation and release of radioactive trace gases and bulk gases from wasteforms and waste packages. ▶ H		J1.6.1 Improved understanding of the process of fracture filling. ▶ L		
		J1.5.11 Developing a geochemical model for volatile radionuclides. ▶ M			
		J1.5.6 & J1.5.10 Improved understanding of the role of organics (either naturally occurring or as introduced in the wastes) and their influence on radionuclide migration. EJP1 WP COR1 ● M			
Aqueous pathways and radionuclide migration		J1.5.8 Improved understanding of the role of colloids and their influence on radionuclide migration. ▶ M			
	J1.5.2 Improved representation of sorption mechanisms and coupled chemistry/ transport models for various media. ▶ H		1.6.3 Developing models of groundwater evolution ▶ M		
		J1.5.9 Improved understanding of the influence of redox on radionuclide migration. ▶ M		J2.2.6 Enhanced treatment of climate change, non-human biota, land-use and parameter derivation in biosphere models ▶ M	
		J1.5.7 Improved understanding of the influence of temperature on radionuclide migration and representation of effects in geochemical models. ▶ M			
		J1.5.5 Improved understanding of bounding conditions for the effects of microbial perturbations on radionuclide migration to support performance assessments. ▶ H			
	J1.5.4 Improved understanding of the transport of strongly sorbing radionuclides. ▶ M				
	J1.6.4 Impact of rock matrix diffusion on travel time through the geosphere				

Programme Objectives	RD&D Activities	Strategic Studies	Knowledge Management Activities	H High Priority	M Medium Priority	L Low Priority	▶ Future	● Currently In Progress
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Roadmap Theme 5: JP Priorities and Activities of Common Interest that relate to Geological disposal facility design and the practicalities of implementation

	Phase 0: Policy, Framework & Programme Establishment	Phase 1: Site Evaluation & Selection	Phase 2: Site Characterisation	Phase 3: Facility Construction	Phase 4: Facility Operation and Closure
<p>Theme 5 Geological disposal facility design and the practicalities of construction, operations and closure</p> <p>Sub-themes:</p>	<p>Includes conceptual design and preliminary qualitative safety analyses</p> <ul style="list-style-type: none"> Based upon first ideas of the geological possibilities and taking the properties of the wastes to be disposed of into account, develop together with EBS possible broad design concepts for evaluation by safety Assess these broad options with respect to: <ul style="list-style-type: none"> technical feasibility and technology readiness and implement corresponding measures cost 	<p>Includes preliminary site(s) design and generic safety case(s) / analyses</p> <ul style="list-style-type: none"> For the sites evaluated / eventually selected and for the wastes to be disposed, develop different design concepts in co-operation with EBS and safety Assess these concepts in co-operation with EBS and safety with respect to: <ul style="list-style-type: none"> technical feasibility and technology readiness the necessary infrastructure cost Refine selected variants according to programme needs 	<p>Includes detailed design and site safety case / analyses for construction license</p> <ul style="list-style-type: none"> For the site selected, optimize the design concept chosen in co-operation with EBS and safety. Ensure compatibility of construction method and construction materials with EBS and safety taking the the wastes to be disposed of into account For construction, get the construction concepts ready (construction methods, installations needed, logistics, etc). If necessary, make together with EBS demonstration experiments / prototypes (to demonstrate understanding and/ or industrial feasibility) 	<p>Includes final design and site safety case / analyses for operational license</p> <ul style="list-style-type: none"> Construction of facility (surface facilities and underground structures) according to plans, incl. QS measures to ensure that the facility is constructed as planned (incl. limited damage to host rock barrier) Allow for geological characterization of underground structures Make adjustments to construction / construction method and materials if needed Implementation of technical installations and equipment according to plans 	<p>Includes maintenance and update of license documentation, as required</p> <ul style="list-style-type: none"> Construction of additional disposal rooms according to plan Operation of facility (packaging waste into disposal canisters, emplacement of canisters, backfilling and closure of disposal rooms), incl. QA measures to demonstrate that waste has been emplaced according to plans Perform maintenance according to plans Closure of facility according to plans (removal of equipment/ installations, preparation of seals, construction/ implementation of backfill and seals), incl. QA measures to demonstrate that closure has been implemented according to plans
Facility and disposal system design	J2.5.5 Assessment of the technical feasibility and lifecycle adaptation of a geological disposal concept for a specific site and specific nuclear waste type.  	J3.12 Managing co-disposal  	J2.4.8 Asset management  		
Constructability, demonstration and verification testing		J2.5.8 Developing cost-effective asset management strategies for use in the design.  	J2.5.6 Improved robustness of disposal system designs using large scale mock ups.  	J2.5.7 Optimisation of backfilling and other major implementation processes, including waste emplacement, retrieval and sealing technologies.  	
Health and safety during transport, construction, operations and closure	J3.13 Radiation protection optimisation principle  	J2.4.2 Developing flooding risk assessment methodologies.  	J2.4.4 Accident management and emergency preparedness  		
Monitoring and retrievability		J3.17 Reversibility of decisions or retrievability of waste  	J2.5.1 Developing monitoring strategies appropriate to the operational phase (including facility construction and work acceptance) of geological disposal facilities that will not adversely affect the performance of the disposal system.  	J2.5.2 Developing appropriate monitoring technologies for closure and a period of post-closure institutional control in links with relevant parameters for safety  	J2.5.3 Developing innovative monitoring technologies.  

Programme Objectives	RD&D Activities	Strategic Studies	Knowledge Management Activities	H High Priority	M Medium Priority	L Low Priority	 Future	 Currently In Progress
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Roadmap Theme 6: JP Priorities and Activities of Common Interest that relate to Siting and Licensing

	Phase 0: Policy, Framework & Programme Establishment	Phase 1: Site Evaluation & Selection	Phase 2: Site Characterisation	Phase 3: Facility Construction	Phase 4: Facility Operation and Closure
<p>Theme 6 Siting and Licensing</p> <p>Sub-themes:</p>	<p>Includes conceptual design and preliminary qualitative safety analyses</p> <ul style="list-style-type: none"> Develop broad concepts based on input from geology (T3), from EBS (T2), from repository design (T5) and safety (T6) taking the wastes to be disposed of into account (input from T1) Develop siting program based on national policy, legislation and regulatory guidance. Define different steps and needed activities. This also includes a document that describes and justifies the different steps and the criteria to be used to narrow down the siting possibilities. This needs to be done in close co-operation with geology, safety, EBS and facility design taking the waste properties into account. Furthermore, also work on and coordinate with land-use planning and with environmental impact assessment to ensure that the corresponding issues are properly considered. Develop a program of public involvement in siting, search of consent with key stakeholders Check for synergies if more than one geological repository will be implemented 	<p>Includes preliminary site(s) design and generic safety case(s) / analyses</p> <ul style="list-style-type: none"> Implement program and initiate and coordinate work by geology, EBS, facility design and safety In each of the narrowing-down steps, manage the evaluation of the different criteria and come to conclusions (synthesis). Manage the process to ensure compatibility with land-use planning. Implement the environmental impact assessments Manage the process of involving the stakeholders and interest groups during the stepwise narrowing-down process Go through the different steps as planned and prepare the necessary documentation to describe and justify the selected site, the EBS and facility concept, the expected safety, the compatibility with land-use planning and the environmental impact assessment Prepare the necessary documentation for any licensing decisions on siting 	<p>Includes detailed design and site safety case / analyses for construction license</p> <ul style="list-style-type: none"> Prepare the start of the field work by geology and refinement of work by all other disciplines (EBS, facility design, safety) Monitor continuously progress with site characterization and manage the process of evaluating any new findings by the different disciplines Ensure that land-use planning aspects and environmental impact assessment are properly covered 	<p>Includes final design and site safety case / analyses for operational license</p> <ul style="list-style-type: none"> Prepare the start of construction work (incl. geological characterization) Monitor continuously progress with construction and manage the process of evaluating any new findings by the different disciplines (EBS, geology, facility design, safety) 	<p>Includes maintenance and update of license documentation, as required</p> <ul style="list-style-type: none"> Prepare the start of operation (and construction in parallel, incl. geological characterization) Monitor continuously progress with operation and manage the process of evaluating any new findings by the different disciplines (EBS, geology, facility design, safety) Manage the process with involving the stakeholders and interest groups Prepare the syntheses and corresponding documents for the periodic safety evaluations and for the closure license and manage the licensing process Prepare the start of closure and implement closure
Site selection process	<p>3.3 Site selection process</p> <p>M</p>				
Detailed site investigation		<p>J1.6.5 Maintaining and developing understanding of tools and techniques for developing site descriptive models</p> <p>3.1 Methodologies for site uncertainty treatment EJPI WP UMAN</p> <p>M</p>	<p>J1.6.2 Developing state-of-the-art on the methods of uncertainty management associated with site characteristics</p> <p>M</p>		
Licensing			<p>3.2 Site evolution models, and how to manage data as it is obtained during the site characterisation phase</p> <p>H</p>		

Programme Objectives	RD&D Activities	Strategic Studies	Knowledge Management Activities	H High Priority	M Medium Priority	L Low Priority	Future	Currently In Progress
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Roadmap Theme 7: JP Priorities and Activities of Common Interest that relate to Performance assessment, safety case development and safety analyses

	Phase 0: Policy, Framework & Programme Establishment	Phase 1: Site Evaluation & Selection	Phase 2: Site Characterisation	Phase 3: Facility Construction	Phase 4: Facility Operation and Closure
<p>Theme 7 Performance assessment, safety case development, and safety analyses</p> <p>Sub-themes:</p>	<p>Includes conceptual design and preliminary qualitative safety analyses</p> <ul style="list-style-type: none"> Based upon first ideas of the geological possibilities and taking the properties and inventories of wastes to be disposed of into account, provide input / requirements to EBS (T3) to develop EBS concepts Assess these broad options with respect to barrier functions, taking long-term evolution into account Perform first system analyses to assess feasibility that a sufficient level of overall system safety can be achieved Start first activities to increase understanding of repository performance (waste, EBS, geological barrier) and its long-term evolution Start developing an and exchange with stakeholders 	<p>Includes preliminary site(s) design and generic safety case(s) / analyses</p> <ul style="list-style-type: none"> For the sites evaluated / eventually selected and for the wastes to be disposed of, refine input / requirements to EBS to further develop EBS concepts and to repository design for facility design (optimization) Assess EBS options and facility design with respect to barrier functions (initial full containment, radionuclide immobilization/retention), taking long-term evolution into account Continue activities to increase understanding of repository performance (waste, EBS, geological barrier) and its long-term evolution. This may lead to the start of an experimental programme If needed, prepare safety report for site selection license 	<p>Includes detailed design and site safety case / analyses for construction license</p> <ul style="list-style-type: none"> For the site selected and for the wastes to be disposed of, provide refined input / requirements to EBS to further develop EBS layout and to repository design for facility design (optimization) Assess EBS layout and facility design with respect to barrier functions (initial full containment, radionuclide immobilization/retention), taking long-term evolution into account Continue activities to increase understanding of repository performance (waste, EBS, geological barrier) and its long-term evolution. Continue experimental programme Analyze any new findings from site characterization Prepare safety report for construction license 	<p>Includes final design and site safety case / analyses for operational license</p> <ul style="list-style-type: none"> Provide input to EBS layout and facility design (optimization) and make assessments of proposals as far as needed Analyze any new findings during construction Continue activities to increase understanding of repository performance (waste, EBS, geological barrier) and its long-term evolution. Continue experimental programme Prepare safety report for operation license 	<p>Includes maintenance and update of license documentation, as required</p> <ul style="list-style-type: none"> Analyse any new findings from operation Prepare input and documentation for periodic safety evaluations. Provide input for any optimization, if needed Prepare safety report for closure license
Integration of safety-related information	J3.9 Safety case management and review M	J2.2.3 Improved understanding of the spatial extent and evolution with time of oxidative transients, as well as the possible impact on safety functions L J2.2.4 Improved understanding of the upscaling of THMC modelling for coupled hydro-mechanical-chemical processes in time and space H J2.1.5 Natural analogues M	J2.2.1 Improved understanding and models for the impact of THMC on the behaviour of the host rock and the buffer materials H J2.4.3 Impacts of operational safety M	J2.1.1 Improved understanding of the influence of pre-closure disturbances on long-term safety M J2.4.3 Improve understanding of the impacts of operational safety L J2.3.7 Improved computing M J2.4.1 Improved fire and impact assessment L	
Performance assessment and system models	J2.1.2 Assessment methodologies M J2.1.4 Dose thresholds L J2.3.1 Improved performance assessment tools H J2.3.2 Open-source performance assessment code H	J2.3.5 Improved understanding for the role of physical/chemical processes at different scales and linking bottom-up and top-down approaches in performance assessments H J2.2.6 Enhanced treatment of climate change, non human bi land-use and parameter derivation in biosphere models M J1.5.1 Further develop transparent and quality assured thermodynamic databases for use in performance assessments H	J2.3.6 Improved treatment of heterogeneity M J2.2.2 Improved understanding of the performance of plugs and seals H J2.3.3 Improve geosphere transport models M J2.3.4 Improved multi-scale reactive transport models H	J2.1.5 Improved understanding for the impact of deviations in planned implementation scenarios on the performance assessment outputs of the disposal facility L	
Treatment of uncertainties			J2.1.3 Further refinement of methods to make sensitivity and uncertainty analyses M		

Programme Objectives	RD&D Activities	Strategic Studies	Knowledge Management Activities	H High Priority	M Medium Priority	L Low Priority	Future	Currently In Progress
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