Nuclear Decommissioning Authority

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Position Paper of NDA Research Board NDARB021

Review of NDA's Technology Baseline and Underpinning Research and Development (TBuRD) Process

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About the Independent NDA Research Board

Despite its title, the Research Board has terms of reference which cover the Research and Development (R&D) interests for waste management and decommissioning of the UK, not just the that of the NDA. Given the scale of the NDA's work in this sphere however, much of its time is dedicated to the NDA's own programme. Although the Board works cooperatively with the NDA, which provides the secretariat, it is independent. Neither its programme of work or published opinions have to be agreed with the NDA. Its membership comprises experts in the field and senior representatives of key stakeholder organisations such as Government departments and regulatory bodies. Its role is advisory only, reporting to the main NDA Board and to Government departments via their Chief Scientific Advisors. Further information on the Research Board can be found on the NDA website (www.gov.uk/nda).

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1. Introduction

This Position Paper reports the NDA Research Board's (RB) conclusions and recommendations from its examination of the Technical Baseline[1] and underpinning Research and Development (TBuRD) process. It is based on the evidence presented to the Board and other information available up to the date of and shortly after its ninth meeting (14/04/2015); any more recent developments have not been included in this review.

Under the Energy Act (2004) the NDA is required to promote and, where necessary, carry out research in relation to its primary function of decommissioning and clean up across the sites of its estate. Its R&D strategic objective is therefore to ensure that the delivery of its mission is technically underpinned by sufficient and appropriate R&D.

NDA's approach is that, where possible, R&D is undertaken by the Site Licence Companies (SLCs) who are under contract to the NDA to manage sites and deliver the remediation programmes. However, the nature of these contractual relationships is that the NDA ultimately still carries the major financial risk. Amongst NDA's top risks is that technical solutions adopted for key projects do not deliver the desired outcome, as has been experienced historically on a number of occasions. Where necessary, the NDA also carries out R&D under its own strategic R&D programme[2]. It also has in place a system to oversee the NDA estate's R&D programme to ensure, as far as possible, that the SLC programmes will successfully deliver the remediation[3] of the sites. This is the TBuRD process.

The total cost of the NDA's remediation programme is estimated to lie in the range of £95B to £218B. Research and Development is one key element in keeping the outturn to the lower end of this range, by ensuring that technological choices are appropriate and function as expected and also by introducing innovation to deliver at lower cost or to shortened timescale. The estimated cost of the currently envisaged R&D programme is some £800M over the next 20 years.

The importance of the TBuRD process is abundantly clear, given the scale of both the estimated remediation programme costs and the costs of R&D intended to underpin it. The Research Board (RB) first looked at this process during its meeting in April 2012. At its meeting in April 2015 the RB returned to the topic for a more in depth consideration, after a period in which the TBuRD process has been maturing. This current examination used its now standard approach of assessing the position against a set of five questions. For this topic these questions were:

[1] The technical baseline is the set of processes and associated technologies used or planned to be used to deliver the NDA mission of completing the remediation of the NDA's sites.

[2] This programme has three aims: informing strategy choices, innovation potentially impacting a number of sites and maintaining and/or developing technical skills.

[3] Remediation covers all activities necessary to achieve the desired site end state, hence, among other things, waste management, decommissioning, spent fuel management, management of special nuclear materials (uranium and plutonium etc.) and removal of ground contamination as necessary.

1. Is the approach soundly based?
2. Are the mechanisms for review adequate?
3. Is the Technical Baseline and underpinning R&D adequately communicated to stakeholders?
4. Is the process robust to future change?
5. Are there areas that members would like to investigate further?

This Position Paper reports the RB's conclusions and recommendations. It is based on the evidence presented to the Board and other information available up to the date of and shortly after its ninth meeting (14/04/2015); any more recent developments have not been included in this review.

2. The TBuRD Process

The requirement on SLCs is that they report against the requirements of the TBuRD process annually. The TBuRD is not a single document but rather a suite of documents submitted over any one particular year. These documents are:

1. Process Wiring Diagrams (Delivered in March).
2. The R&D Table (Delivered in March).
3. The Technology Map (Delivered in March).
4. The Annual Technical Report (Delivered in September, covering the previous financial year)
5. The Technical Management Summary (Delivered in September, if there is significant change from the position reported in the previous year).

Each of these is described in a little more detail below.

2.1 Process Wiring Diagrams

These are Site Licence Company and Site Level visual representations of the technical baseline. These should include:

- Tasks and processes and any interaction between them.
- Planned technologies against the process steps[4] but also including any contingency or alternative approaches.
- Technology Readiness Levels.
- R&D activities classified as to whether these are driven by needs, risks or opportunities.
- Links to the R&D Table.

Examples of Process Wiring Diagrams are presented in Appendix 1.

2.2 R&D Table

This is a spreadsheet summarising all R&D tasks. Its purpose is to demonstrate that the R&D activities required to support the SLC's lifetime plan (LTP) are being implemented on the required timescales and that innovative R&D activities are being initiated with a view to acceleration or cost reduction. The R&D table should include:

- The high-level scope (task title, overview of R&D requirement etc.) and key outputs.

[4] Guidance on process steps and their definitions is provided in EGG10, see section 2.6 later.

- Key start and “need by” dates.
- The project status (current and target TRL, whether on target etc.).
- Planned costs.
- Technical key words (to assist analysis of the total programme).

2.3 Technology Map

These maps provide a summary of the SLC technical baseline using a consistent structure upon which to organise a large volume of information. They summarise the overall SLC R&D and provide the starting point for further analysis. As necessary, they allow focus on areas of particular need or concern and provide the basis on which to conduct future “deep dives”, in depth examinations of particular areas or projects. The maps should show:

- The status of key process steps (e.g. for Integrated Waste Management a process step might be storage, pre-treatment, process treatment, product packaging etc.) against the NDA Strategic Themes (Spent Fuels, Nuclear Materials, Integrated Waste Management, and Site Restoration).
- Whether the task responds to a need, a risk or an opportunity and the scale of the risk or opportunity.

An example of a Technology Map is presented in Appendix 1.

2.4 Annual Technical Report

This report is a vehicle for presenting the SLC’s R&D activities over the financial year. It should include:

- Any changes to technical governance and assurance arrangements.
- Any changes to the technical baseline and reasons for the change in approach. Also a commentary on any new or deleted R&D tasks.
- R&D successes and challenges.
- R&D costs.

2.5 Technical Management Summary

The Technical Management Summary is a description of the technical governance and assurance arrangements, including document references. It should particularly highlight the following:

- A gated approach to project and expenditure sanctioning which specifically addresses technology and engineering aspects.

- Accountabilities, roles and responsibilities for technical assurance.
- A system for assessing technology maturity using Technology Readiness Levels[5] (TRLs, see Appendix 2 which has the NDA's definitions of the 9 TRL levels).
- A system for coding[6] all R&D activities in the Lifetime Plan[7] (LTP).
- Any additional processes that support the management of the R&D programme.

2.6 NDA TBuRD Guidance Document, EGG10

These above five outputs summate to a relatively complex suite of documents. In order to enable comparisons and "roll-up" to generate integrated information on the total NDA programme it is important that the documents are as consistent as possible in the detail of their presentation. The EGG10 guidance includes, inter alia:

- An example of a good practice wiring diagram.
- Definitions/descriptions of the strategic themes (Nuclear Materials, Spent Fuels, Integrated Waste Management, Site Restoration).
- A standardised list of process step descriptions (e.g. inventory and characteristics, pre-treatment, process treatment/conditioning, product/package etc.)
- A standardised list of descriptions for areas, groups and sub-groups for materials, wastes, plants and land (e.g. Wastes (area), Higher Activity Wastes (group), wet/potentially mobile ILW (sub-group)).
- A list of headers and content descriptions for the R&D Table.
- Definitions/descriptions of the nine Technology Readiness Levels.
- An example of a Technology Map and a set of definitions for the symbols and colours to be used in completing these maps.

EGG10 states that the overall objective of the TBuRD process is to provide transparency and visibility of the technical baseline for the SLC LTP and the accompanying R&D requirements intended to enable its successful delivery. Ensuring consistency enables the "roll up" to the overall NDA mission. This should serve the following purposes:

- Provide confidence in the technical deliverability of the SLC's plans.
- Provide overall visibility of R&D across the NDA estate to ensure that appropriate R&D is carried out in a timely manner.

[5] NDA has published a guide to how TRLs should be used, "Guide to Technology Readiness Levels for the NDA Estate and its Supply Chain", EDRMS ref: 22515717.
[6] Guidance on coding is provided in NDA document EGG10, see section 2.6 later.
[7] The Lifetime Plan (LTP) is the detailed and costed plan to take each site from its current condition to the desired end state.

- Identify where coordinated R&D programmes could result from common needs, risks and opportunities.
- Enable key R&D needs at NDA level to be identified, prioritised, costed and scheduled in the LTP's.

3. Continuous Improvement of the TBuRD Process

The TBuRD process has been in use in NDA since 2006, with a major revision in 2010. There have been two main routes by which the NDA checks the health of the process and seeks to continuously improve it. These are:

- A Nuclear Waste and Decommissioning Research Forum[8] (NWDRF) working group.
- Periodic independent external reviews.

3.1 NWDRF TBuRD Working Group

This NWDRF working group has membership from across the NDA sites and also includes UK nuclear industry non-NDA members from AWE and EDF Energy. UK nuclear regulators also regularly attend as observers. The key aims of the working group are stated as:

> *"To provide a forum for identifying good practice and improving the effectiveness, consistency and transparency of the TBuRD submissions. To use the available information to develop a Working Group Plan and where appropriate to implement solutions to improve the identification and prioritisation of R&D issues and opportunities."*

The mandate of the working group is to identify issues and opportunities with the TBuRD process and implement solutions, where possible, by:

- *"Sharing evidence and observations on the steps involved in producing TBuRD submissions;*
- *Analysing SLC TBuRD submissions, the TBuRD tools and guidance;*
- *Discussing issues and opportunities to make the TBuRD process more effective;*
- *Developing a Working Group Plan which clearly identifies specific deliverables and timelines,and following through on actions;*
- *Revision to NDA guidance (EGG10) where improvements have been identified;*
- *Providing progress updates to each NWDRF meeting including highlighting issues of strategic importance."*[9]

In its exploration of the TBuRD process, the RB took evidence from a co-chair of the working group to seek the view from the sites. The RB is aware that the resource necessary to complete the TBuRD requirements is significant. The RB wanted reassurance that sites saw this as more than a bureaucratic burden.

[8] Information on the NWRDF can be found on the NDA website (www.gov.uk/nda)
[9] Taken from NWDRF TBuRD Working Group - Terms of Reference, August 2015

It was clear that, at working level, there was a great deal of enthusiasm and support for the process. There are indications, however, that its value may not always be fully appreciated at the most senior levels in the SLCs. It is important that the NDA continues to keep in mind, with the assistance of the NWDRF Working Group, what is fit for purpose to meet its needs whilst appropriately minimising the demands on SLCs' resources. Lack of enthusiasm at more senior levels is probably because, for those sites where the Lifetime Plan is more straightforward, senior management regard execution of the plan as mostly an exercise in project management, with little need for R&D. While there was some integration with programme management, better TBuRD integration with SLC programme management processes could be of value.

Recommendation: The NDA should consider, with the assistance of the NWDRF TBuRD working group, how better TBuRD integration with existing programme management processes can be achieved.

The Board was also informed that the majority of the work was in setting up the reporting system for the various elements of the TBuRD process. Once this had been done the work to provide the annual updates was much less demanding. The RB learnt that DSRL had the most developed reporting system, which was seen as the exemplar of good practice. Not surprisingly, given the scale of its Lifetime Plan, Sellafield Ltd had the most difficulty in achieving consistency within its submission (see section 5 below).

Observation: The DSRL TBuRD process seems to be widely recognised as best in class. The Board encourages the work of the NWDRF working group in general and the adoption of best practice from the DSRL approach where possible.

The RB noted the good practice that, post-submission, SLC's conducted peer to peer reviews of each other's submissions. Feedback from the working group was also complimentary about the collaborative working between the NDA and the SLC's on developing the process and the smooth implementation of enhanced guidance because of prior consultation.

The Board noted especially that the non-NDA member organisations represented on this NWDRF working group had been sufficiently impressed by the system to adopt similar processes within their own organisations.

3.2 Independent External Reviews

The NDA has commissioned two external reviews of the TBuRD process, both by the consultancy Cogentus Consulting Ltd. The RB had reviewed the results of the earlier of these when it first explored the TBuRD process at its April 2012 meeting. The following is an extract from the Conclusions and Recommendations of the summary document of that external review:

> *"From a thorough review of a large number of published documents on R&D management and oversight, it is clear that the NDA TBuRD is an excellent methodology.*
>
> *It should be seen as best practice in that it:*
>
> - *Provides evidence based data for decision making and oversight of complex, inter-site R&D.*

- *Allows the NDA to understand what R&D is being undertaken across the estate and to know where the major areas of work are in order to prioritise R&D effort.*
- *Helps to identify potential synergies in order to save time and cost across the estate.*
- *There is not anything comparable in any of the US Agencies or in UK and EU public and private sectors."*

In its most recent (20th February 2015) summary report, Cogentus Consulting Ltd conclude:

> *"The review of the TBuRDs shows that all SLCs had good compliance with the requirements set out in EGG 10."*

And also:

> *"All SLCs could demonstrate that their Lifetime Plans were underpinned by sufficient and appropriate research and development."*

Hence the good news is that Cogentus Consulting Ltd conclude that, although there may be some difficulties with the detail of implementation of the requirements, the SLCs are, by and large, successfully managing an appropriate response and the process is delivering the TBuRD objective of underpinned LTPs. The detail of the report contains an evaluation of the SLC submissions which, together with the analysis in the earlier report, shows that the degree of compliance with the requirements of EGG 10 has been steadily improving (A view also expressed by the NWDRF working group). The report goes on to identify some general areas for improvement and, importantly, significant number of areas for potential collaboration.

Recommendation: The NWDRF TBuRD WG should be asked to review the suggested improvements and, where appropriate, include these in their forward programme.

Recommendation: The Cogentus Consulting Ltd assessment of areas of potential collaboration should be provided to the NWDRF technical working groups for their assessment of the priorities for collaboration and integration into their forward programmes.

Recommendation: A summary of the latest Cogentus Consulting Ltd review should be published. This should promote stakeholder confidence in the process and also allow the supply chain to contribute proposals in areas of R&D need.

4. Further developments

The Board was informed of two areas of further developments, the intentions to:

- Publish the NDA's Technical Baseline report.
- Investigate the development of and potential use for System Readiness Levels as a further supplement to TRLs.

These are further discussed below.

4.1 Technical Baseline Report

This is a document setting out at high level, but an appropriate level of detail, the management arrangements for the NDA estates R&D programme and the technologies and processes by which the NDA mission will be accomplished. The purposes of the publication are two-fold:

- To provide a vehicle to communicate the Technical Baseline to key stakeholder groups (government, regulators, the supply chain, academia and the public).
- To enable the supply chain to have good knowledge of the R&D needs and priorities, encouraging them to bring forward ideas for how they could contribute.

4.2 System Readiness Levels

The NDA makes effective use of TRLs in the TBuRD process. However, it notes in its document, Guide to Technology Readiness Levels for the NDA Estate and its Supply Chain, that TRLs relate to individual technologies/plant items. They do not indicate that individual plant items at appropriate TRLs can be integrated and will work together in an effective system. Clearly this is needed in a technically complex programme. The NDA is investigating System Readiness Levels (SRLs), which is a tool that may provide the necessary reassurance at system level.

Observations:

- The Board is very supportive of the production of the Technical Baseline Report. There is an excellent story to tell and the presentation should reflect this in the report and should be positive in tone.
- The Board is also supportive of:
    - The intent to investigate the development of SRLs,
    - The NDA's continuing efforts to survey the R&D management techniques used by other organisations, with the potential that they could be usefully incorporated into the process at some future date. Such investigations must obviously include consideration of the balance of cost and resource requirements against the benefits that could be delivered.

5. Discussion

It was clear from the Cogentus Consulting Ltd report and from the discussions held with the NWDRF working group co-chair that, understandably, Sellafield Ltd had the most difficulty in preparing the necessary responses to the TBuRD requirements. Further discussions were therefore held with appropriate representatives of Sellafield Ltd and with NDA staff. In this discussion section the Sellafield Ltd issues are addressed first, before moving to some more general observations arising from the Cogentus Consulting Ltd analyses.

The Sellafield difficulties stem largely from the scale and complexity of the work on the site. For example, the second most demanding site, Dounreay, has only about 150 lines of entry on its R&D Table, whereas that for Sellafield approaches 1000 lines. The top five programme areas for Sellafield are each larger than that for the total Dounreay programme. Of the approximately £800M to be spent on R&D over the next 20 years, over 90% will be spent on Sellafield issues. This scale has led to consistency difficulties across the site, with each project area doing things somewhat differently; there were also difficulties with the quality of the data entries, but with 30,000 entries this is not easy. In addition, in NDA's opinion, the Process Wiring Diagrams have not been adequate. From NDA's perspective this leaves them in a position where both the overall approach adopted by the site and the current status of technical underpinning is unclear and there is uncertainty as to whether all the technical needs have been identified.

From Sellafield's perspective, one major difficulty has been that in one area in particular the site overall approach has not been settled, and the Technical Baseline changes as the site programme changes. The Sellafield view is that the TBuRD process cannot easily cope with this; the NDA view is that, while to include options on one process wiring diagram makes it very unwieldy, this could be accommodated by a separate process wiring diagram for each approach. A further Sellafield concern was that TBuRD does not give a visual time based programme[10]; Sellafield felt the need for technology roadmaps as a supplement to the TBuRD process.

For Sellafield Ltd, the resources needed to respond to the TBuRD requirements were significant, of the order of £400,000. However, given the size of the Sellafield R&D programme at approximately £85M/annum it did not consider this unreasonable (~0.5%) to manage such a large programme. Sellafield would like to see better integration of the overall process with the programme management tools. It did not see the value of the Technology Map. NDA accepts that the Technology Maps are of more value to itself than to the individual sites, as they bring together the overall position across the many sites and they value them as a tool for communicating with external stakeholders.

Recommendation: The NDA should explore the need for and benefit from adding Technology Road Maps to the TBuRD process. It may be that they are only a necessary addition for a complex site such as Sellafield.

[10] While start dates and need by dates are included in the R&D Table, Sellafield Ltd feel more than this is needed.

Recommendation: For the process and the Technology Maps in particular to be of real value it may be necessary to provide even more guidance in EGG10 or supplementary documents on how to judge the entries, with a finer level of detail and examples. Unless the entries are on a consistent basis, the overall picture will be blurred or lost. Adding such additional detail must, of course, be balanced against the need for the guide to be pragmatic and fit for purpose.

Recommendation: NDA should review the value of the Technology Maps to itself and the sites/SLCs. If this is confirmed it should engage with the sites/SLCs to persuade them of the benefit so as to encourage a quality return.

In general there was an impression that this SLC, in addition to the difficulties in providing the quality of the returns required, had historically been unconvinced of the value of the overall process. However, much of the hard work had been done in setting up its TBuRD systems and it now had an improvement programme. The NDA and site teams continue to work constructively together to improve the submissions and the value of the outcome and the Research Board encourages this to continue. It seems to the Research Board that it is surely for a site of this complexity with by far the biggest remediation expenditure, representing 90% of the R&D spend in the next two decades and where the overall direction has yet to be settled, that TBuRD should bring the most benefits.

Observation: As the most complex and difficult site, it is important that the TBuRD process delivers the maximum benefit possible to the Sellafield programme. The Board encourages the NDA and site teams to continue their work together to realise this objective.

Moving on to more the more general messages coming from the two Cogentus Consulting Ltd reports , the RB previously observed from the first of these that the percentage of R&D related to opportunities was relatively low at approximately 15% and that directed at resolution or amelioration of risks was also low, at 16%. The RB made recommendations at that time that these low percentages be investigated. In the latest Cogentus Consulting Ltd report, 3 years later, these percentages have dropped to 12.5% for opportunities and 8% for risks[11]. While it is to be expected that, over time, these percentages will fall as programmes become more certain, the RB is concerned that these shares of the overall programme may still be too low. It reiterates here its earlier note and recommendations, quoted directly from the FY2012/13 Research Board Annual Report.

> *"Noting that the percentage of R&D related to opportunities is relatively low (~15%)[12] the Board recommends the NDA consider whether there is more that can be done to identify additional opportunity related R&D.*
>
> ***Recommendation:** In this respect, the Board recommends an analysis of NDA's liability costs against technical areas. Opportunity related R&D could then be directed at those technical areas that consume the greatest cost.*

[11] See Figure 8 of the February 2015 Cogentus Consulting Ltd report.
[12] 12.5% in the February 2015 Cogentus Consulting Ltd report.

Recommendation: *The Board also noted that some 16%[13] of R&D was directed at resolution or amelioration of risks, but that almost all of this was directed at issues on the Sellafield site. The Board recommends:*

a. *A review of risks related to liability issues at other sites to ensure that relevant R&D is not being missed.*

b. *Consideration of how more could be done to link risks with the R&D programme."*

The Board consider these earlier recommendations remain valid, but the first of these has caused some misunderstanding. In order to clarify the issue, the Recommendation is reworded here:

Reworded Recommendation: In this respect, the Board recommends an analysis of the NDA's total liability costs against technical activities (e.g. sludge retrieval, sludge packaging, contaminated concrete removal etc.). Opportunity related R&D could then be directed at those technical activities that consume greatest cost in a search for improved or innovative techniques.

The EGG10 standardised list of process steps could provide the starting point for the cost breakdown structure envisaged against technical activities. The Board recognises, however, that this is not an easy task.

From the Cogentus Consulting Ltd analyses[14], in 2012 the peak of the R&D expenditure was at 2013, falling away rapidly after this. The 2015 report shows the peak of expenditure in 2018, again falling away beyond that date. Similarly, in the 2012 analysis there was a large number of tasks of low TRL that were needed to be completed by 2013. In 2015 there is now are a large number of low TRL tasks needing completion by 2017. As Cogentus Consulting Ltd said in the earlier report,

> *"The … graphs may well demonstrate the classic "bow-wave" effect where the new starts and expenditure profiles simply move to the right as every year brings into focus more immediate activities. This has implications for the R&D programme … but also for the site Lifetime Plans since the target date is driven by those requirements. Any drifting of these programmes could well adversely affect delivery of the lifetime plans."*

Recommendation: The NDA should examine the causes of this "bow-wave" drift with a view to understanding, if any, what actions should be taken and the impact on the Lifetime Plans.

The Board also notes that recent contracts awarded to SLCs are target cost based with gain/pain share provisions. This may emphasise the project management delivery, SLCs preferring to stick with known technologies rather than investing in R&D to look for innovative solutions. This may, in part, explain the apparently significant reduction in opportunity related R&D over a three year period.

[13] 8% in the February 2015 Cogentus Consulting Ltd report.
[14] The 2012 report uses 2011 TBuRD data, the 2015 report 2014 TBuRD data.

6. The Five Questions

Returning to the five questions set out in section 1, the Board has concluded the following.

Question 1: Is the approach soundly based?

The development of the TBuRD process started in 2006 and it was subjected to a major revision in 2010. In 2011 the process was reviewed by an independent external consultant organisation under contract to the NDA to compare it against similar processes used by other organisations, as discussed in section 3.2 above. They concluded, *"From a thorough review of a large number of published documents on R&D management and oversight, it is clear that the NDA TBuRD is an excellent methodology"*, that there was no parallel elsewhere and that it should be seen as best practice.

Since that time the process has been updated on an annual basis using the NWDRF TBuRD working group as the discussion forum for any changes. This arrangement is continuing with a visible forward programme. The Board has been impressed by the close and cooperative relationship between the NDA and other members of this working group. Also that other outside members of the group, not directly related to the NDA estate, have chosen to adopt a similar process for their own organisations.

The Board also notes and supports the use of TRLs as an integral part of the process and that the NDA is continuing to strengthen their use across the NDA estate. It commends the NDA for issuing its own guidance on the use of TRLs to facilitate consistent use.

Research Board Position: The Board concludes that the approach is soundly based.

Question 2: Are the mechanisms for review adequate?

The NDA has arranged for periodic independent external review of the process, comparing the approach to those used by other organisations, analysing the returns and making recommendations for further improvements. The Board also notes that NDA continues to investigate technology management tools in use outside of the nuclear industry for possible adoption as part of the process of continuous improvement.

The process has also been updated on an annual basis using the NWDRF TBuRD working group as the discussion forum for any changes. SLCs are encouraged to suggest how the TBuRD process could be simplified whilst still meeting the objective of supporting the NDA in ensuring that the NDA mission is underpinned by sufficient and appropriate R&D. Any recommended changes in the process are reviewed by the NDA Technical Assurance Manager and require approval by the NDA Head of Technology before implementation.

TBuRD submissions are reviewed by the SLCs prior to submission to NDA and SLCs must demonstrate that they have been approved by appropriate members of the SLC's team. Via the NWDRF working group, SLCs also have an arrangement of peer to peer reviews of each other's submissions.

Research Board Position: The Board compliments the NDA for its arrangements for continuous improvement of the TBuRD process and the NWDRF for its own positive contribution to this. The Board concludes that the NDA's mechanisms for review of the process are excellent.

Question 3: Is the Technical Baseline and underpinning R&D adequately communicated to stakeholders?

Some SLCs have published their TBuRD submissions on a regular basis. Previous versions of the NDA TBuRD requirements document EGG10 did not ask SLCs to do this, but the latest version does now require this, subject to security and commercial considerations (i.e. a redacted version may be necessary). In the case of Sellafield, for security reasons and, as discussed above, because the submission is so large, a summary version may be all that it is reasonable to publish. In addition all SLCs publish news articles on their technical programme on a regular basis.

NDA has published on its website the earlier Cogentus Consulting Ltd independent review of the TBuRD process. In section 3.2 above, the Board has recommended that a summary of the latest Cogentus Consulting Ltd independent review should also be published. The 2015 report includes an analysis of the common issues across the estate, allowing the supply chain a view of where they might be able to offer an innovative contribution.

Again, as discussed above, the NDA is preparing a "NDA Technical Baseline" report, a draft version of which has been discussed with Research Board. The document aims to communicate, at a high level, the process and technologies that are planned to be used to deliver the NDA mission.

Research Board Position: The Board concludes that the TBuRD process and its outcome are adequately communicated and the future publication of the Technical Baseline report will enhance this position.

Question 4: Is the process robust to future change?

The close working relationship with the NWDRF Working Group gives confidence that this is the case. The working group have prepared a detailed two year forward programme which includes, inter alia, reviewing the process, peer-review of SLC submissions and identifying best practice with regard to technical governance and assurance.

The periodic external reviews are also a good practice that the Board commends and which should enable awareness of developments elsewhere.

Research Board Position: The Board concludes that the process is robust to future change.

Question 5: Are there areas where members would like further investigation?

Research Board Position:

The Board:

- Supports the NDA intention to explore the value of System Readiness Levels as to whether they can be a useful addition to the process and commends the NDA's continuing surveillance of the R&D management approaches used by others.
- Would like to see the NDA explore the possibility for better integration of the TBuRD process with other programme management tools.
- Would like an exploration of the need for and benefit from including Technology Roadmaps in the process, possibly just for the more complex sites.

- Would like to see a follow up to its earlier recommendations on opportunities and risks.

7. Short Summary of Conclusions

The Reader is asked to note that this Position Paper is based on information provided to the independent Research Board up to the date of and shortly after its meeting in April 2015. Any developments after that period are not part of the considerations presented here. The Board has reviewed the NDA's Technical Baseline and Underpinning Research and Developments (TBuRD) process, which the NDA uses to manage the R&D across its estate. The Board has reviewed this process against a set of questions and these and a summary of its conclusions are set out below. The Reader is directed to the main text for more detail and for the associated observations and recommendations.

The Board's overall observation is that the TBuRD process is a commendable success. The external reviews show it to be best in class and that the degree of compliance by the SLCs with its requirements has been steadily improving. The NDA and the NWDRF working group continue to develop the process in an effort to maintain its preeminent positon and ensure that it is fit for purpose, delivering the intended benefits at an appropriate cost.

Question 1: Is the approach soundly based?

In 2011 the process was reviewed by an independent external consultant organisation under contract to the NDA to compare it against similar processes used by other organisation. This independent external review concluded, "*From a thorough review of a large number of published documents on R&D management and oversight, it is clear that the NDA TBuRD is an excellent methodology"*, that there was no parallel elsewhere and that it should be seen as best practice.

Since that time the process has been updated on an annual basis using the NWDRF TBuRD working group as the discussion forum for any changes.

Research Board Position: The Board is therefore of the opinion that the approach is soundly based.

Question 2: Are the mechanisms for review adequate?

The NDA has arranged for periodic independent external review of the process, comparing the approach to those used by other organisations, analysing the returns and making recommendations for further improvements. The Board also notes that NDA continues to investigate technology management tools in use outside of the nuclear industry for possible adoption as part of the process of continuous improvement.

The process has also been updated on an annual basis using the NWDRF TBuRD working group as the discussion forum for any changes.

Research Board Position: The Board therefore concludes that the NDA's mechanisms for review of the process are excellent.

Question 3: Is the Technical Baseline and underpinning adequately communicated to stakeholders?

Some SLCs have published their TBuRD submissions on a regular basis and all are now required to do so. NDA has published on its website the earlier Cogentus Consulting Ltd independent review of the TBuRD process. In section 3.2 above, the Board has

recommended that a summary of the latest Cogentus Consulting Ltd independent review should also be published. The NDA is also preparing an "NDA Technical Baseline" report which aims to communicate, at a high level, the processes and technologies that are planned to be used to deliver the NDA mission.

Research Board Position: The Board concludes that the TBuRD process and its outcome are adequately communicated and the future publication of the Technical Baseline report will enhance this position.

Question 4: Is the process robust to future change?

The close working relationship with the NWDRF Working Group gives confidence that this is the case. The periodic external reviews are also a good practice that the Board commends and which should enable awareness of developments elsewhere.

Research Board Position: The Board concludes that the process is robust to future change.

Question 5: Are there areas where members would like further investigation?

Research Board Position:

The Board:

- Supports the NDA intention to explore the value of System Readiness Levels as to whether they can be a useful addition to the process.
- Would like to see the NDA explore the possibility for better integration of the TBuRD process with other programme management tools.
- Would like an exploration of the need for and benefit from including Technology Road Maps in the process, possibly just for the more complex sites.
- Would like to see a follow up to its earlier recommendations on opportunities and risks.

Appendix 1: Examples of Process Wiring Diagrams and a Technology Map

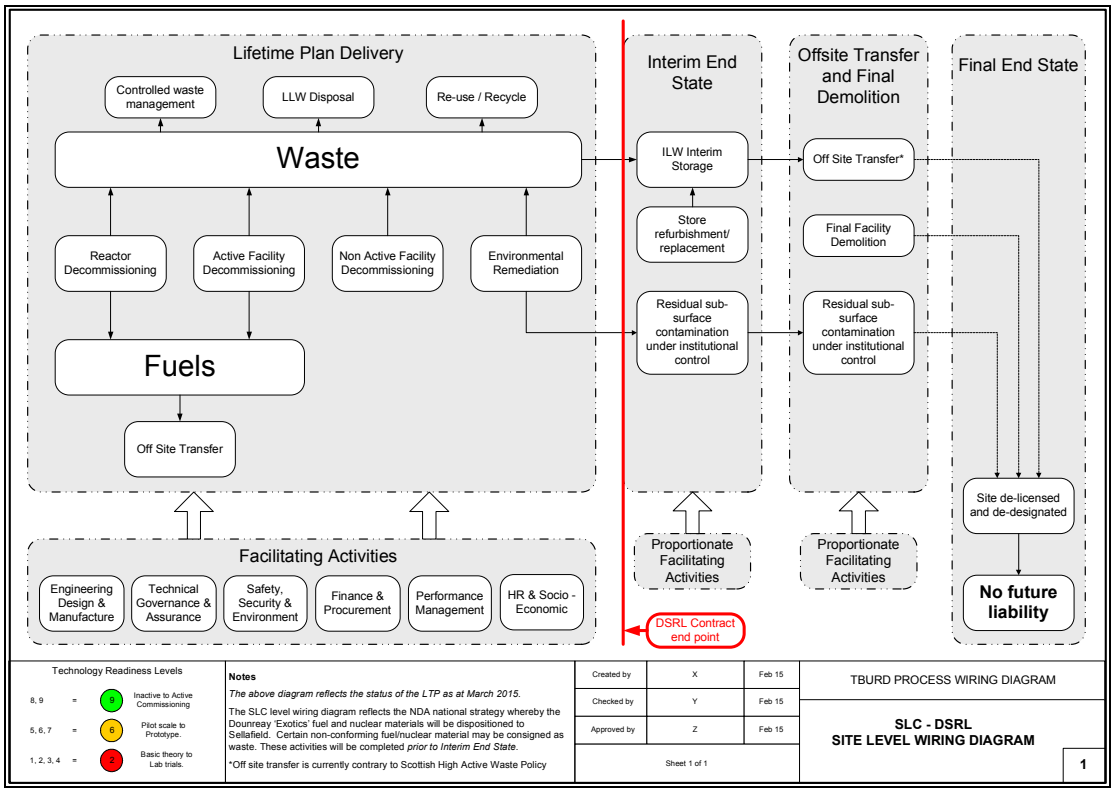

Figure 1: Site Level Process Wiring Diagrame for DSRL

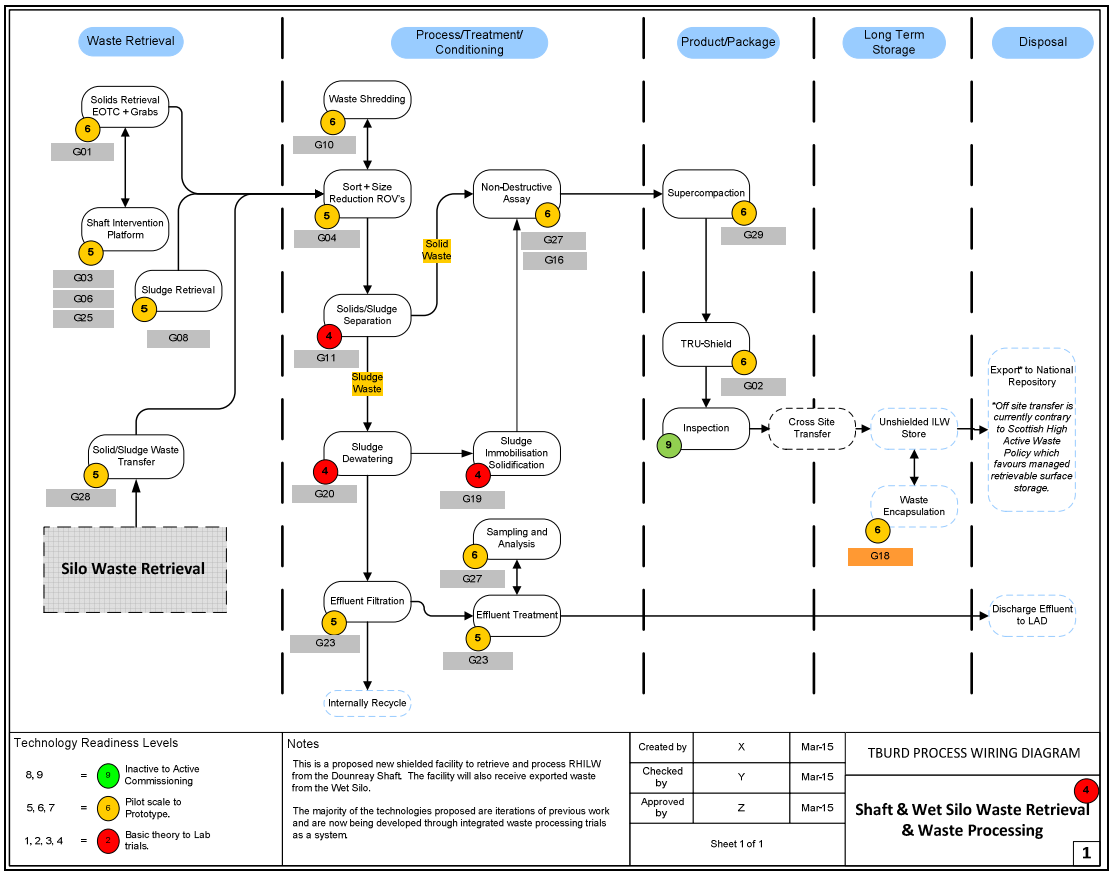

Figure 2: Example of a DSRL Process Wiring Diagram

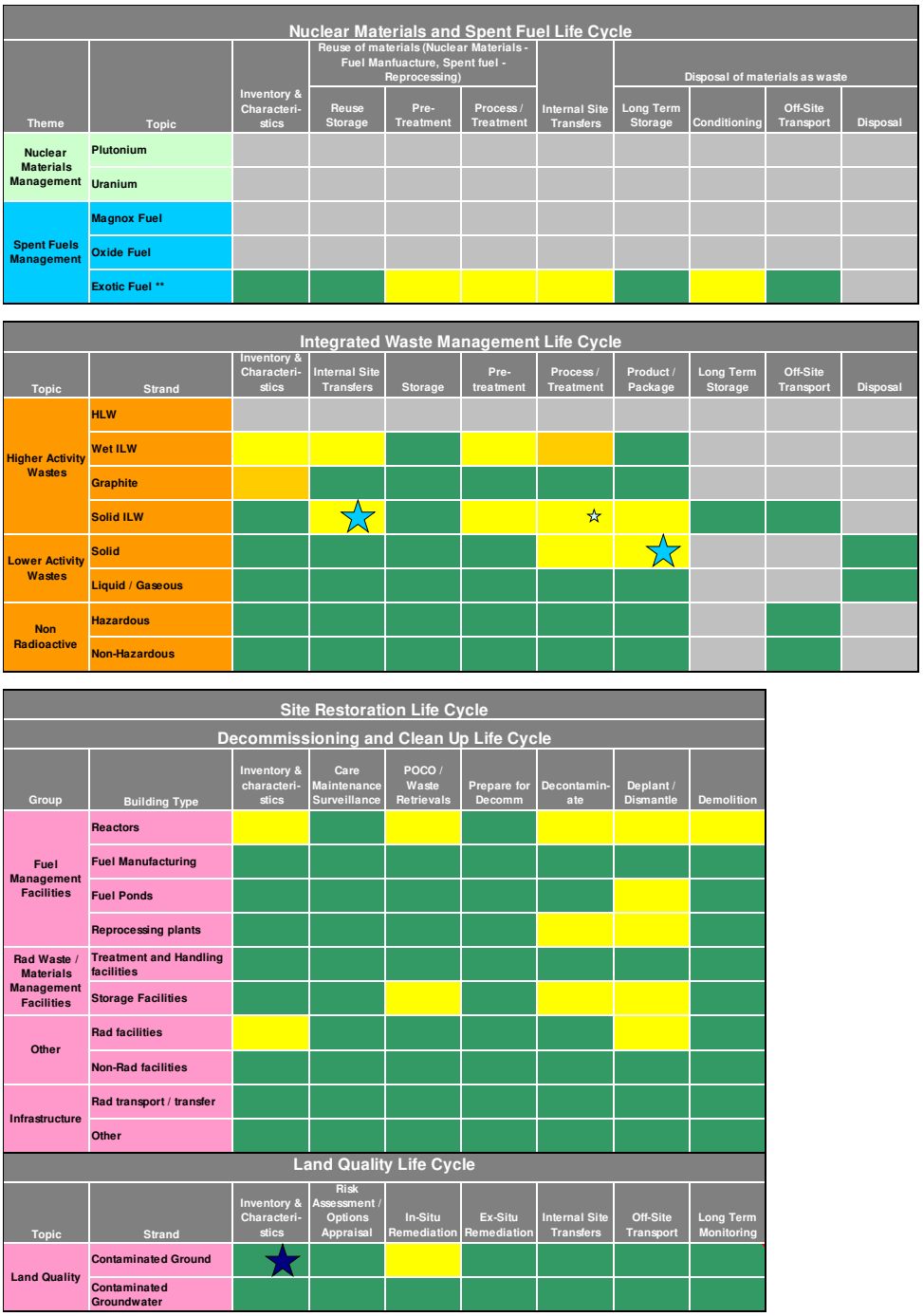

Figure 3: DSRL Technology Map

Appendix 2: Technology Reference Levels

NASA developed Technology Reference Levels (TRLs) in the early 1970s as a means of addressing whether emerging technology was suitable for space exploration. By the 1980s it was in use across many US Government agencies, including the Department of Defense and the Department of Energy. The use of TRLs has spread and they are now in common use in the UK, including by the NDA.

In order to use TRLs on a consistent basis across the NDA's sites, EGG 10 (Technical Baseline and underpinning Research and Development (TBuRD) Requirements) contains guidance in its Appendix 2. In order to assist the reader in understanding the TBuRD process, Table 4 (Technology Readiness Level Scale) from EGG 10 is reproduced here. NDA's guidance on the use of TRLs is further expanded in the NDA document "Guide to Technology Readiness Levels for the NDA Estate and its Supply Chain".

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
System Operations	TRL 9	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	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

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
		relevant environment	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	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.
Basic Technology Research	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.

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
	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.