ISOLUS TECHNICAL OPTIONS STUDY

Independent Peer Review Report

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Table of contents

Definition of acronyms

AGR	Advanced Gas-cooled Reactor
ALARP	As Low As Reasonably Practicable
ALARA	As Low As Reasonably Achievable
CIOP	Consultation on Outline Proposals
DTi	Department for Trade and industry
HPA	Health Protection Agency
IPR	Independent Peer Reviewer
ISOLUS	Intermediate Storage of Laid-Up Submarines
LMU	Liabilities Management Unit
NDA	Nuclear Decommissioning Authority
NII	Nuclear Installations Inspectorate
NSAN	National Skills Academy for Nuclear
OECD	Organisation for Economic Co-operation and Development
RC	Reactor Compartment
RPV	Reactor Pressure Vessel
SCC	Sector Skills Council

1. Introduction

This document is the Independent Peer Review report on the ISOLUS Technical Options Study. It has been prepared at the request of the Ministry of Defence for the ISOLUS Project Team and is the result of the Independent Reviewer (Professor Malcolm Joyce) observing the Technical Options Study in process, including attendance at both workshops 1 & 2 and via consideration of both the Data Report and the Technical Options report. On no occasion did the Independent Peer Reviewer contribute to the discussion of either workshop nor the content of the associated documents, save for a minor point of clarification early in the discussion at the first workshop.

The structure of this document is as follows:

- The process is described and any comments arising from the observation of the process.
- The quality and content of the workshops.
- The quality and content of the Data Report.
- The quality and content of the Options Report.
- Conclusions of the Independent Peer Review report.

2. Declaration

The information contained in this report represents the opinions and perceptions of the author, based on their experience and considered expertise in this field, but not those of any organisation by which they may be otherwise gainfully employed or could be deemed to represent.

3. The Process

The process as summarised in each of the reports associated with the ISOLUS Technical Options Study and described in the Methodology Report was followed throughout. There were some minor deviations from the original plan, as follows:

- Early in the first workshop stakeholders expressed an unease with the prospect of weighting attributes in a strictly quantified way. This was discussed both at the meeting and in between the workshops and the more qualitative approach was adopted as is described in an associated note and used in the Options Report.
- One of the stakeholders expressed concern about the ability to represent the public so long after the last consultation on this issue was carried out, and this was accepted by the ISOLUS Project Team.
- The timescale slipped slightly, largely as a result of the summer period and the need to extend the duration of the second workshop to two days.

This flexibility has not appeared to have adversely affected the outcomes from the study and was managed in an effective and expedient way by the facilitators.

4. The quality and content of the workshops

4.1 General comments

The overall quality and content of the workshops was very high. The facilitation of the workshops was flexible, coordinating, unbiased and professional. Considering the extent and breadth of backgrounds of the stakeholders and the project team as a whole present at the meeting, and distances and conflicting diary commitments of the many people associated with this programme, the workshop sessions proceeded without major difficulty. Furthermore, the representation present at the second workshop was largely consistent with that at the first, excepting that the NDA could

not make the second workshop and that the HPA were not present at the first. It is highly unlikely that greater consistency could have been achieved across the ~25 representatives present at the workshops. An endpoint is essential in an exercise such as this and thus the improvisation in scope (and specifically with regard to weighting) was both necessary and defensible.

When it became apparent that the second workshop would benefit from being run over two days as opposed to one as previously planned, this was implemented effectively and the schedule did not slip outrageously, especially since much of the planning of this occurred over the summer period. Furthermore, as there was not time for two of the attributes to be considered fully at the second workshop (security and intergenerational endowment) it is clear that the extra time was both necessary and its use had been worthwhile. The workshops were administered in a flexible but guided way that maintained the schedule and ensured that, whilst some flexibility was available in the approach to considering the options, a comprehensive review was achieved.

4.2 Specific observations of the workshops by the IPR

On several occasions during both workshops, a tendency to treat radiological and non-radiological safety issues differently became apparent. The discussion on radiological issues appeared to engender a greater degree of respect and involvement from stakeholders than that on non-radiological safety. Whilst much historical experience suggests that immediate risks to workers associated with non-radiological hazards are greater than radiological hazards, the latter sustained greater discussion at the workshops. Furthermore, it is likely that more quantitative data exists on the radiological hazards associated with the various options than non-radiological hazards. Less time was needed to debate the implications of each option regarding non-radiological risks to workers at the second workshop, despite the risk of injuries arising from non-radiological hazards being widely-accepted as higher in the nuclear industry.

Stakeholders frequently mentioned the findings of several, published epidemiological studies during both workshops. It would have been useful to have had these made available to all at the second workshop, as it was not clear whether they were deemed relevant or otherwise to the Options Study; neither was it clear whether everyone at the workshops was familiar with these studies.

Significant debate ensued at the workshops relating to the benefits of delaying action in order to exploit the potential benefits of technological advances. This is described further in reference to ‘future flexibility’. The debate omitted important issues associated with the nature of what drives technological development i.e. significant consumer/sociological need and investment, and as to whether ISOLUS is likely to be a catalyst for such development. Conversely, the inevitable decay in both the submarines’ physical state and that of the associated knowledge base will be a casualty if delays were to be an implicit part of the chosen option. This could complicate the decommissioning task significantly, as has been that case in several areas on land-based decommissioning projects.

The skills issue arose on several occasions and exposed a lack of expertise at the workshop, in spite of the significant developments that have attempted to quantify this concern in the nuclear sector in this area over the last 8 years. It was surprising that specific representation from NSAN, the SCC or academia was not sought to represent and inform this aspect of the debate.

With hindsight it was a pity that the debate surrounding intergenerational endowment was cut short by the end of the second workshop, and by the need for several stakeholders to leave to make transport connections. This debate was short and

succinct but did not appear to have sufficient time to mature, and was certainly not afforded as much time as, for example, radiological safety issues despite the implications associated with it being arguably as significant. It was surprising that RC storage was highlighted by stakeholders as the most appealing option with regard to intergenerational endowment, since it 'closed off the least number of options to future generations'. An alternative perspective that was not considered is that the responsibilities of the current generation are being delegated to the next generation instead of grasping the opportunity ourselves, as had been expressed in the Data Report and the CIOP before it.

5. The Data Report

5.1 General comments

It is important to view the content of the Data Report in the context of there being little if any practical experience in the complete dismantling of reactor plant from submarines. Whilst submarines have been tackled in other countries, these projects have been almost entirely limited to the RC being cut out and stored (Option 1). Therefore the majority of the data referenced in the Data Report has arisen from detailed proposals by contractors, literature searches of similar activities on similar land-based reactor plant and modelling activities. There are clearly discrepancies in the detailed designs of the plant across all of these approaches and these need to be borne in mind. However, the operating circumstances i.e. length of service, refit schedules etc. of all the submarines in question will be well-known, which should mitigate against significant surprises, especially with regard to radiological inventory and arisings. Furthermore, the processes and methodology used to dismantle the plant are likely to bear some similarity.

The Data Report prepared for the ISOLUS Technical Options Study represents quite an achievement in that it contextualises a great deal of information from a diverse array of sources and aligns this against each of the attributes. Also, it was prepared in a relatively short space of time following the agreement of the attributes in July 2008. That notwithstanding, the period of time afforded between its publication and the Options workshop was a cause for concern raised by several stakeholders, and it was apparent that some had not sufficient time to digest it in its entirety. This was exacerbated by the desire for many to read the numerous accompanying references, and there clearly had not been sufficient time for that. With the benefit of hindsight, had a more discursive style been adopted in the Data Report to provide a précis of the references' findings, then it might have better received. It is worth emphasising that this need not have constituted an *analysis* but merely needed to assist with the assimilation of the data at the subsequent workshop. However, this may have resulted in further delay to the programme. In conclusion, a satisfactory compromise was sought, especially since it is unusual for a reader of a technical document to expect to review all of the references as well.

5.2 Detailed comments

Flexibility

It is noted that even at the time of the CIOP the issue with regard to the approval of the RC as a valid transit and storage container was highlighted (page 18, para 2), which supports Recommendation 3 in the Options report (see section 6.6 below).

Skill set

The reference to skills and the potential hiatus with regard to Options 2 and 3 (page 19, para. 5) was reflected in the debate on this issue at the workshops and in the Options Report (see below). However, this reference omits the need to consider the

training of the trainers which is currently an important strategic goal of NSAN and the SSC, for example. Also, there may be value in considering some further scenarios in light of the effects of the current recession and the anticipated drop in the number of young people entering specialist education over the next 20 years, resulting from the imminent decline of this age-group in the national population.

Safety of the public (routine operation – radioactive discharge)

This aspect of the Data Report, and others which refer to radioactive exposure, appear inconsistent in their reference to 'dose': at times it has to be assumed that the exposure is *dose equivalent* but this is not at all obvious. Elsewhere (page 28, para.1 & 3) the exposure used appears to be a *dose rate* but again this is not clear.

The concern expressed in the FEC of dose limits being too high seems at odds with the safety culture of the nuclear industry, where dose limits are *not* a guide for safe working but rather ALARA is, at doses well below any limit, and is enforced by UK law. It is important to bear in mind that different approaches to dose management have been used in other countries, should examples of decommissioning activities in France and the US be used as comparisons in future.

Intergenerational endowment

The CIOP and the FEC are in apparent contradiction over this issue (page 30, para. 4 & 5), and this contradiction was sustained at the Options workshop (see below) despite there being little time to debate it fully. The FEC (or at least its summary in the Data Report) then appears to contradict itself noting the 'responsibility to act now', and the relevance of the skills issue. There also appears to be a conflict with 'compliance with policy' on this issue, in the government's acceptance of recommendation 2, 'to make wastes as passively safe as soon as possible'.

Radioactive waste

This section (page 38, para. 2 onwards) highlights the potential value of a study to provide greater technical clarity as to, for example, the radioactive inventory arising from each of the three options. Indeed, Figure 3.25 (page 40) is an example of data that could be improved by such a study; the accuracy and precision of this data in its current form, as given in the Data Report, are not immediately apparent. However, some concepts such as the unlikely prospect of ILW decaying to LLW should be taken at face value; the gulf between these classifications and the contrast in radioactive inventory usually renders this to be the case.

6. The Options Report

6.1 General comments

The Options Report represents a concise and accurate description of what was discussed, debated and recommended at the second workshop. Specific comments regarding this discussion, the options scoring, the options review and its recommendations as described in the report, follows.

6.2 The options discussion

The discussion described in the Options Report is largely without issue except for the following points that the IPR wishes to highlight:

Cost and cost profile

The issue associated with a potential contractor having a preference for the option with increased upfront cost (page 16, para. 2) assumes two issues: The first assumption is that there is widespread choice in terms of a contractor 'skilled and

suitably qualified' who might be selected to carry out this work. Given the skills issues in the nuclear sector highlighted in numerous reports since 2000, it is likely there will be a small number of companies suited to the ISOLUS tasks, drawing on a limited contracting pool of expertise. Their specific experience in areas of relevance to the options may need to be borne in mind in future. This issue also assumes that the contractor has no implicit, relevant experience that might influence options' choice where in reality they may, by way of detailed project management planning of a given option, identify pitfalls of options that may have escaped the ISOLUS Project Team. This is an unlikely prospect but not an impossible one.

Facilities and skills: skillset

The issue raised regarding skills and jobs in the nuclear sector (page 18, para. 6) is of great significance since, not only was it the subject of a DTi (at the time) report but also the subject of an earlier report by the OECD commissioned by the NII. The time is ripe for an update to these reports in light of the likely impact of new nuclear build. In isolation of such an update, there are clear implications for skills in the nuclear sector, further to these reports, due to the ongoing decommissioning programmes stimulated by the NDA and the support requirements of the existing nuclear power fleet, especially regarding for example boiler maintenance on the AGR plant.

Whilst it was expressed several times during the workshops that the specific skills associated with the ISOLUS Technical Options are not profoundly different from that required to decommission any large process plant, the key skills that will be in short supply, certainly as per the findings of these earlier skills studies, are those associated with engineering project management, safety assessment, safety case preparation and radiological protection. Whilst it is very important to benefit from the experience of those doing similar jobs today (page 18, para. 7), it is also important to bear in mind the impact of widespread contractorisation, the ageing workforce and retirement of people in key skills areas and the timescale issues associated with integrating such people into the training sector. For example, this might be achieved via closer association with training organisations and public sector colleges.

Also in this section, the first reference to several aspects of discussion is given associated with the benefits of future technologies and developments in expertise (page 19, para. 2), also discussed in the section on 'The future – flexibility'. This is a common theme in many debates about 'difficult' challenges that would appear to benefit from future discoveries and developments. However, a degree of caution is necessary in this area: Firstly, many significant technological achievements have been the result of a perceived commercial need and significant investment has often been made in order to get technology to a level of maturity at which it can be used, such as the advent of the PC. By comparison, such developments rarely happen by way of the pure research and development programmes of industry and the university sector. Secondly, during the period that work is delayed by the prospect of future developments, the submarines' infrastructure will degrade further possibly exacerbating the problem from that of its current state; this is a common thread of many legacy issues in the nuclear power industry. Thirdly, during this period much of the existing expertise and knowledge base will retire and/or will die. Finally, on several occasions during the second workshop, the view was expressed that none of the options presented challenges that were sufficiently complex as to rely on the prospects of future research particularly heavily. Conversely, it is clear that to wait introduces several other areas of complexity and uncertainty.

The future – flexibility

In addition to the comments in the paragraph above, it is important to clarify some of the implications of the supporting discussion in the context of this attribute. First of

all, the potential for human ingenuity to be able to unravel the consequences of any decision made now, in the future (page 44, para. 2) may prove feasible if unlikely. However, such *unravelling* is unlikely to be easy – just the shear energy requirements of reversing the consequences of modern immobilisation processes could be very significant. It would appear wise to at least assume that the options under discussion represent end-points in terms of mid-term likely reversibility.

Occasionally during the discussion and in the Options Report, reference is made to the construction industry and its safety record. This was a common theme of debate during the early stages of the formation of the NDA from the LMU, for example, and concerns continue as to the integration of the cultures of nuclear safety and construction safety in these programmes. However, with regard to ISOLUS, the process at hand is a much more localised and generic dismantling of process plant where the design is known and understood, as opposed to the demolition of civil structures with incomplete historical records. Furthermore, since this debate began in the late 1990's, a decommissioning sector of its own has started to evolve incorporating specialist demolition contractors where appropriate, and an assumption on the latter's merits or otherwise in terms of safety culture being the same as the construction sector may no longer be accurate. It might perhaps be better to consider the decommissioning/demolition sector itself and perhaps consider the merits of the experience of existing teams stimulated by the nuclear decommissioning projects, amongst other non-nuclear decommissioning activities.

6.3 Review of options scores

Interpretation of the options scores

It is clear that the data indicate RPV storage should not be pursued further, as confirmed in the report (page 48, para. 2). Given the spectrum of debate during the workshops and the decision not to score the options on a quantitative basis, this is an entirely satisfactory outcome, demonstrating progress in the ISOLUS approach to dealing with this problem. It also demonstrates the merits of the methodology adopted for the Technical Options study.

Workshop observations

It is noted that the Options Report's account of Frazer-Nash experience of these activities reflects that stakeholders' views were rarely if ever influenced by the discussion and debate that took place during the workshops. The IPR concurs with this observation; examples of where it was particularly evident were with regard to the data and the clarification by experts as to assumptions about the ease and experience held with regard to some of the tasks under discussion. This did not undermine the effectiveness of the workshops as a whole but is somewhat surprising: if it is not possible to learn from each other in the context of a gathering of so much stakeholder experience, and be prepared to have our preconceptions changed, a significant potential benefit of such gatherings is lost.

In the context of this issue being symptomatic of stakeholders being uncomfortable making decisions on imperfect data, again, the IPR concurs with this impression. The implications of this preference are significant: whilst more detail will undoubtedly arise during the course of further study and exploration of the options, it will always be necessary to make judgements on what might be perceived as *imperfect* (or more accurately perhaps *incomplete*) information. Whilst more data becomes available over time, there is also the risk that existing knowledge is lost (via the issues described under *future flexibility*). Hence, the completeness or otherwise of data and knowledge is a dynamic issue. It is dependent on the thoroughness of our current understanding, the loss of understanding through skillbase issues and complications

that arise with time as the issues at the focus of the ISOLUS study change with age. Whilst greater clarification of ISOLUS processes will arise it is very unlikely that a sufficiently complete picture will develop to satisfy all stakeholders.

6.4 Points of accuracy

Reference to the first workshop, at which the attributes were identified, is not given in the summary of the Options Report and, since it is likely this report will be read in isolation of other documents, the IPR feels it is relevant that as concise a description of the Technical Options Study process is provided as a preamble in all associated documentation.

It is noted that whilst there was not time for sufficient debate on the attributes of security and intergenerational endowment, as noted in the Options Report, entries for them have been made to complete the Overview of Results (Table 5.1, page 47) and this has been justified in the supporting discussion for these attributes.

6.5 Outcomes

The IPR has no comments on the stated outcomes in the Options Report other than they are a representative summary of the outcomes of the second workshop.

6.6 Review of the recommendations made in the Options Report

1 **Skills:** This recommendation is sound. Whilst the difficulty in understanding the skills and experience needed for ISOLUS activities was evident at the workshop, it is important to emphasise that a lot of work has already been done in this area by the DTi (as was), NII, OECD and, latterly, NSAN. It is important to build into this context the current shortages in engineers across most backgrounds and the widely-held belief that critical shortages exist in the areas of experienced engineering project management, radiation protection, safety case preparation / examination. As time elapses, expansion in the nuclear power sector coupled with major, non-nuclear engineering projects will compete for these skills.

2 **Doses & discharges:** This recommendation is sound (see generic comment below).

3 **RC integrity versus Nirex box:** This recommendation is sound (see generic comment below).

4 **Public consultation:** This recommendation is sound however the critical descriptor appears to be ‘best information available’. Given that some time has elapsed since the CIOP (2003) and also that some difficulty in accepting the *current data* by stakeholders was experienced during the Options Study, this descriptor needs further development. A commitment by stakeholders as to the attributes to be met by ‘best available information’ to be credible to all parties might be appropriate.

5 **Radiation and level of harm:** This recommendation is sound. It should be borne in mind that the apparent difference of opinion (at least in the IPR’s recollection of discussion at the workshops) appears to stem from the long-running debate concerning the linear, no-threshold theory of radiation effects on living tissue and a general lack of comfort with the adoption and implementation of the ALARP principle in radiation protection. Whilst global radiobiological research continues to pursue this issue, greater clarification of the radioactive inventory can only stand to inform the implementation of ALARP but is unlikely to subvert its use in the near future.

It is clear from the Options Report and from the IPR's observations of the workshop(s) that greater technical clarity of the ISOLUS process is a common theme arising from the study and which supports many of the recommendations referred to above. Such a study, designed to yield ISOLUS-specific data on radiological discharge and dose levels, the relative integrity of the RC as a transport container and the effects of any variance in radioactive inventory, dose and discharges on the options under consideration would be very useful. However, such a study is unlikely to be a trivial exercise. For example, aside from security issues that might arise with making available data that could be used to infer classified design aspects of the reactor plant, the following aspects of such a study are also relevant to the debate:

- It is very likely that such a study will yield *quantitative bounds* only. The influence of variation across different submarine plant, and the options themselves is unlikely to yield data with tolerances that would meet with the entire satisfaction of the stakeholders.
- Several hypothetical embodiments of such a study are feasible. For example:
    i. a study could be carried out on a laid-up submarine itself. Much has been learned from the decommissioning of nuclear plant such as the prototype AGR at Sellafield, but such a study would be expensive and will yield data specific to that vessel that will only be open to extrapolation within the bounds described above.
    ii. A virtual reality study could be performed, on the basis of the known lifetimes of the plant, its operations and associated inventory. This would again yield data within bounds as described above and would also require important assumptions to be made.
    iii. There is the potential for this information to be underpinned via information gleaned from the decommissioning of plant elsewhere in the world. However, this would require assurances in terms of security and also the plant are different to those in the UK, so again such information sharing would only yield bounds that serve to inform the debate.

This comment should not be interpreted as overly negative on the issue of further investigative studies on the technical issues of ISOLUS. It just means to expose the importance of confidence in the data and the inherent lack of completeness associated with any scientific measurement or estimate on a complex system.

7. Conclusions and recommendations

The conclusions of the IPR's consideration of the ISOLUS Technical Options Study are that the study proceeded as per the process described in the Methodology Report with some important and largely beneficial amendments. The latter were arrived at as a result of discussion at the workshops and via correspondence in between the workshops. The reports (Data Report and the Options Report) represent an accurate record of the outcome of the debate and the information used in the debate at the workshops. It is recognised that key issues were raised by stakeholders at the workshops, specifically with regard to the weighting of attributes and the completeness of the data presented in the Data Report, and this has been recognised in the Options Report and the recommendations made therein.

The IPR has the following recommendations:

1. Greater emphasis needs to applied to the issues of skills with regard to ISOLUS, perhaps via dialogue with NSAN and/or SCC, specifically with regard to the impact of the decline in skills and knowledge on the options considered in this programme, the effects of recession, future technologies and the need to train the trainers.
2. A shift in perception from construction/demolition to dismantling might be beneficial in the assessment of non-radiological risks based on preconceptions about safety cultures.
3. The issue of intergenerational endowment would benefit from greater development in the future, possibly via the forthcoming public consultation, as it received limited attention in the options study.
4. In any subsequent exercise to improve the technical clarity of the proposed ISOLUS process, the inevitable compromise between what is achievable and that which is desirable in terms of data needs to be explored more fully.

8. References

ISOLUS Technical Options Study, Methodology Report, FNC Reference 35114/34530R

ISOLUS Technical Options Study, Attributes Report, FNC Reference 35114/34646R

ISOLUS Technical Options Study, Data Report, FNC Reference 35114/34735R

ISOLUS Technical Options Study, Options Report, FNC Reference 35114/35240R