



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

1.0 Technical Baseline and underpinning Research and Development (TBuRD) Requirements

The R&D strategic objective is to ensure that the delivery of NDA's mission is technically underpinned by sufficient and appropriate R&D.

This drives the requirement to provide transparency and visibility of the technical baseline (processes and associated technologies used or planned to be used to deliver the NDA mission) and accompanying research and development requirements that underpin the operation and / or the decommissioning of individual facilities or groups of facilities across the NDA group. This serves the following purposes:

- Provides confidence in the technical deliverability of the NDA group's plans;
- Provides overall visibility of R&D across the NDA group to ensure strategically that appropriate R&D is being carried out in a timely manner;
- Identifies where coordinated R&D programmes may result from common needs, risks and opportunities; and
- Ensures key R&D needs across NDA are identified, prioritised and work programmes are costed and scheduled in the Lifetime Plans (LTP) for individual organisations within the NDA group.

This can be achieved by the individual organisations within the NDA group having the following processes / accountabilities in place:

- A robust gated approach to sanctioning which specifically addresses technology and engineering aspects;
- Clear accountability for technical assurance;
- A consistent system for assessing technology maturity using Technology Readiness Levels (TRLs); and
- Programmes of R&D directly linked to the Lifetime Plans.

In order to provide evidence of the organisation's approach and their corresponding technical underpinning programmes the following outputs are required as a minimum:

- A Technical Management Summary (TMS) detailing the organisation's technical governance and assurance processes;
- Process Wiring Diagrams (PWD) which highlight planned technologies and their maturities taking a whole system approach;
- An R&D Table which details plans to resolve technical issues underpinning delivery;
- A Technology Map giving a high level representation of the organisation's technology issues and opportunities; and



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

- An Annual Technical Report (ATR) which details any changes in governance / assurance processes and any significant in-year changes to the baseline and R&D requirements.

The following organisations within the NDA group are covered by this process: Dounreay Site Restoration Ltd (DSRL), Low Level Waste Repository Ltd (LLWR), Magnox Ltd, Radioactive Waste Management Ltd (RWM) and Sellafield Ltd.

1.1 Delivery Schedule

The schedule for the TBUrd deliverables is outlined in the NDA's Programme Control Procedures Manual (PCP-M) Section 7.4.8 [Ref 1].

2.0 TBUrd Template

This section provides the organisation with a template upon which to base their TBUrd submission. Guidance on the NDA requirements is given in each section.

Although each organisation must comply with these requirements, due to the nature of the individual organisation's activities, it is recognised that it may be inappropriate for each organisation to present their technical baseline in exactly the same manner. A glossary of terms, abbreviation list and appropriate diagram keys should be provided in order to support overall understanding. Organisations should seek guidance from NDA should they wish to adopt a particularly novel approach to their TBUrd submission in order to ensure the approach meets NDA requirements and to avoid potentially nugatory work.

2.1 Technical Management Summary (TMS)

Technical management includes the planning, directing, control and coordination of the research and development of technology and the generation of the associated underpinning technical information so that organisations can deliver their designated missions in an efficient and effective manner. It includes needs-driven, risk-mitigation and opportunity-led components.

A short summary (i.e. <30 pages) of the organisation's technical management arrangements should be provided along with any referenced internal processes. The summary should include sections on the following technical management activities with the key questions clearly and concisely answered:



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

- 1. R&D Strategy**
 - a. What is the organisation's approach to ensuring that the delivery of the organisation's mission is technically underpinned by sufficient and appropriate R&D?
 - 2. Identification**
 - a. How are technology needs identified?
 - b. How are technical risks identified?
 - c. How are technology opportunities identified?
 - d. How are internal ideas accessed?
 - e. How are external ideas accessed?
 - 3. Selection**
 - a. How are technologies selected amongst alternatives?
 - b. What criteria are used to select technology?
 - c. How is the overall technical portfolio managed?
 - d. How is the balance between near-term and long-term objectives managed?
 - 4. Acquisition**
 - a. How is the Make-Collaborate-Buy decision made?
 - b. How is R&D contracted? Who are the significant R&D contractors?
 - c. Are there any significant R&D collaborations?
 - 5. Project Management**
 - a. What project management tools and techniques are used to manage technical projects?
 - b. How is a gated process for project progression implemented?
 - c. How are R&D spends coded into the organisation's lifetime plan?
 - d. How is progress of technical projects monitored?
 - 6. Technical Assurance**
 - a. How are technical projects assured?
 - b. How are the outputs of technical projects assured?
 - c. How are Technology Readiness Levels applied?
 - 7. Protection**
 - a. What is the organisation's approach to protection of intellectual property?
 - b. What is the organisation's approach to protection of key technical skills?
 - c. What is the organisation's approach to protection of technical information?
 - 8. Dissemination**
 - a. How is technical information disseminated internally?
 - b. How is technical information disseminated externally?
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Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

9. Review

- a. How is the impact of the technical programme measured?
- b. What Key Performance Indicators (KPIs) are used to measure performance of the organisation's technical programme?
- c. How is continuous improvement in technology management implemented?

10. Organisation structure

- a. Who are the key individuals involved in the management of the organisation's technical programme? What are their roles and responsibilities? Please provide organogram.
- b. What the key boards associated with the management of the organisation's technical programme?

2.2 Process Wiring Diagrams (PWD)

2.2.1 Organisation Process Wiring Diagram

This wiring diagram should represent the organisation's activities at a high level and should highlight any links between the major activities and individual process wiring diagrams thus representing an overview of the organisation's operations, both present and future, which may be linked together for example by programme, waste, process and / or time. These diagrams may reference Work Breakdown Structure (WBS) level 7 activities (Ref 1) and should present current strategy and contingency / alternative plans covered in Site Strategic Specifications (likely to be represented by dotted lines / boxes). A PWD key should be provided.

2.2.2 Site Process Wiring Diagrams

Each site or operating / programme area (depending on site size) should develop their own set of Process Wiring Diagrams and R&D Tables. Individual Process Wiring Diagrams may be combined if a common approach is being adopted. The Process Wiring Diagrams will be presented in appendices or in separate referenced documents whereas the R&D Table and Technology Map will be presented in a single MS Excel Spreadsheet which will be used in conjunction with the diagrams for ease of reference.

These wiring diagrams should present the technical baseline of the sites and demonstrate a structured and integrated approach to technical underpinning of LTP activities which considers the interdependencies between tasks across the lifecycle. These must contain the following:

- Tasks and processes and any interactions between them (e.g. process flow);



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

- Planned technologies against process steps – see appendix 1 for a list of TBuRD descriptors including suggested process steps (these support the NDA in developing an estate wide perspective on technology issues and opportunities (see section 2.3.3) and therefore should be used where possible);
- Technology Readiness Levels – see appendix 2 for guidance on TRL application;
- Technology needs, risks and opportunities relating to key decision points and alternative baselines and linked to R&D programmes (set out in the R&D table) where appropriate; and
- References to additional information such as LTP Detailed Volumes (DVs), Work Breakdown Structures (WBS) and risk registers.

The level of detail presented in the PWDs should be representative of the complexity of the system being described, the complexity of the R&D and the maturity of the project / process e.g. a single PWD may be appropriate for an existing operational process whereas multiple PWDs may be needed for a complex system that is in the process of being developed. The number of diagrams is therefore likely to be representative of the complexity of the site and the maturity of its technology plans. A PWD key should be provided.

Any needs, risks or opportunities, shown in the PWDs should be identified as R&D requirements in the R&D Table and the link should be clearly identified e.g. use of common R&D ID.

2.3 R&D Table

In order for the NDA to support clean-up programmes and delivery of scheduled commercial operations across the organisation's programmes, sufficient information regarding the R&D activities is required to establish that:

- Activities needed to underpin the LTP are supported;
- Activities are being implemented on timescales required to deliver the LTP; and
- Innovative R&D activities are being initiated by the site contractor with a view to improving the technical baseline (e.g. cheaper, faster, safer, less environmental impact).

This R&D Table should include all R&D being directly funded by the organisation (includes PhDs and involvement in Innovate UK supported projects) and will include all the needs, risks and opportunities identified in the PWDs. For the purposes of the TBuRD, R&D is defined as any activity that supports the technical underpinning of the plan and therefore includes any activities undertaken to increase the Technology Readiness Level (TRL) of specific technologies, mitigate technical risks and take advantage of technological opportunities including technology insertion as identified in the diagrams described above. R&D does not include general plant support / maintenance but does include process optimisation (e.g. additional cost to implement incremental improvement)



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

and specific technical commissioning activities (e.g. additional cost to eliminate technical uncertainties). Although detailed routine commissioning activities do not need to be specified, summary information is required to highlight expected increases in TRLs at this point and provide references to appropriate documentation (between TRL7 and 9).

R&D costs therefore include any direct costs assigned to the activities described above including any specific overheads whereby if the activity were not undertaken the cost would be eliminated. This therefore does not include any site overheads and only includes training and management support when it is directly related to the R&D activity rather than it being related to the deployment and operation of the technology / technique. See appendix 5 for a more detailed explanation of R&D costs and some examples.

The R&D Table includes all technical underpinning and summarises R&D activities as follows:

- Information on the organisation and site associated with the R&D task.
- Information on the actual R&D task including R&D task title, summary of the current position (what is the technology and the description of the gap (technical need, risk, opportunity)) and link / reference to the appropriate PWDs and WBS.
- Information that allows the R&D task to be grouped with related R&D tasks. This includes strategic theme, process step, building type and waste / material.
- Information on the current and target TRL.
- An overview of the R&D requirement including the activity required to resolve the issue.
- Key outputs / actions / benefits of the R&D work - what will the R&D produce, what impact will it have and what will the benefits be.
- A start date and need by date for delivery of the planned output aligned with the insertion points required in the LTP and link / reference to any risk management tasks.
- An estimated R&D cost, in thousands of pounds (£k), for the current year (i.e. For March 2020 submission, the cost during FY2019/20), the following year and any remaining years, aligned with LTP R&D coding.
- The current status of the R&D task giving an indication of whether the task is on schedule, at risk of delay, late, completed or deleted.
- A list of technical keywords specifying the problem, solution, technique or technology (A list of suggested keywords are provided in the R&D table template (Ref 2)).

Any changes since the previous submission should be highlighted in red in the table and significant changes (e.g. significant change in cost, schedule) detailed within the subsequent Annual Technical Report. Any deleted activities should be highlighted by filling the background of the activity in grey. R&D tasks completed or deleted in previous years should be removed from the latest submission unless there are close-out costs associated with the R&D task in the current year (i.e. R&D task reported as complete or



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

deleted in March 2019 submission should be removed from March 2020 submission unless there are costs for FY2019/20).

The information contained in the table should be understandable by an external user with an appreciation of the organisation's requirements. The level of detail should also reflect this. Abbreviations should be defined. Once the R&D Table has been completed, the verification checklist (Ref 2) should be completed and the table only submitted once this form confirms full compliance with EGG10.

Appendix 3 provides further details on the table content requirements. The table is provided electronically (Ref 2) to maintain a consistency of approach across the NDA group.

2.4 Organisation Technology Map

Technology Maps are a tool to support a structured integrated approach to technology development and clearly and succinctly present the scale and breadth of technology issues and opportunities for technology insertion against strategy topics across the NDA group. The maps provide a consistent structure upon which to visualise a large volume of information. This allows areas of particular need / concern to be identified and helps NDA to develop the NDA technical baseline. The maps are also designed to support the sharing of information across organisations and promote collaborative working.

A technology map is represented by four strategy lifecycle matrices, colour coded to clearly highlight technology issues (colour and number of R&D tasks) and opportunities (star indicating scale of opportunity). It presents an overview of the organisation's TBuRD.

A single Technology Map should be presented for each organisation and should be submitted with the R&D Table. The template is provided in the R&D Table template (Ref 2), sheet entitled "Technology Map".

A guide to the development of a Technology Map is given in appendix 4. This should be followed and the template used.

3.0 Annual Technical Report

This section provides the organisation with a template upon which to base their Annual Technical Report submission. The NDA's requirements are stated under each area. Where specific R&D activities are being referenced, the PWD / R&D Table unique identifier should be used.



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

3.1 Changes to Technical Governance and Assurance Arrangements

Where there are no changes a statement to this effect should be provided. Where minor changes have been made these should be described. However, where significant changes have been made, the organisation should provide a full description of the arrangements and the resultant impact. If multiple significant changes have been made then a full Technical Management Summary should be submitted at the same time as the Annual Technical Report.

3.2 Changes to the Technical Baseline

This section should focus on any in-year changes to the technical baseline. It should include when any alternatives to the previous technical baseline have been implemented and the reason for the change in approach. It should also include commentary on any new or deleted R&D tasks. It is recognised that not all identified risks or opportunities will be funded in the LTP, however it is expected that all needs (requirements to meet LTP) will be funded.

3.3 R&D Successes and Challenges

This section should focus on in-year R&D successes, where TRLs have increased, opportunities are being realised or risks mitigated. This section should also provide details of any significant R&D challenges, where TRLs have decreased, opportunities have been eliminated or R&D programmes are behind schedule. This is to support learning from experience being captured. This section should also set out and explain the key R&D successes and challenges expected in the coming year.

3.4. R&D Costs

In order to provide confidence in the existence of sufficient R&D funding, associated costs should be transparent within LTP schedules. Annual R&D costs should therefore be presented in this section for the previous (actual), current (actual and previously predicted value) and future (predicted) financial years (i.e. Sept 2020 ATR should include R&D costs for FY18/19, FY19/20 actual, value for FY19/20 predicted in Sept 2019 ATR and predicted value for FY20/21). Any discrepancy with information included in the relevant R&D Table should be explained (e.g. inclusion of any indirect R&D costs, updated cost information). Similarly any significant discrepancy between the previously predicted R&D spend and the actual R&D spend for the current financial year should be explained.



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

The costs should include all spend on work to technically underpin the LTP and should refer to activities coded as R&D in the LTP. This includes the cost of activities undertaken to increase the technology readiness level of specific technologies, mitigate against technical risks and take advantage of technological opportunities. For further guidance on R&D costs see Appendix 5. This information should be split into Research, Development and Deployment using the following guidelines:

- Research is "work required to achieve a TRL of 3" or is "a methodical study aimed at increasing knowledge in a specific area in order to support resolution of a specific technical issue"
- Development is "work required to increase the TRL from 4 to a TRL of 6" or is "the invention, advancement, significant improvement or alteration to a technology / product / process in order to complete a specific task satisfactorily"
- Deployment is "work to increase the TRL from 7 to 9" or "the application of knowledge gained or developed techniques which enable the project or operation to proceed"

Please note that R&D does not include general plant support / maintenance but does include process optimisation. Where R&D is embedded within a project, the cost of the R&D element of the project should be included. Where possible, costs provided should be underpinned however where this is not possible a best estimate should be provided. The method of determining the R&D costs should be clearly explained.

If a submission is made for R&D tax relief, a link to the appropriate submission should be provided here or the value stated.

4.0 References and Further Information

The US Department of Energy has produced a useful guide to technology development (Ref 3) which suggests a number of approaches. This document provides further information on Technology Maturation Plans, Critical Technology Elements and Technology Readiness Assessment Reviews.

Ref 1 Baseline Management System Programme Controls Procedure (PCP-M) Rev3, March 2019

Ref 2 EGG10-F01, R&D Table Template, October 2017

Ref 3 US Department of Energy Technology Readiness Assessment Guide, DOE G 413.3-4A, 15th September 2011

Ref 4 Guide to Technology Readiness Levels for the NDA Estate and its Supply Chain, 13594, 6th November 2014, 505/02, Issue: 2



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

Appendix 1 – TBUrd Descriptors

Where possible the following process steps and material / waste descriptors should be used to provide consistency across the NDA group. These should be used in both the Process Wiring Diagrams and the R&D Table. By using a consistent set of process steps and descriptors the NDA can use the information to develop a national view and evaluate common technology issues and opportunities. In order to retain consistency across the NDA group these will be updated as necessary. A description of each process step is provided below.

- **Inventory & Characteristics:** Understanding of the inventory and characteristics of the waste or materials under consideration.
- **Pre-Treatment:** Includes usually low tech solutions to prepare items for treatment and includes such things as segregation for LLW, decontamination for ILW, dismantling / de-canning for spent fuel etc.
- **Process / Treatment / Conditioning:** Changes the waste / material in some way e.g. waste super-compaction or encapsulation, spent fuel reprocessing.
- **Product / Package:** Relates to the design, structure, and longevity of the product / package and includes Letter of Compliance requirements.
- **Internal Site Transfers:** Transfers of waste or materials between locations other than by off-site transport e.g. pipes, skips, drums includes the infrastructure required.
- **Off-Site Transport:** Off-site transport of wastes or materials, e.g. by road for LLW, rail for spent fuel. The technology relates to the containers, vehicles and infrastructure.
- **Short / Medium Term Storage:** Temporary short to medium term storage of waste or materials usually prior to some treatment process e.g. FHP for spent fuel, HAST tanks for HLW.
- **Long Term Storage:** More permanent storage, e.g. interim storage prior to disposal, where waste is stored until its final use is determined or its disposal facility is available.
- **Disposal:** Disposal of wastes, e.g. GDF for ILW, LLWR for LLW.
- **Care Maintenance Surveillance:** Activities required to manage the site and its buildings under care and maintenance and surveillance and maintenance.
- **POCO / Waste Retrievals:** Activities required to move a building through Post-Operational Clean-Out (POCO) or where bulk inventory is retrieved.
- **Prep for Decom:** Decommissioning enabling works prior to decommissioning.
- **Decontaminate:** Part of decommissioning and relates to the decontamination of the building structures, for example pond and cell walls.
- **Deplant / Dismantle:** Part of decommissioning and includes the dismantling of building contents and internal structures.
- **Demolition:** Final demolition of the building.



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

- **Risk Assessment / Options Appraisal:** Risk assessment work and options appraisal to evaluate the risk and the preferred options.
- **In-Situ Remediation:** In-situ management or treatment of ground and ground water.
- **Ex-Situ Remediation:** Ex-situ management or treatment of ground and ground water.
- **Long Term Monitoring:** Long term monitoring techniques relating to Land Quality management.

Materials, waste, plants and land likely to be influenced by the processes above have also been grouped and are described below. Note that the plant specified should relate to the original purpose and use of the building.

- **Materials**
 - Nuclear Materials
 - Plutonium
 - Uranium
 - Spent Fuel
 - Magnox Spent Fuel
 - Oxide Spent Fuel
 - Exotic Spent Fuel
- **Wastes**
 - Higher Activity Wastes
 - HLW
 - Solid / immobile ILW
 - Wet / potentially mobile ILW
 - Graphite ILW
 - Lower Activity Wastes
 - Solid LLW / VLLW
 - Liquid / Gaseous LLW / VLLW
 - Non-Radioactive Waste (inc. exempt)
 - Hazardous
 - Non-hazardous
- **Plants**
 - Fuel Management Facilities
 - Reactors
 - Fuel Manufacturing
 - Fuel Ponds
 - Reprocessing plants
 - Rad Waste / Materials Management Facilities
 - Rad Treatment and Handling Facilities
 - Rad Storage Facilities
 - Other



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

- Rad Facilities
- Non-Rad Facilities
- Infrastructure
 - Rad Transport / transfers
 - Other
- Land
 - Contaminated Land
 - Contaminated ground
 - Contaminated groundwater

An example of good practice in Process Wiring Diagrams is shown in Figure 1.

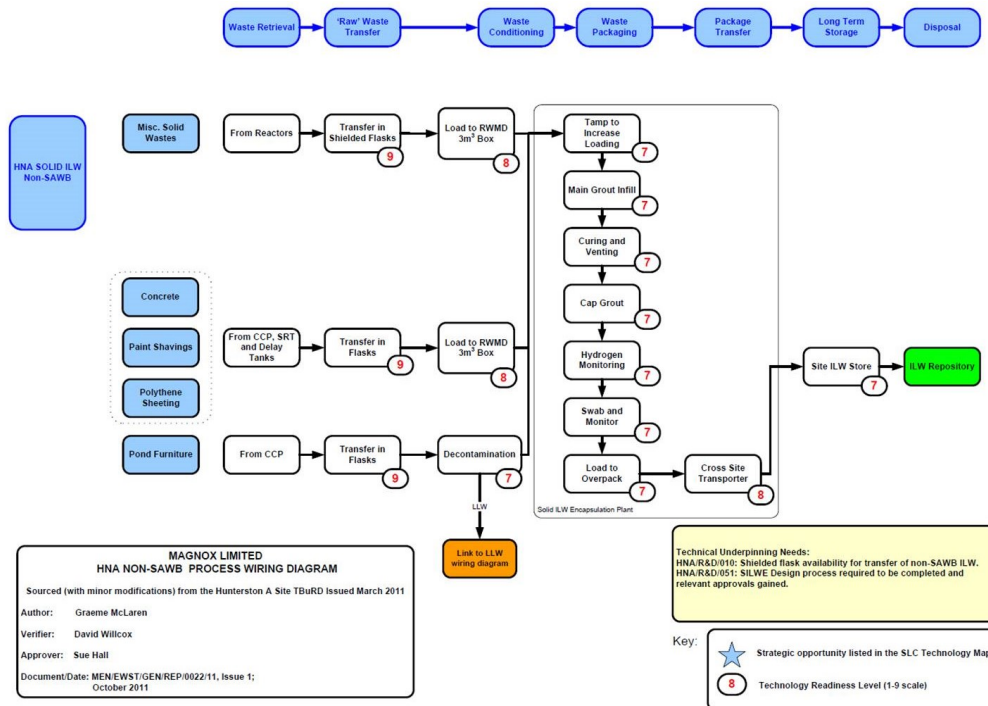


Figure 1: Process Wiring Diagram Example

Below is an overview of the relevant NDA strategy themes. This should be used to help group activities within the R&D Table.

- **Nuclear Materials (NM):** The lifecycle management of plutonium and uranic materials.
- **Spent Fuels (SF):** The lifecycle management of spent fuel (Magnox, Oxide and Exotic). This does not include the management of any waste products (e.g. PCM / CHILW) or the consideration of fuels in any case where they have been re-classified as waste, this is covered within IWM.
- **Integrated Waste Management (IWM):** The management of all radioactive and non-radioactive wastes from the point where the waste has been retrieved or



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

generated from source. This therefore includes the re-use / recycling, minimisation, treatment, packaging, transport, storage and disposal of waste.

- **Site Decommissioning and Remediation (SD&R):** The decommissioning and clean up of nuclear facilities. This therefore includes any Post-Operational Clean-Out (POCO) and retrieval of any waste within these facilities and any decontamination and dismantling of building infrastructure and final demolition activities. Land quality management which incorporates the management of any land within a nuclear licensed site including any risk assessments and options appraisals, monitoring, remediation (including in-situ and ex-situ) and transportation. This does not include management of any waste products, this is covered within IWM.



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

Appendix 2 – Technology Readiness Level Guidance

Technology Readiness Levels (TRLs) provide an indication of readiness of a technology to be applied for a specific purpose and should be applied to monitor technology readiness within a project / task and across a programme.

The scale, as applied by NASA, is recognised as good practice and used across the USA and increasingly across the UK. Further guidance on the specific steps on the scale is provided below.

- **System Operations**
 - TRL9 – Actual system operated over the full range of expected conditions.
 - The technology is in its final form and operated under the full range of operating conditions. Examples include using the actual system with the full range of wastes in hot operations.
- **System Commissioning**
 - TRL 8 – Actual system completed and qualified through test and demonstration.
 - The technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental testing and evaluation of the system with actual waste in hot commissioning.
 - TRL 7 – Full-scale, similar (prototypical) system demonstrated in relevant environment.
 - This represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment. Examples include testing full-scale prototype in the field with a range of simulants in cold commissioning.
- **Technology Demonstration**
 - TRL 6 – Engineering/pilot-scale, similar (prototypical) system validation in relevant environment.
 - Engineering-scale models or prototypes are tested in a relevant environment. This represents a major step up in a technology's demonstrated readiness. Examples include testing an engineering scale prototypical system with a range of simulants.
- **Technology Development**
 - TRL 5 – Laboratory scale, similar system validation in relevant environment.
 - The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects. Examples include testing a high-fidelity, laboratory scale system in a simulated environment with a range of simulants and actual waste.
 - TRL 4 – Component and/or system validation in laboratory environment.



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

- The basic technological components are integrated to establish that the pieces will work together. This is relatively “low fidelity” compared with the eventual system. Examples include integration of ad hoc hardware in a laboratory and testing with a range of simulants and small scale tests on actual waste.
- **Research to prove feasibility**
 - TRL 3 – Analytical and experimental critical function and/or characteristic proof of concept
 - Active research and development (R&D) is initiated. This includes analytical studies and laboratory-scale studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative tested with simulants.
 - TRL 2 – Technology concept and/or application formulated.
 - Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are still limited to analytic studies.
- **Basic Technology Research**
 - TRL 1 – Basic principles observed and reported.
 - This is the lowest level of technology readiness. Scientific research begins to be translated into applied R&D. Examples might include paper studies of a technology’s basic properties or experimental work that consists mainly of observations of the physical world.

The following bullets however provide further guidance to the application within the NDA group:

- Where the scale descriptors provided do not appear to fit the problem, expert judgement should be used to estimate the TRL on a scale of 1 to 9 and the issue highlighted to the NDA.
- The TRL for a specific system should relate to the TRL of the most immature Critical Technology Element (CTE).

A technology element is “critical” if the system being acquired depends on the technology element to meet operational requirements (with acceptable development, cost and schedule; and with acceptable production and operations costs) and if the technology element or its application is either new or novel (Ref 2).

Guidance adapted from a Department of Energy document (Ref 3).

Further guidance on TRLs was published by NDA in 2014 (Ref 4).



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

Appendix 3 – R&D Table

Technology needs, risks and opportunities are defined as:

- **Needs** – work that must be completed to underpin delivery of the site LTP.
- **Risks** – work to be completed that mitigates / reduces / quantifies technical risks identified within the site LTP.
- **Opportunities** – work that technically underpins opportunities to change the LTP.

R&D activities presented should not include routine services provided to the site contractor e.g. annual plant inspection, annual inventory assessment, routine analytical samples etc.

Further details of the columns in the R&D Table and what is required within them is provided below. All cell descriptors should be less than 255 characters long.

- **NDA ID:** Unique identification reference to be populated by the NDA.
- **Organisation:** The Site Licence Company or Organisation.
- **Site:** A specific site or where the programme applies across multiple sites.
- **WBS Reference:** Work Breakdown Structure (WBS) reference which links directly to relevant LTP documentation.
- **PWD Reference:** Reference to the relevant process wiring diagram(s) to allow easy navigation through the PWDs. Where common issues are presented and the R&D requirement links to more than one process wiring diagram this can be highlighted here.
- **R&D ID:** Reference to the relevant R&D task linking directly between the task in the table and in the PWD. Each line item should have a unique ID with no duplication.
- **Title:** High level descriptor of what the R&D need / risk / opportunity relates to. The title should be less than 50 characters in length.
- **Strategy Theme:** The overarching strategic theme – NM, SF, IWM or SD&R. See appendix 1 for a description of what is incorporated within these themes.
- **Process Step:** Where the application of the technology applies to a specific process step. Where the R&D requirement covers multiple process steps or no process step this field should be marked 'Multiple' or 'N/A' respectively.
- **Building Type:** Where the process relates to a specific building type or is applied within a specific building type. Where it relates to multiple building types this column should be marked 'Multiple'.
- **Waste / Material:** Where a waste / material is managed using this technology. Where mixed waste is considered, the highest activity waste should be specified (detail provided in later column).
- **Technique / Context (task + gap):** Summary providing context – What is the current position (technology planned) and what is the issue? (technology need, risks or opportunity).



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

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- **Current TRL:** Current TRL as specified in Process Wiring Diagrams.
 - **Target TRL:** Target TRL (lowest CTE) expected following completion of this R&D activity.
 - **Sub-grouping:** This allows the Site to utilise their own sub-grouping that would allow them to easily search or group information. This is not a required field.
 - **Need / Risk / Opp:** Whether the issue is a technology need, risk or opportunity should be stated here.
 - **Risk ID:** Reference linking directly to the organisation's risk management process.
 - **R&D Requirement:** What is the R&D requirement? – Activity required to resolve the issue.
 - **Key Outputs, Actions and Benefits:** What will the R&D activity produce? e.g. technical report, laboratory-scale inactive demonstration, pilot-scale active demonstration. What actions are required? e.g. sanction for further funds, updated business case. What will the benefits be? e.g. technical baseline improved (lower cost, earlier completion, less waste). Where R&D is completed and the outputs / benefit is different to that expected, then this should be noted and the consequences highlighted e.g. change in planned technical baseline, additional R&D programmes added.
 - **Technical Keywords:** A list of technical keywords to improve user searches, specifying the problem / solution / technique / technology. It is recommended that five or less key words are specified per R&D item. For the latest list of technical keywords see Ref 1. Where new key words are proposed these should be agreed with the NDA prior to submission.
 - **Current Year Cost:** Estimated R&D costs for current financial year (i.e. For March 2020 submission, the cost during FY2019/20). The estimated costs should be provided in thousands of pounds (£k). If no cost during this period is identified a 0 should be entered. Organisations can update the header to the actual year if they wish
 - **Next Year Cost:** Estimated R&D costs for next financial year (i.e. For March 2020 submission, the estimated cost during FY2020/21). The estimated costs should be provided in thousands of pounds (£k). If no cost during this period is identified a 0 should be entered. Organisations can update the header to the actual year if they wish
 - **Outyears Cost:** Estimated R&D costs for outyears (i.e. For March 2020 submission, the estimated cost for FY2021/22 onwards). The estimated costs should be provided in thousands of pounds (£k). If no cost during this period is identified a 0 should be entered. Organisations can update the header to the actual year if they wish
 - **Start Date:** Financial year when the R&D should start in order to meet the plan. This is expected to include contingency time dependent on the risk to success.
 - **Need By Date:** Financial year when the R&D activity needs to be completed and thus when the target TRL should be reached to successfully deliver the LTP.



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

- **Status:** Background fill of cell and associated text.
 - **RED** (Red: 255; Green: 0; Blue: 0) = Late or delayed with no possibility of recovery
 - **AMBER** (Red: 255; Green: 192; Blue: 0) = Delayed but with possibility of recovery
 - **GREEN** (Red: 146; Green: 208; Blue: 80) = On schedule for successful completion
 - **BLUE** (Red: 0; Green: 176; Blue: 240) = Completed
 - **GREY** (Red: 191; Green: 191; Blue: 191) = Deleted
- **Key Reference Documents:** Description of reference documents (e.g. scope documents or interim reports for R&D that is yet to be completed, final reports for completed R&D). Document number and version should be included.
- **User Definable 1-10:** Data cells that the organisation can tailor for their own use. Title of column should be updated to reflect contents (e.g. Specialist Skills, Facilities).



Technical Baseline and underpinning Research and Development Requirements

Doc No: EGG10

Appendix 4 – Organisation Technology Maps

1.0 Overview

The organisation Technology Map provides a consistent structure upon which to visualise a large volume of information. Four separate matrices make up a complete Technology Map; these include Nuclear Materials and Spent Fuel, Integrated Waste Management, Decommissioning and Clean Up and Land Quality life cycle maps which align to the NDA’s strategy topics and present each entity against process steps in their life cycle.

The four strategy topics and matrices are described below:

- **Nuclear Materials:**
 - Nuclear Materials and Spent Fuel Management Life Cycle
- **Spent Fuels:**
 - Nuclear Materials and Spent Fuel Management Life Cycle
- **Integrated Waste Management:**
 - Integrated Waste Management Life Cycle
- **Site Decommissioning and Remediation:**
 - Decommissioning and Clean Up Life Cycle
 - Land Quality Management Life Cycle

The matrix formation used allows the scale and breadth of an organisations R&D portfolio to be visualised. An example is shown in Figure 2.

Integrated Waste Management Life Cycle											
Topic	Material	Inventory & Characteristics	Waste Retrieval	Internal Site Transfers	Short / Medium Term Storage	Pre-treatment	Process / Treatment	Product / Package	Long Term Storage	Off-Site Transport	Disposal
Higher Activity Wastes	Higher Activity Waste (Generic)							1			
	HLW	3	6	1		3	7	4	1		
	Wet ILW	5	12 ★	2		2	15 ★	7 ★	1	1	
	Graphite	2	3	1		3	2	1	1	1	
	Solid ILW		6				1 ☆	1	1		

Figure 2: Technology Map Example

2.0 Key

The cell colours represent whether the area is within the scope of the organisation and whether R&D is identified. The size and colour of the star indicates the number and size of any opportunity driven R&D. Guidance is given below on the colour coding to be used.

- **Dark blue cell background** (Red: 0; Green: 112; Blue: 192)
 - R&D tasks identified in organisation R&D Table submission.



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

- Number reflects the number of R&D tasks in this area.
- Comment reflects the R&D task with lowest current TRL – Use R&D ID.
- **Light blue cell background** (Red: 197; Green: 217; Blue: 241)
 - Within current mission of organization.
 - No R&D tasks identified in organisation R&D Table submission.
- **Grey cell background** (Red: 191; Green 191; Blue:191)
 - Outside current mission of organisation.
- **Large, dark orange 5-point star** (H: 0.98cm, W: 1.03cm; Red: 228; Green: 108; Blue 10)
 - One or more significant opportunities identified in R&D Table
 - Opportunities likely to have significant benefits across NDA group
 - Comment reflects most significant opportunity - Use R&D ID
- **Large, light orange 5-point star** (H: 0.98cm, W: 1.03cm; Red: 252; Green: 213; Blue 181)
 - One or more good opportunities in R&D Table
 - Likely benefits within an organisation but reduced benefits outside
 - Comment reflects most significant opportunity - Use R&D ID
- **Small, light orange star** (H: 0.37cm, W: 0.4cm; Red: 252; Green: 213; Blue 181)
 - One or more small scale opportunities in R&D Table
 - Likely to relate to a single site only
 - Comment reflects most significant opportunity - Use R&D ID
- **No star**
 - No opportunities identified in R&D Table

The columns in the matrices relate to process steps whereas the rows represent entities that flow through the steps (nuclear materials, spent fuel, waste, structures and land respectively). Each box therefore relates to a specific entity at a specific step in its lifecycle. The number of relevant R&D tasks is recorded in the box. The box comment reflects the R&D tasks with i) the lowest TRL and ii) the most significant R&D opportunity.

3.0 Additional Requirements

A Technology Map is presented as follows:

- A star is only placed on a box when an opportunity has been identified and its potential benefit on the NDA mission can be described. The opportunity does not need to be funded to be included.
- Where the organisation has no interest in the area the box should be filled grey (no star present).

A number of additional points should be made:



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

- The activities do not necessarily have to flow in the direction described by the matrix e.g. long-term storage may be required before treatment. This does not matter as the flow of activities will be detailed within the PWD of the site.
- Where an activity does not appear to fit into the matrix the activity should be placed in the process step which is dependent upon that activity for its success.



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

Appendix 5 – Supplementary guidance on R&D Costs

In order to provide evidence of sufficient R&D, associated costs should be transparent within the organisation's LTP schedules, and presented in the TBUrd. The type of R&D should be split into:

- i. Research (basic and/or applied)
 - a. work to achieve a TRL of 3
 - b. a study aimed at increasing knowledge in a specific area to support resolution of a technical issue
- ii. Technology development
 - a. work to increase the TRL from 4 to 6
 - b. the development, invention, advancement, significant improvement or alteration to a technology / product / process in order to complete a task
- iii. Technology deployment or implementation within a larger system
 - a. work to increase the TRL from 7 to 9
 - b. the application of knowledge gained or developed techniques which enables the project or operation to proceed

R&D does not include:

- General plant support
- Maintenance and routine monitoring
- Design, build and commissioning of an overall facility or system that contains or supports the technology element, if the facility or system is not novel
- Physical assets such as equipment and facilities
- Management and support where this cannot be solely assigned to the R&D activity
- Training of technical staff
- Safety Case activities
- Assurance activities
- Regulatory requirements / compliance activities
- Sanction & validation activities

R&D does include:

- All activity costs if sub-contracted to the supply chain (including universities) for TRL 6 or below
- All activity costs that the organisation would normally attribute to a project if delivered in-house
- For projects that increase TRL above 6, activity costs for the design, testing, manufacture and commissioning of the novel technology element or combination (including any supply chain costs)
- Process optimisation



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

The costs should include all spend on work to technically underpin the LTP.

This includes the cost of activities undertaken to:

- Increase the TRL of technologies
- Mitigate against technical risks
- Take advantage of technological opportunities

Where possible, costs provided should be underpinned, however, where this is not possible a best estimate should be provided. The method of determining the R&D costs should be clearly explained. Where the estimation process changes between submissions this should be stated and the rationale for the change explained.

If a submission is made for R&D tax relief, a link to the appropriate submission should be provided or the value stated.

In the R&D table, costs should be reported for each R&D activity and not merged with other R&D activities.

The organisation should be consistent in communicating their annual R&D spend both internally and externally and refer to their TBU RD value wherever possible.

Further examples of the type of R&D activities include the following:

- Package approvals including letter of compliance submissions and radioactive material transport approvals.
 - R&D includes underpinning work including any trials, studies, modelling and testing.
 - R&D does not include production and submission of reports unless they are associated with reporting new experiments or analysis. Responding to subsequent questions.
- Characterisation and/or sampling activities.
 - R&D includes investigations to underpin historic data and increase knowledge, investigations to support the development of new programmes and development of new/novel characterisation techniques.
 - R&D does not include support of routine operations or decommissioning activities.
- Option studies including Front End Engineering Design.
 - R&D includes research into options and overall assessment (i.e. Best Available Technique (BAT) assessments).
 - R&D does not include the design of full scale plant where the whole system is not novel.
- Design and commissioning (inactive and active) activities.
 - R&D includes the design, trialing and commissioning of novel equipment or plant.



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

- R&D does not include activities which are routine or use off-the-shelf technology for any plant, system or equipment e.g. ventilation, electrics, pipework, system testing etc.
- Facility and plant / equipment modifications.
 - R&D includes optimisation activities or a change of use that is novel.
 - R&D does not include routine maintenance or upgrades.
- Decommissioning methodologies.
 - R&D includes activities that technically underpin the proposed decommissioning methodology or technique.
 - R&D does not include when methodologies are based on other known, tried and tested approaches.
- Processing techniques and wastefrom development.
 - R&D includes new or novel techniques.
 - R&D does not include duplicating existing processes.
- Opportunities to change the strategy/methodology.
 - R&D includes opportunities that require technical underpinning work.
 - R&D does not include when no additional technical underpinning work is required.



Technical Baseline and underpinning Research and Development Requirements

Version: 8
Date: 10/2019

Doc No: EGG10

Record Description: Technical Baseline and underpinning Research and Development Requirements (Doc No: EGG10, Version 8, 10/2019)

Record Owner: Technical Assurance Manager

Record Format: Electronic

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