SDP MoD Proposed Options Study
Desk Officers' MPOS Conference Report

FNC 36995/36702R Issue 1

Prepared for SDP Project Team

SYSTEMS AND ENGINEERING TECHNOLOGY

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Originating Office: FRAZER-NASH CONSULTANCY LIMITED
Stonebridge House, Dorking Business Park, Dorking, Surrey, RH4 1HJ, UK
T: +44 (0)1306 885050 F: +44 (0)1306 886464 W: www.fnc.co.uk

SUMMARY

The Submarine Dismantling Project (SDP) has been tasked with the development and implementation of a safe, environmentally responsible, secure and cost-effective solution for the dismantling and eventual disposal of the UK's nuclear powered submarines in a manner that inspires public confidence.

The objective of the MoD Proposed Option Study (MPOS) is to compare the technical aspects of the three options under consideration for the interim storage of intermediate level waste from the dismantling of nuclear submarines. These options are:

- **Option 1:** Reactor Compartment Storage
  Storage of intact reactor compartments cropped from the submarine;
- **Option 2:** Reactor Pressure Vessel Storage
  Storage of the reactor pressure vessel together with other large items; and
- **Option 3:** Packaged Waste Storage
  Storage of separated and packaged Intermediate Level Waste.

In order to consider the wide range of issues associated with the three options it was appropriate to seek inputs from significant stakeholders. To facilitate this study the methodology was structured around a stakeholder workshop. The workshop provided the opportunity for a cross section of stakeholders including the MoD, subject matter experts and representatives from the MPOS Advisory Group to contribute to the study. Prior to the workshop, a range of assessment criteria were developed from the attributes used in previous studies and distributed to the invitees with a data report which discussed the performance of each option against each criterion.

The objective of the workshop was to determine how each of the three options perform against each of the criteria and to understand the relative importance of the criteria by completing a weighting exercise. This document presents a structured commentary of that workshop, and draws together the outcomes.

Upon review, Option 3 (packaged waste storage) was positively differentiated from Reactor Compartment and Reactor Pressure Vessel storage by a significant margin. This particular outcome from the workshop appears robust and was neither reversed, nor the margin of preference significantly eroded in any of the sensitivity studies conducted.

It was also noted that this outcome was unchanged whether weighted or raw scores are considered.

CONTENTS

1. INTRODUCTION

1.1 OVERVIEW

The Submarine Dismantling Project (SDP) has been tasked with the development and implementation of a safe, environmentally responsible, secure and cost-effective solution for the dismantling and eventual disposal of the UK's defuelled nuclear powered submarines in a manner that inspires public confidence.

During a previous phase of the project (known then as the ISOLUS project), three options were identified for the interim storage of intermediate level waste, prior to packaging in NDA packages for final disposal. The options are independent of the site(s) at which the activities will be carried out; the siting of the processes will not be considered in this study.

The options are:

- **Option 1:**
  Storage of intact reactor compartments cropped from the submarine;
- **Option 2:**
  Storage of the reactor pressure vessel together with other large items; and
- **Option 3:**
  Storage of separated and packaged Intermediate Level Waste.

The SDP team is now conducting the MoD Proposed Option Study (MPOS) to identify a single proposed option to be put forward during the forthcoming Public Consultation.

1.2 AIM

The aim of the MPOS is to identify the single proposed option for the interim land storage of intermediate level waste arising from the dismantling of de-fuelled nuclear submarines.

1.3 PROCESS

The approach to the MPOS is described in the methodology statement (FNC 36995/63422V Issue 2 dated April 2010).

The overall approach is shown in figure 1, below:

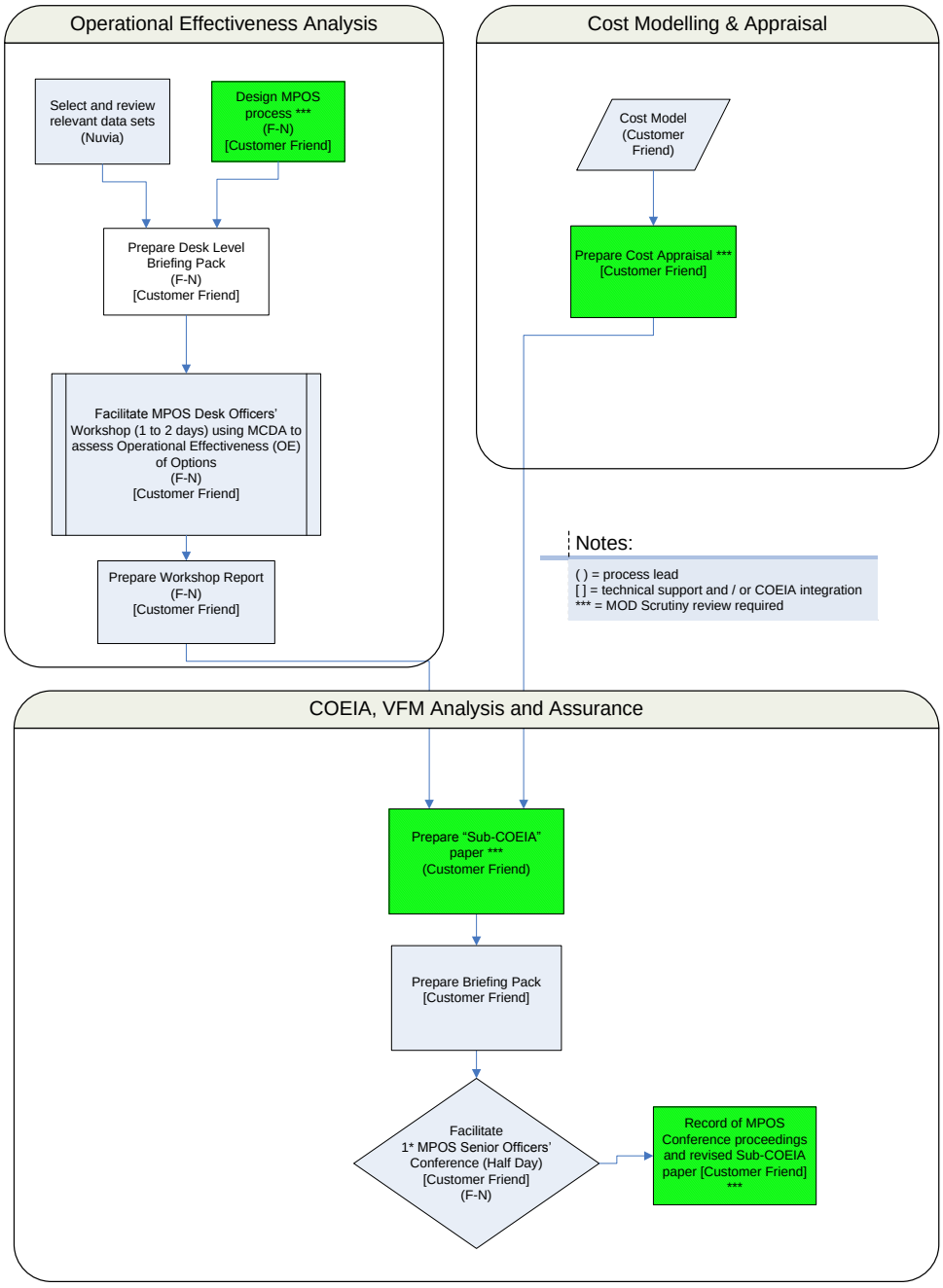

Figure 1: - Approach to the MPOS Study

A two-stage approach to the MPOS has been undertaken. In the first stage, desk officers representing the MoD Senior Officers followed a facilitated Multi Criteria Decision Analysis process to reach a recommendation on the MoD proposed option. This workshop was attended by MoD technical experts and representatives of the MoD Senior Officers. The workshop was observed by members of the SDP advisory group and MoD scrutiny.

In the second stage, the outcome of this workshop was combined by the MoD with the cost appraisal work conducted by Deloitte into a COEIA. The MPOS Conference, of MoD senior staff was then be convened to challenge and ratify the recommendation of the sub-COEIA.

This document reports the outcome of the MPOS Desk Officers' workshop, held on 12 May 2010. The draft issue was issued to invitees to the Desk Officers' Workshop for comment prior to the senior MPOS conference, held on 16th June 2010.

Issue 1 of this document incorporates the comments received on the draft issue to 23rd July 2010.

2. CONDUCT OF THE WORKSHOP

2.1 APPROACH

The MPOS desk-officers' workshop was conducted as a multi-criteria decision analysis. A multi-criteria decision analysis consists of 6 stages:

1. Definition of the options to be assessed;
2. Derivation of a set of specific, measurable criteria that allow workshop attendees to distinguish between the options;
3. Scoring of each option against each of the criteria;
4. Weighting of the criteria;
5. Combining the scores and weights to produce preference values for the options; and
6. Sensitivity analysis.

Step 1 was carried out by the SDP project team in advance of the workshop. Frazer Nash, Nuvia and the SDP project team prepared a draft set of criteria to be used to assess the options. These were provided to the desk-officers in advance of the MPOS workshop to allow any additional criteria to be incorporated.

Steps 3-5 were carried out by the desk officers during the workshop, supported by technical experts. The multi-criteria decision analysis provided the background against which the desk officers identified the recommended option.

2.2 ATTENDANCE

2.2.1 Roles

The desk-level MPOS workshop was attended by desk-officer representatives of the MoD Senior Officers, technical experts, facilitators, MoD scrutiny and SDP Advisory Group observers.

- MoD senior staff (or their representatives) are those responsible for identifying the proposed option. Referred to as "the panel" in this report, they scored and weighted the options and discussed the outcome of the decision analysis;
- Facilitators guided the process, chair and record the meeting;
- Technical experts were present to present information, and answer clarifying questions from the panel as required; and
- SDP Advisory Group members attended the workshop as informers, to provide information on the historical, process and stakeholder issues attached to some of the criteria.

2.2.2 Attendees

Table 1 shows the invitees to the desk-officers' MPOS conference held on 12 May 2010 at MoD Foxhill, Bath. Apologies were received from [redacted], [redacted], [redacted], [redacted], [redacted] and [redacted]. [redacted] substituted for [redacted] (Nuvia) and [redacted] (Babcock Marine) attended alongside [redacted].

Name	Affiliation	Role	Representing	Attended
[redacted]	D Scrutiny, MOD	Observer		Yes
[redacted]	D Scrutiny, MOD	Observer		Yes
[redacted]	Submarine Safety, MOD	Desk Officer	[redacted] (SO)	Yes
[redacted]	SM S&E, MOD	Desk Officer	John Van Griethuysen (SO)	No
[redacted]	Superintendent Nuclear Works, HMNB(D), MOD	Informer (Technical Expert)	[redacted] (SO)	Yes
[redacted]	ISM - SDP, MOD	Informer (Technical Expert)		Yes
[redacted]	ISM - SDP, MOD	Desk Officer	[redacted] (SO)	Yes
[redacted]	ISM - SDP, MOD	Graduate		Yes
[redacted]	Defence Estates, MOD	Desk Officer	[redacted] (SO)	Yes
[redacted]	Defence Estates, MOD	Informer (Technical Expert)		Yes
[redacted]	NBCC, MOD	Desk Officer	[redacted] (SO)	Yes
[redacted]	NDA	Informer		No
[redacted]	Cap-DUW, MOD	Desk Officer	Paul Hollinshead (SO)	Yes
[redacted]	ISM - SUSM	Desk Officer	Alasdair Stirling (SO)	No
[redacted]	SM-NP	Desk Officer	Steven Dearden (SO)	Yes
[redacted]	SDP Demonstrator, MOD	Desk Officer	[redacted] (SO)	Yes
[redacted]	Frazer-Nash	Facilitator		Yes
[redacted]	Frazer-Nash	Facilitator		Yes
[redacted]	Frazer-Nash	Recorder		Yes
[redacted]	DNSR	Informer (Technical Expert)		Yes
[redacted]	SDP Advisory Group	Informer (SDP Advisory Group)		Yes
[redacted]	SDP Advisory Group	Informer (SDP Advisory Group)		Yes
[redacted]	NBCD RPA	Informer (Technical Expert)		No
[redacted]	SDP Advisory Group	Informer (SDP Advisory Group)		Yes
[redacted]	Babcock Marine	Informer (Technical Expert)		Yes
[redacted]	Babcock Marine	Informer (Technical Expert)		Yes
[redacted]	Nuvia	Informer (Technical Expert)		Yes
[redacted]	Nuvia	Informer (Technical Expert)		Yes
[redacted]	Deloitte	Informer (Technical Expert)		Yes
[redacted]	Polaris Consulting	Informer (Technical Expert)		Yes
[redacted]	NII	Informer (Technical Expert)		No
[redacted]	EA	Informer (Technical Expert)		No

Table 1: - SDP MPOS Desk Officers' Conference Attendees

2.3 COMMENTARY

The workshop proceeded in four parts:

- The SDP project team gave an overview of the options to be assessed;

- Frazer-Nash facilitated a review of the criteria to be used to assess the options;
- The participants were guided in a scoring exercise to score the performance of each option against each criterion; and
- Following a short break, the participants were guided in a swing-weighting exercise to establish their willingness to trade between performance on each criterion.

Section 3 of this document describes the options, section 4 reviews the criteria and section 5 discusses the scoring and weighting processes.

2.4 OBSERVATIONS

The MCDA process employed during the workshop was designed to allow a panel of experts to debate a series of issues (the criteria), and form a series of consensus views (the scores) on each criterion.

During the workshop a number of behavioural observations were made, which supported the conclusion that the panel were properly debating the issues and forming new views as they reached a common understanding of the issues.

- It was clear that individual panel members had specific areas of experience coming into the conference and hence a particular perspective that did not always cover the full scope of the criteria. It was through discussion of all criteria that all of the applicable facets of the option identification were aired. This enabled the panel to review their assessments based upon a more complete understanding of the issue that emerged during the debate. There were a number of occasions where participants were seen to modify their views as they gained a better understanding of the issues through discussion with the other panel members and the technical experts.
- A number of assumptions about the options were changed during the debate, as a result of the better understanding which emerged. These were recorded, agreed by the panel and are summarised at Annex A. In several cases, making the underlying assumptions explicit was the trigger to facilitating consensus.
- The panel members did not always reach a consensus. In these cases the alternative views were recorded and the panel members were content that the effect of these views would be explored during the sensitivity analysis.
- The panel were extremely well qualified in their areas of expertise. It was noticeable that where the facilitator tested this by proposing scores which he knew to be incorrect, they were quick to challenge and debate the issue.

The weighting phase of the workshop was cut short due to pressure of time on the day. However on balance the facilitators felt that it was preferable to gather the initial views of the panel - and to treat them as such - rather than to lose the opportunity to gather this information. The study of the sensitivity of the outcome to the weightings applied (presented in section 6.1) is hence an important aspect of the study in determining the robustness of the outcome.

3. OPTIONS

Three options were considered by the MPOS desk-level conference. Full descriptions of the technical processes which would be undertaken for each option are given in the MPOS Study Data Report (Nuvia document reference 89330/PDT/TAF6/006 Issue A, 4 May 2010). This report also provided information on the performance of each option against each criterion, and was referred to heavily by the workshop participants in scoring the options against the criteria.

All three options have the same start and end points. Each option begins with an intact, de-fuelled, de-equipped submarine and ends with ILW interred in the Geological Disposal Facility and LLW interred in the central low level waste repository. The main difference between the options is the point in time at which the various dismantling, packaging, transportation and intermediate storage activities are carried out.

3.1 OPTION 1: - REACTOR COMPARTMENT STORAGE

This option requires the Reactor Compartment (RC) to be separated from the fore and aft sections of the submarine. It is then sealed, and transported intact to an interim storage location and stored until the planned central Geological Disposal Facility (GDF) becomes available. The RC itself serves as the transport and interim storage container for the Intermediate Level Waste (ILW) contained within it. When the GDF is able to accept waste from submarine dismantling, the RC will be transported to a suitable dismantling facility where it will be dismantled, the plant components cut up and the ILW packaged for disposal and interred in the GDF. The Low Level Waste (LLW) contained within the reactor compartment will also be packaged and disposed of at the central Low Level Waste Repository at this time.

This option is summarised in figure 2, which is reproduced from the MPOS Study Data Report.

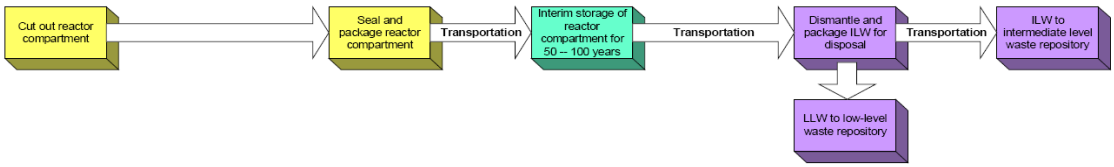

Figure 2: - Option 1 – RC Storage

3.2 OPTION 2: - REACTOR PRESSURE VESSEL STORAGE

This option sees the reactor pressure vessel (RPV) and other primary plant components which meet the definition of ILW removed from the submarine. Any LLW remaining in the reactor compartment after removal of these components is disposed of to the central Low Level Waste Repository. The RPV is then packaged for transportation, transported to an interim storage location, and stored until the planned central GDF becomes available. At this time it is transported to a suitable dismantling facility, cut up, and the ILW separated and packaged for disposal, then interred in the GDF. The LLW contained within the stored primary plant components will also be packaged and disposed of at the central Low Level Waste Repository at this time.

This option is summarised in figure 3, which is reproduced from the MPOS Study Data Report.

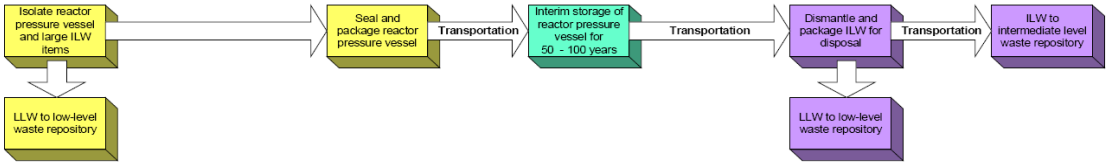

Figure 3: - Option 2 – RPV Storage

3.3 OPTION 3: - PACKAGED WASTE STORAGE

This option sees the reactor pressure vessel (RPV) and other primary plant components which meet the definition of ILW removed from the submarine. Any LLW remaining in the reactor compartment after removal of these components is disposed of to the central Low Level Waste Repository immediately. The reactor pressure vessel is then cut-up immediately and packaged in NDA packages, which are the intended disposal containers to be accepted by the GDF when it becomes available. The NDA packages are then transported to an interim storage location and stored until the GDF becomes available. At this time they will be transported to the GDF and interred.

This option is summarised in figure 4, which is reproduced from the MPOS Study Data Report.

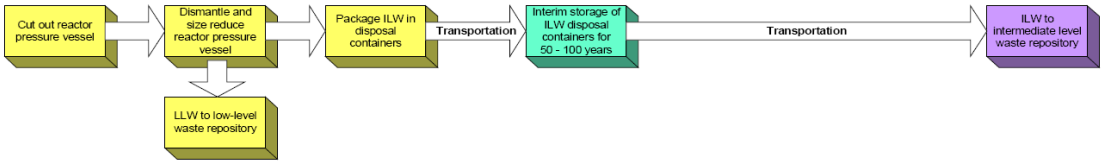

Figure 4: - Option 3 – Packaged Waste Storage

4. CRITERIA

4.1 DERIVATION

The criteria used in the MPOS desk officers' workshop have been derived over several iterations from those used in the ISOLUS options study. An initial set of criteria for the MPOS conference was proposed by Frazer-Nash (FNC 36995/61627V Issue 1). These attributes were selected from the set used in the ISOLUS options study and reported in the Options Report (FNC 35114/35042R Issue 1, dated December 2008).

These criteria were subject to peer review by Nuvia (89330/TAF2/002, 2 Oct. 2009) and a number of additional criteria were suggested (89330/TAF6/009, 13 January 2010). Since that date MoD has also held a workshop to identify possible Measures of Effectiveness for use in the SDP COEIA.

The scope of the MPOS options study was changed in April 2010 to more closely support the sub-COEIA approach (FNC 36995/56227L dated 7 April 2010), and the criteria were revisited by Frazer-Nash and Nuvia and a revised criteria set proposed in FNC 36995/63406V Issue 1 dated April 2010.

The attendees at the MPOS desk-officers' conference were briefed on this criteria set in a series of telephone conferences and face-to-face briefings during the week ending 23rd April 2010.

4.2 CRITERIA USED IN THE MPOS DESK-OFFICERS' WORKSHOP

The criteria presented to the MPOS desk-officers' workshop are given in table 2, below. The rationale for the selection of these criteria, and their relationship to the project Key User Requirements is given in FNC 36995/63406V Issue 1 dated April 2010.

Attribute	Definition
Volume of ILW to GDF	The total volume of ILW anticipated to be transferred to the GDF after the interim storage period.
Interim Storage Area	The footprint required for an interim store.
Volume of LLW to central LLW Repository	The total volume of LLW anticipated to be transferred to the central LLW Repository.
Industrial Skill Set	The availability of the skills needed to undertake the work.
Flexibility of Location	The number of potential sites available for most site-restricted part of the process.
Technical Challenges	A measure of the technical difficulty of carrying out each option.
Worker Dose	The worst-case radiation dose expected in routine operations.
Radioactive Discharges	The radioactive discharge in routine operations.
Accidental Radiological Discharges	The radiological discharges and emissions resulting from accidents and deliberate actions (a measure of passive safety).
Intergenerational Equity	The endowment of cost and / or burden to future generations.
Adaptability	The ability for future developments to provide a better solution.
Vulnerability	The vulnerability of material to accidental or deliberate misuse.
Regulatory Compliance / Statutory Approvals	The relative difficulty of attaining regulatory / statutory approvals for the option.

Attribute	Definition
Nuisance	The statutory and non-statutory nuisances and other environmental impacts which differentiate between the options and are not captured elsewhere.

Table 2: - Proposed Attributes for the MPOS Workshop

4.3 REVIEW OF CRITERIA

The criteria set was discussed and reviewed by the workshop participants before any scoring of options took place. A general discussion on background assumptions was followed by specific points relating to some of the criteria.

4.3.1 Background Discussion

A member of the panel asked if any facility for the disposal of ILW is available to the MoD today as they felt that this would impact upon the decision making. Another member of the panel explained that whilst the French, for example, have a facility to dispose of ILW, we do not have a facility like this in the UK today.

A discussion followed on the availability and timescales of the GDF. It was suggested that this issue is not pertinent to the discussion because it does not discriminate between the Options; - none of the options can inter their ILW until the GDF is available. However, it was noted that there is no intention for the MoD to do anything differently than the wider nuclear industry with respect to the long term storage of waste. It was also noted that the Low Level Waste Repository may not be available or viable as a future waste store, since it could become 'full' in the intervening period.

An observer asked if there would be different waste streams generated by each of the three Options. At this stage in the discussions the panel explained that was not the case and therefore is not a discriminator between the options. Later in the workshop, subtle differences in the quantity of wastes produced by each option were developed, and these are discussed in section 5 of this report.

The scope of the project, and the decision-making within this workshop was explored, and it was confirmed that the project assumes that the hull is clean outside of the RC. The SDP project team explained that none of the options would increase the spread of contamination throughout the submarine, and hence this issue does not discriminate between the options.

One technical expert wished to highlight the importance of transportation issues in differentiating between the options, and sought reassurance that this would be captured during the decision process. Other technical experts explained how transportation is represented as a facet of each option, and is assessed in a number of criteria, particularly the "technical challenges" area reported in section 5.5 of this document.

One member of the panel reminded the conference to be clear and precise about the use of language. For example, anything that is termed 'waste' would still need to be inspected, but this will not necessarily be possible for reasons of security. Inadvertent use of incorrect terminology in the future may cause presentational difficulties for the MoD during public consultation.

4.3.2 Discussion of Criteria

A member of the panel asked if cost would be included in the adaptability criteria. It was answered that cost was not included in the MPOS study, but it was suggested that this should be included in the cost model if advances in technology introduce additional cost. Discussions should then be taken forwards into the cost modelling exercise.

Some attendees expressed surprise that the local and public acceptability criteria had been removed. It was explained that the MoD cannot presume to know what is locally acceptable, and this issue will therefore be addressed during public consultation. Furthermore, the public may be concerned about some of the same issues as the other stakeholders – public acceptability is one stakeholder group's view of the criteria set and its weighting.

A technical expert substantiated this view, and advised that the Environment Agency recommends that public acceptability is not included in MCDA studies for these reasons.

A member of the panel queried why there was no factor that included socio-economic issues. It was answered that in a similar way to public acceptability, socio-economic issues would be covered during the public consultation and that it would be possible that the public view could overturn the discussions held in this workshop.

The meeting concluded that the criteria were appropriate and that the group present was qualified to hold the discussion on these criteria.

5. DISCUSSION

5.1 VOLUME OF ILW TO GDF

5.1.1 Discussion

Discussion on this criterion began by exploring the waste classification regime applicable to the disposal of submarine wastes. The question of whether the UK is likely to move to international definitions on waste classification was raised, and how would this then impact on the volume of ILW. The SDP project team clarified that decisions need to be made based on today's policy, and hence the assumption is that the definition of ILW will not change between now and entry into the GDF. However, it was also noted that the GDF criteria for the definition of ILW do not yet exist. Hence the packaged waste option would require the waste to be divided into ILW and LLW based on an assumption of these criteria. The other options, which package the waste later, will benefit from the availability of the GDF entry criteria when the waste is sub-divided and packaged for disposal.

It was pointed out by one technical expert that a change to the ILW and LLW definitions could reduce the volumes of ILW produced by the options. For example, a move to the IAEA regulations could have this effect, though such a move could require a reinterpretation of current UK legislation. However, under such a scheme there would be a reduction in the total amount of waste classified as ILW, but the relative amounts of ILW for each of the options would not change and hence this uncertainty is not a discriminator between the options.

The discussion then explored any advantages to be gained from physical separation of Short-Lived ILW (SL-ILW) and Long-Lived ILW (LL-ILW) by machining operations. This could reduce the amount of ILW to be consigned to the GDF in all three options, by machining off portions (e.g. of the RPV) which are currently SL-ILW and will be classified as LLW after the decay of the gamma radionuclides. The technical experts suggested that physical separation of SL-ILW from LL-ILW would not be advantageous or represent value for money for the MoD because separation is expensive and risky and the tooling itself becomes contaminated, generating an additional waste stream. The amount of ILW to be held in an interim store does not decrease. Since the practicality of this is uncertain, it was agreed that two cases would be recorded;

- The base case of 4 boxes of ILW for each of options 1 & 2 (assuming physical separation of wastes) and 8 boxes for option 3.
- A sensitivity case of 8 boxes of ILW for each option (assuming no physical separation of wastes).

In each case the volume of LLW to the central LLW repository would be adjusted accordingly.

The SDP project team queried whether the volume of ILW generated (and the potential to separate ILW and LLW) is affected by the cooling off period (decay) of the boats that are already out of service. It was explained that the volumes used for this study were based on the average boat from those within the remit of the SDP.

It was also agreed that a pragmatic approach to ILW would be taken, such that the RPV would not be stripped apart where the additional work would actually increase the amount of waste overall.

The Deloitte representative explained to the workshop that the cost implications for different amounts of waste were being recorded and would form part of the cost modelling exercise.

5.1.2 Scores

The following scores were recorded:

Volume of ILW to GDF	The total volume of ILW anticipated to be transferred to the GDF after the interim storage period.	No of boxes		Number of 3m³ NIREX boxes

		Score
Option 1	Storage of RC	4
Option 2	Storage of RPV	4
Option 3	Storage of Packaged ILW	8

5.2 INTERIM STORAGE AREA

5.2.1 Discussion

Nuvia presented the floor plan areas given in the data report which gave the indicative size of the facilities required for the interim storage of the material. It was clarified that the storage area for option 3 is based on the assumption of 8 boxes of ILW per submarine, and that the floorplan areas for Options 1 and 2 include an inspection and in/out processing area. All options include an allowance for the plant required to handle the waste within the facility.

The discussions identified the assumption that Option 2 has a higher packing efficiency (in terms of volume of waste per m^2 of store footprint) than Option 3, even when Option 3 has its boxes stacked 3 high. The reduced packaging efficiency for Option 3 is because when the waste is size-reduced into a form suitable for disposal in the boxes, taking account of the internal furniture of the box and the grout used to immobilise the waste in the box, the overall volume of boxes per submarine is greater than that in Option 2.

The discussions also clarified that the facility for Option 2 assumes that the RPV will be stored in a shielded container and that no additional NDA packages will be required for other wastes.

5.2.2 Scores

The following scores were recorded:

Interim Storage Area	The footprint required for an interim store.	m²		Area required for interim store

		Score
Option 1	Storage of RC	3574
Option 2	Storage of RPV	574
Option 3	Storage of Packaged ILW	1084

5.3 VOLUME OF LLW TO CENTRAL LLW REPOSITORY

5.3.1 Discussion

The question of whether the storage facilities themselves would create a secondary waste stream was discussed. It was clarified that the storage facilities would not be considered as secondary waste unless there was an escape of radioactive material or additional “radioactive” work was carried out in the store.

The question of ‘hot cells’ was also discussed. It was explained that all of the options would require the construction of one “hot cell” to undertake the cut-up of the RPV and to package the material into the NDA packages. Additionally, option 2 would require a second hot cell to prepare the RPV for storage.

Option 2 is therefore likely to generate more secondary waste. However the discussions established that whilst the volumes of waste generated from the submarines is reasonably well

defined, there is uncertainty surrounding the amount of secondary LLW waste generated from the facilities. It was also noted that additional secondary waste would be generated through the inspection processes required to safely manage and monitor the waste during the storage period. Further work would be required to investigate these uncertainties, and hence the sensitivity to LLW volume should be explored.

The overall view from the technical experts was that, as with the ILW volumes, it would be difficult to discriminate between options based on the volume of LLW.

5.3.2 Scores

The following scores were recorded:

Volume of LLW to national central LLW repository	The total volume of LLW anticipated to be transferred to national central LLW repository.	m^3		Volume of LLW

		Score
Option 1	Storage of RC	11.35
Option 2	Storage of RPV	11.35
Option 3	Storage of Packaged ILW	8.95

Note that during the workshop, scores of 8.95m^3 were initially recorded for all options. During later discussions it was realised that if the volume of ILW was reduced to 4 boxes for options 1 and 2, then the volume of LLW must increase correspondingly.

5.4 INDUSTRIAL SKILL SET

5.4.1 Discussion

The discussion identified the need to separate the skills and experience needed for the radiological dismantling activities from the general submarine dismantling activities. The general ship-breaking tasks are common to all options, and occur at the same time for all options, hence do not discriminate. However option 1 and to some extent option 2 delays certain operations for several decades. This could allow any relevant skills or experience held now to be lost through retirement or death.

It was suggested that if a skills gap exists then it may be closed through investment in developing the required skills. This factor is therefore closely related to the level of investment in the processes and should be incorporated in the cost modelling. However it was realised that experience, as distinct from skill, should also be considered. Skills can be created through investment, however this is not the case for experience, which once lost through the death or retirement of key personnel, is lost permanently.

The definition of skills was clarified to represent whether the skills will be available when they are required for the each of the dismantling operations, whether these occur now, or in the future (as dictated by the definition of each option). The question of the potential increase in the range of skills that would be required for Option 1 as compared Option 2 and 3 was raised.

Discussion on this criterion quickly developed into two areas, to differentiate between skills and experience. It was decided to separate this criterion into two:

- Industrial Skill Set; and
- Industrial Submarine Experience.

Furthermore, security concerns will reduce the available pool of skilled labour. Other countries have experience of submarine dismantling (of both radiological and general ship-breaking tasks), however it was deemed unlikely that foreign nationals would be permitted to work on

dismantling of UK submarines. If foreign nationals cannot be used to plug the gaps in skills and experience, then this may exacerbate the problem.

It was noted that whilst we assume there is a viable succession planning policy in the context of this programme, the project will need to develop an understanding of what this means in practise.

It was also noted that the scores assigned were based on the assumption that the UK would continue in the business of operating nuclear powered submarines.

5.4.2 Scores

The following scores were recorded for "industrial skill set":

Industrial Skill Set	The availability of the skills needed to undertake the work.	Subjective	1 to 9	9 - No specialist skills needed 7 - All specialist skills guaranteed to be available within the UK 5 - All specialist skills likely to be available within the UK 3 - Necessary skills or domain knowledge scarce 1 - Availability of skills and domain knowledge uncertain

		Score
Option 1	Storage of RC	7
Option 2	Storage of RPV	7
Option 3	Storage of Packaged ILW	7

Note: - Some stakeholders felt that the score for option 1 should be 3, due to the degradation of operating experience of the submarines by the time that RC dismantling activities are undertaken. This will be explored in a sensitivity study.

The following scores were recorded for "Industrial Submarine Experience":

Industrial Submarine Experience	The availability of submarine operating and dismantling experience	Subjective	=Criteria! F18	9 - No specialist experience needed 7 - All specialist experience guaranteed to be available within the UK when needed 5 - All specialist experience likely to be available within the UK when needed 3 - Necessary experience scarce when needed 1 - Availability of experience when needed uncertain

		Score
Option 1	Storage of RC	4
Option 2	Storage of RPV	6
Option 3	Storage of Packaged ILW	6

5.5 FLEXIBILITY OF LOCATION

The discussion recognised that the initial submarine dismantling activities (removal of RC or RPV from the submarine) can only be carried out at a small number of UK sites. Hence the siting of these activities is the same for each of the options and does not discriminate between them. The focus of this criterion is hence on the site options for the interim storage stage of each option, and the subsequent activities.

One technical expert identified that transport is the key discriminator between the options for this criterion. Option 1 can only be practicably transported by sea; Option 2 by sea, or possibly by road with careful route selection, since it was identified that the RPV, with its likely transportation over-pack, would fit under standard road bridges. However, for Options 1 and 2 transport regulations would require that the load is taken as far as possible by sea. Option 3 offers more transportation options, being transportable by road.

The SDP project team identified that the flexibility to consider the use of existing ILW stores (most of which could only be reached by road transport) would be advantageous.

On the basis of the discussions, the proposed scoring scale was adapted slightly; - low scores were redefined as "one or two sites" and high scores as "more than 10 sites."

5.5.1 Scores

Flexibility of Location	The number of potential sites available for most site-restricted part of the process.	Subjective	1 to 9	9 - Many sites available for all stages of process 7 - Restricted number of sites for one stage of process 5 - Restricted number of sites for each stage of process 3 - Only 1 or 2 sites available for one stage of process 1 - Only 1 or 2 sites available for each stage of process

		Score
Option 1	Storage of RC	3
Option 2	Storage of RPV	5
Option 3	Storage of Packaged ILW	9

5.6 TECHNICAL CHALLENGES

5.6.1 Discussion

The workshop participants were asked to consider the relative technical challenges in each process step, for each of the options, namely:

- Initial dismantling and size reduction;
- Dismantling and size reduction of RPV;
- Packaging for storage;
- Transport to storage site;
- Interim storage;
- Transport to dismantling facility;
- Dismantle and package ILW for disposal;
- Transport of ILW packages to GDF;
- Transport of LLW to LLW repository; and
- Previous experience.

The SDP project team pointed out that difficulty is subtly different from technical challenge; difficulties can be overcome with investment and persistence, whereas technical challenges represent an unknown with a level of uncertainty attached to them.

After some discussion, it was felt that interim storage, transport of ILW packages to the GDF and transport of LLW to the central LLW repository were equally difficult for all three options, and so did not discriminate. Similarly the dismantling and size reduction of the RPV stage is not required for options 1 and 2, but was felt to be equally difficult to the dismantling and packaging of ILW for disposal stage for options 1 and 2.

It was noted that through there was little technical challenge in the packaging of the waste for storage in Option 3, a small challenge existed in the desire to maximise the packing density of waste in the NDA packages. Similarly in dismantling and size reduction of the RPV (whether before or after storage) the technical challenge lies in characterising the waste correctly to minimise the volume of ILW produced.

Much of the discussion then centred on the remaining transportation issues. It was assumed that transport to storage site represented a transportation movement between sites, whilst transport to the dismantling facility was assumed to be on the same site as the interim storage for Options 1 and 2. One technical expert pointed out that the Department of Transport has onerous requirements and that it may be necessary to develop an over-pack for the RPV for

transportation. In addition, due to the deterministic nature of the DfT regulations, some form of over-pack may be required for the RC. It was also noted that it could be difficult to re-approve the RC as a transport container after a period of interim storage, were this necessary.

The movement of a Reactor Compartment has never been undertaken in the UK and such a movement could be subject to civil regulations, as the Compartment would no longer be part of a 'military facility'. Regulations set by the DfT will need to be met, which are based upon IAEA regulations which will never have considered such a move. The concept will be entirely new to DfT, who may not have experience in this area, and will, in turn be dependent upon other UK regulators, international views and public consultations.

The discussion established that there is a distinction in technical difficulty between packaging waste for storage as compared to packaging for transport and that packaging for transport is more expensive than for storage. It was assumed that a single transportation over-pack is developed for option 2, which is re-used for each RPV to be transported. It was noted that this could increase the dose burden accrued by packaging the waste for transportation, then repackaging for storage.

The panel did not reach consensus on the scoring of the difficulty of transportation, with one member recording a score of “7 or 8” for the difficulty of transportation to the storage site for Option 1.

During this discussion, the D Scrutiny observer expressed concern that there was a wider difference in opinion between members of the panel on this issue and that this was not represented by the spread of scores being captured. The panel responded that the difference was due to an initial lack of understanding and once this had been resolved they were happy with the record of the scores. The misunderstanding had been that it had been assumed that the same package would be used for transportation as for storage but this was not necessarily the case.

The discussion then tended toward regulatory issues. It was suggested that the issues surrounding regulation were not in meeting the regulation per-se but in providing the proof and evidence that justifies the claim that the regulations have been complied with. It was suggested that regulatory approval is dealt with elsewhere and that this is not a technical issue.

5.6.2 Scores

The following sub-scores were recorded for technical challenges:

Technical Challenges High = 9 Med = 5 Low = 1 None = 0	1 RC	Option 2 RPV	3 Packaged
Step			
Initial dismantling and size reduction	2		
Dismantling and size reduction of RPV	N/A	N/A	5
Packaging for storage		2	1
Transport to storage site	4	6	2
Interim storage			
Transport to dismantling facility	1	1	N/A
Dismantle and package ILW for disposal	5	5	N/A
Transport of ILW packages to GDF			
Transport of LLW to LLW repository			
Previous experience			
Sum	12	14	8

A sensitivity case with a score of 8 for transport to storage site of Option 1 was also recorded.

These led to the following overall scores:

Technical Challenges	A measure of the technical difficulty of carrying out each option.	Subjective	81 to 0	Sum of challenges (high = 9, med = 5, low = 1, none = 0) in each of the 9 steps of the process

		Score
Option 1	Storage of RC	12
Option 2	Storage of RPV	14
Option 3	Storage of Packaged ILW	8

The sensitivity case of Option 1 scoring 16 was also recorded.

5.7 WORKER DOSE

5.7.1 Discussion

The collective dose estimates from the data report were presented by the technical experts. These had subsequently been updated, and a verbal report of the updated figures was provided.

It is understood that the IAEA are considering further reductions in the annual dose limit. It was noted that this project must meet the legislation in force at the time the activities are undertaken.

The SDP project team explained that there is a difference between the dose levels presented to this meeting and those in previous reports. The difference arises from undue conservatism in previous studies, in the light of recent assessment the dose levels have been revised downwards. It was also clarified that these dose levels relate to what is believed to be the worst-case submarine.

In order to provide context, one technical expert pointed out that more dose is accrued during the handling of LLW than in activities related to the ILW, since the radioactivity of the ILW will preclude manual handling and require specialist remote handling capability. Furthermore, it was stated that that the annual dose for the average person in the UK due to background radiation is around 2.2 mSv.

The panel asked if there is an additional dose burden from inspection, the answer was no; any dose arising from inspection activities was already included in the calculation of the figures presented.

Subsequent to the meeting, Babcock Marine provided an updated dose calculation of 9 man mSv for Option 1. This figure has been substituted directly for the 12 man mSv recorded during the workshop.

5.7.2 Scores

Worker Dose	The worst-case radiation dose expected in routine operations.	man mSv		Collective worker dose

		Score
Option 1	Storage of RC	9
Option 2	Storage of RPV	47
Option 3	Storage of Packaged ILW	50

5.8 ROUTINE DISCHARGES

5.8.1 Discussion

The discussion recognised the imperative to drive down the discharges, whichever option was chosen. One member of the panel suggested that this factor does not discriminate between options because the use of technology will drive each option to the same (regulated) level of discharge. Another member of the panel countered that there is the potential to end up with increased discharge with Option 2 but the relative difference between options would be very small.

The SDP project team noted that the OSPAR regulations may allow the levels of discharges to be increased; however, there will be a legal requirement to meet Best Available Technology (BAT) to minimise discharges.

When the criterion was assessed, it was renamed “Routine Discharges.”

5.8.2 Scores

The following scores were recorded:

Radioactive Discharges	The radioactive discharge in routine operations.	Subjective	20 to 0	Sum of level of discharge (high = 5, med = 3, low = 1, none = 0) in each each of the 4 processing stages

		Score
Option 1	Storage of RC	1
Option 2	Storage of RPV	2
Option 3	Storage of Packaged ILW	1

5.9 ACCIDENTAL RADIATION EXPOSURE

5.9.1 Discussion

The panel considered the possibility of accidental radiological discharges, but could not see an eventuality in which this discriminated between the options. In particular, it was assumed that the RC would be drained and hence there was no increased risk of radiological discharge compared to the other options.

Hence the criterion was amended to represent the possibility of accidental radiation exposure, including the potential dose to the public, which could arise from the option. This covers eventualities such as an accidental radiation exposure arising from a loss of shielding.

When the criterion was assessed, it was renamed “Accidental Radiation Exposure.”

5.9.2 Scores

The following scores were recorded:

Accidental Radiological Discharges	The radiological discharges and emissions resulting from accidents and deliberate actions (a measure of passive safety).	Subjective	9 to 0	Sum of risk of discharge (high = 3, med = 2, low = 1, none = 0) in each each of the 3 critical stages

		Score
Option 1	Storage of RC	2
Option 2	Storage of RPV	3
Option 3	Storage of Packaged ILW	3

5.10 INTERGENERATIONAL EQUITY

5.10.1 Discussion

It was suggested that this attribute should include leaving both decision-making as well as activities to future generations. The panel realised that these issues were not separable, since decisions (for example on the use of certain sites, or the processes to be carried out) cannot be made in advance on behalf of future generations.

The panel were reminded that the policy is that the waste producer deals with the waste and this drives us to identify an Option that does more sooner rather than later. It was pointed out that for Option 3 there would be little for future generations to do other than to transport the waste to the GDF.

5.10.2 Scores

The following scores were recorded:

Intergenerational Equity	The endowment of cost and / or burden to future generations.	Subjective	1 to 9	9 - No burden on future 7 - Few defined activities left to future 5 - Some un-defined activities left to future 3 - Critical activities left to future 1 - All activities left to future

		Score
Option 1	Storage of RC	2
Option 2	Storage of RPV	5
Option 3	Storage of Packaged ILW	8

5.11 ADAPTABILITY

5.11.1 Discussion

The panel identified that there may be certain advantages to leaving the packaging of waste until after the interim storage period, since this will allow any technical or regulatory developments to be taken advantage of. In particular, options 1 and 2 have the potential to take advantage of any future ILW reclassification, or change to the entry criteria for the GDF and/or LLWR to minimise the amount of waste classified as ILW. There may also be the opportunity to take advantage of future developments in the separation of short and long-lived ILW to reduce the ILW volume.

One informer suggested that changes to economic conditions and financial markets should be included because of the effect on what may be achievable in the context of investment availability. It was suggested that this takes the discussion away from the central point and that these considerations could be included in the cost model if appropriate.

5.11.2 Scores

The following scores were recorded:

Adaptability	The ability for future developments to provide a better solution	Subjective	1 to 9	9 - Future developments will improve the whole solution 7 - Future developments will improve elements of the solution 5 - Future developments may improve the solution 3 - Future developments may affect elements of the solution 1 - Future developments will not affect the solution

		Score
Option 1	Storage of RC	8
Option 2	Storage of RPV	5
Option 3	Storage of Packaged ILW	3

5.12 VULNERABILITY

5.12.1 Discussion

The discussion identified that vulnerability should include the vulnerability of the material to disclosing protectively marked information (e.g. releasing design information by inspection) as well as vulnerability to misappropriation of the material. The panel agreed that the longer the waste is left unprocessed, the more vulnerable it is.

The panel was in agreement that whilst there may be a difference between each of the options, the difference is small.

5.12.2 Scores

The following scores were recorded:

Vulnerability	The vulnerability of material to accidental or deliberate misuse.	Subjective	1 to 9	9 - Totally immune to attack or misuse 7 - System vulnerable during few stages 5 - System vulnerable during some stages 3 - System vulnerable during the majority of stages 1 - No protection against attack or misuse

		Score
Option 1	Storage of RC	4
Option 2	Storage of RPV	5
Option 3	Storage of Packaged ILW	6

5.13 REGULATORY COMPLIANCE

5.13.1 Discussion

A technical expert initially suggested that the effort in applying for planning applies equally across all three options and is therefore not a discriminator.

The conversation developed further and the SDP team suggested that the most uncertainty will be associated with Option 1, because it is not known exactly what activities will be required to undertake the option (see comment in section 5.10.1 regarding not committing future generations to detailed courses of action). Hence it is not possible to know the regulations and planning issues that will have to be met. It was also noted that Options 1 and 2 will require two stages of planning, whereas Option 3 will require one stage only.

There was some discussion on whether Option 1 should be scored "1" due to the uncertainty in obtaining planning and transport approvals in the future, however a consensus score of "2" was eventually recorded. Option 2 was scored at "3" as the volume of waste to be stored is reduced, hence it is likely to be slightly easier to gain planning approvals for the smaller facility required. It was agreed that the sensitivity of the decision to scoring option 3 as "8" would be explored.

5.13.2 Scores

The following scores were recorded:

Regulatory Compliance / Statutory Approvals	The relative difficulty of attaining regulatory / statutory approvals for the option.	Subjective	1 to 9	9 - No barriers to gaining the necessary approvals 7 - Some work required to achieve necessary approvals 5 - Significant work (and risk) required to achieve necessary approvals 3 - Some approvals can only be achieved in future 1 - Process for gaining approvals cannot be defined

		Score
Option 1	Storage of RC	2
Option 2	Storage of RPV	3
Option 3	Storage of Packaged ILW	7

5.14 OTHER / NON-RADIOLOGICAL ENVIRONMENTAL IMPACTS

5.14.1 Discussion

During the review of criteria, it was suggested that the term nuisance (originally used for this criterion) creates the wrong impression. The panel agreed that this was the case and the criterion would be renamed, noting that care would have to be taken to ensure it does not become a catch all term. When the criterion was assessed, it was renamed "Other / Non-Radiological Environmental Impacts."

The panel noted that the RC storage option has a higher visual impact since a larger and taller building will be required for interim storage, however it was advised that the environmental impact comes mostly from the laying of concrete in the ground and not from the size of the building. Option 1 may further require dredging in order to permit transport by sea, though this will depend on the site chosen as the interim storage location.

One technical expert suggested that there is scope here to include a positive impact on waste by considering recycling and early return to use of materials. The recycling of high grade metals means that we will not have to procure more materials, with both cost and environmental consequences.

5.14.2 Scores

The following scores were recorded:

Other / Non-radiological environmental impacts	The statutory and non-statutory nuisances and other environmental impacts which differentiate between the options and are not captured elsewhere.	Subjective	1 to 5	5 - Significant nuisance 3 - Moderate nuisance 1 - Insignificant nuisance

		Score
Option 1	Storage of RC	3
Option 2	Storage of RPV	2
Option 3	Storage of Packaged ILW	1

It was also agreed that the sensitivity of the outcome to a score of 2 for Option 1 would be explored.

5.15 SUMMARY OF SCORES

The scores of each option against each criterion are summarised in table 3, below.

Scores			**Option**		
			1	**2**	**3**
Criteria	**Scale**		**RC**	**RPV**	**Packaged**
Intergenerational Equity	Subjective	1 to 9	2	5	8
Flexibility of Location	Subjective	1 to 9	3	5	9
Industrial Skill Set	Subjective	1 to 9	7	7	7
Technical Challenges	Subjective	81 to 0	12	14	8
Worker Dose	man mSv		9	47	50
Adaptability	Subjective	1 to 9	8	5	3
Interim Storage Area	m^2		3574	574	1084
Volume of ILW to GDF	No of boxes		4	4	8
Volume of LLW to central LLW repository	m^3		11.35	11.35	8.95
Accidental Radiological Discharges	Subjective	9 to 0	2	3	3
Radioactive Discharges	Subjective	20 to 0	1	2	1
Vulnerability	Subjective	1 to 9	4	5	6
Regulatory Compliance / Statutory Approvals	Subjective	1 to 9	2	3	7

Scores			Option		
			1	2	3
Criteria	Scale		RC	RPV	Packaged
Other / Non-radiological environmental impacts	Subjective	1 to 5	3	2	1
Industrial Submarine Experience	Subjective	1 to 9	4	6	6

Table 3: - Summary of Scores

The recorded alternative scores for exploration as sensitivity studies were:

Study 1			Option		
			1	2	3
Criteria	Scale		RC	RPV	Packaged
Volume of ILW to GDF	No of boxes		8	8	8
Volume of LLW to central LLW repository	m^3		8.95	8.95	8.95

Study 2			Option		
			1	2	3
Criteria	Scale		RC	RPV	Packaged
Industrial Skill Set	Subjective	1 to 9	3	7	7

Study 3			Option		
			1	2	3
Criteria	Scale		RC	RPV	Packaged
Technical Challenges	Subjective	81 to 0	16	14	8

Study 4			Option		
			1	2	3
Criteria	Scale		RC	RPV	Packaged
Regulatory Compliance / Statutory Approvals	Subjective	1 to 9	2	3	8

Study 5			Option		
			1	2	3
Criteria	Scale		RC	RPV	Packaged
Other / Non-radiological environmental impacts	Subjective	1 to 5	2	2	1

5.16 EXAMINATION OF SCORES

Figure 5 presents the overall outcome without weighting the criteria against each other. This analysis was conducted after the workshop and hence was not shown to the stakeholders before they conducted the weighting exercise. Packaged waste is preferred with a score of 66, over RPV storage with a score of 37, and RC storage with a score of 36. The equally weighted outcome is useful for comparing which option "wins" on the most attributes; Figure 5 shows that Packaged Waste Storage is the most preferred (or jointly most preferred) option on 10 criteria; RC storage is preferred (or jointly most preferred) on five criteria. The thinner "stripes" which make up the bulk of the height of the RPV storage score show that this option's score is mainly composed from being the "middle" option of the 3 on 7 criteria, as well as being most preferred, or jointly most preferred on 3 criteria.

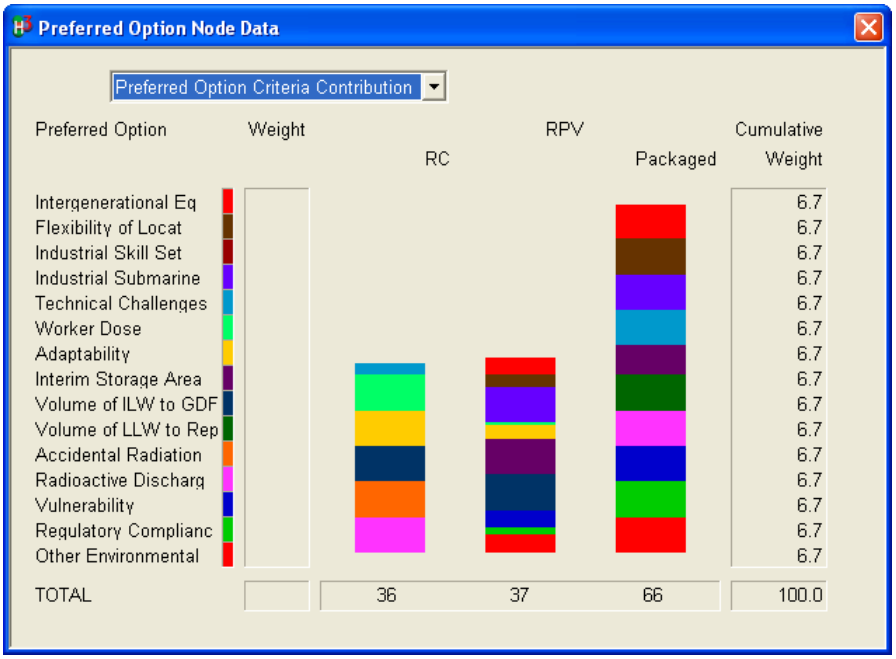

Figure 5: - Equally Weighted Outcome

5.17 WEIGHTING

5.17.1 Approach

Due to time constraints in the workshop it was only possible to allow a short break between the scoring and weighting exercise. The facilitator explained to the workshop that the intention was to develop a swing-weighting scheme. Swing weighting is distinct from the more common importance weighting in that it seeks to explore participants' willingness to trade performance on one criterion for performance on another and was used to judge the importance of the factors relative to each other. "Exchange rates" between criteria are developed to determine, for instance, how many m^3 of LLW to the central LLWR would compensate for a $1m^2$ increase in the footprint of the intermediate store.

Furthermore, it was explained that this process could only properly be conducted in the knowledge of the scores ascribed to each criterion. For example, if the volume of waste generated by each option were judged to be very small, then little value would be ascribed to reducing it further. By contrast if the volume of waste was very large, participants would be expected to place great emphasis on reducing it, and apply a high weighting to this criterion.

5.17.2 Discussion

The participants were asked to select the criterion that they judged to be most important. One member of the panel expressed the view that intergenerational equity is a major attribute, because the whole project is concerned with positioning the MoD to be able to stabilise the problem and reduce the liability of its nuclear legacy. Another member argued that lack of an available skill set could present problems to the project, whilst intergenerational equity would not.

To further the discussion intergenerational equity was chosen as a potential "most important" criterion, and ascribed an initial weighting by positioning a slider bar against this criteria to the maximum position. Each criterion was then discussed in turn, and its weighting ascribed by positioning a slider bar next to the criterion, such that all of the weights were assigned relative to

the weight ascribed to intergenerational equity. The outcome of this weighting process is shown in figure 6.

Interim storage area was judged to be much more tradable than intergenerational equity. Indeed some members of the panel felt that storage area is a “go/ no go” issue. If the space is available the store can be built; if it is not, it cannot.

The volume of ILW to GDF and volume of LLW to the central LLW repository were both judged to be equally important, due to their inherently linked nature – a reduction in ILW volume produces a corresponding increase in LLW volume, and vice-versa. A member of the SDP project team offered some context to this discussion by explaining that the ILW arising from the SDP is estimated to be only 0.2% by volume of the total UK ILW inventory. One member of the panel argued that there is a practical and moral justification for reducing the amount of waste that will enter the GDF, and another asked that any change in cost resulting from any difference in the amount of waste stored to be entered into the cost model.

Due to the amount of discussion on the weighting of these criteria, it was agreed that sensitivity analysis would be undertaken to explore the effect of weighting on the levels of waste.

One technical expert expressed the opinion that the overall amount of waste and the cost of dealing with that waste cannot be traded. A member of the panel clarified that the total waste is the same, so reducing ILW will increase LLW. Another technical expert expressed the view that if we wish to reduce overall levels of waste then we should be consistent across LLW and ILW.

The SDP project team recommended that if waste reduction is driven by policy (i.e. it is a measure of effectiveness against the project requirement) then it should be included but if it is cost driven then it should not be included here but factored into the SDP cost model and associated cost appraisal. It was decided it was right to include consideration of the volumes of waste in this study (i.e. ascribe them a non-zero weight). It was also noted that any cost implications should be brought across into the cost model.

One member of the panel had to leave the conference during this discussion. This delegate was invited to complete the weighting exercise offline; their weightings will be applied as a sensitivity study when they are received.

The discussion moved to worker dose. One member of the panel with expertise in this area suggested that the same arguments should be applied to worker dose as are being applied to levels of waste; i.e. dose is very important, but will be reduced to ALARP levels for all options and hence should not be scored highly as it is not tradable. Furthermore the public’s perception of the MoD’s approach to safety is a significant issue and so accidental radiological discharge should be weighted more highly than worker dose.

Another member of the panel stated that he was more interested in keeping things safe than if the volume of the store is big or small This drove an adjustment of the relative weightings of worker dose, radioactive discharges and accidental radiological discharges.

Another member stated that just because you can meet the regulatory dose level does not necessarily mean that the relevant risks have been reduced to “As Low As Reasonably Practicable” (ALARP). The regulations will demand that the radiation is managed to ALARP levels rather than the regulatory limit. Whilst this is particularly relevant for radiation issues it applies across most of the regulations the project will encounter. In addition, there are good neighbour issues at play here and the “reputation” of MoD may be diminished if it is not seen to be pursuing an ALARP approach.

The discussion turned to vulnerability. It was noted that the levels of waste should be reduced as far as a possible and that all of the options are relatively invulnerable. Other members of the panel supported this, and hence vulnerability was ascribed a low weighting, since it was felt that there was little desire to trade off performance on other criteria to reduce the vulnerability of the options.

At the conclusion of the weighting exercise, discussion returned to intergenerational equity. One member of the panel concluded that intergenerational equity should be weighted highly, lest the public take the view that the MoD was not serious about dealing with its nuclear liabilities. Overall it was felt that intergenerational equity was still the criterion which participants were least willing to trade off, however the weighting was reduced to only slightly ahead of the second least tradable criterion (Regulatory compliance / statutory approvals).

5.17.3 Weightings

Figure 6 shows the position of the slider bars at the end of the discussion. Table 4 then records the numerical values of the weightings derived during the workshop.

Figure 6: - Weightings Ascribed During the Workshop

Weights Criteria	Weight	Cumulative Weight
Intergenerational Equity	81	12.6%
Flexibility of Location	64	9.9%

Weights Criteria	Weight	Cumulative Weight
Industrial Skill Set	23	3.6%
Technical Challenges	70	10.9%
Worker Dose	21	3.3%
Adaptability	49	7.6%
Interim Storage Area	23	3.6%
Volume of ILW to GDF	68	10.6%
Volume of LLW to central LLW repository	68	10.6%
Accidental Radiological Discharges	37	5.8%
Radioactive Discharges	10	1.6%
Vulnerability	2	0.3%
Regulatory Compliance / Statutory Approvals	78	12.1%
Other / Non-radiological environmental impacts	27	4.2%
Industrial Submarine Experience	23	3.6%
	644	100.0%

Table 4: - Criteria Swing Weights

5.18 OVERALL OUTCOME

Table 5 shows the respective scores for each criterion with the “best” option being highlighted in green. It should be noted that on some criteria, higher scores are preferred, but on others lower scores represent better performance. This is purely a facet of the scales on which the criteria were scored. The mathematical analysis in the multi-criteria decision analysis normalises the scores and accounts for those scores whose scales display such reversed polarity

Scores			Option		
			1	2	3
Criteria	Scale	Good Score is:	RC	RPV	Packaged
Intergenerational Equity	Subjective	High	2	5	8
Flexibility of Location	Subjective	High	3	5	9
Industrial Skill Set	Subjective	High	7	7	7
Technical Challenges	Subjective	Low	12	14	8
Worker Dose	man mSv	Low	9	47	50
Adaptability	Subjective	High	8	5	3
Interim Storage Area	m^2	Low	3574	574	1084
Volume of ILW to GDF	No of boxes	Low	4	4	8
Volume of LLW to national central LLW repository	m^3	Low	11.35	11.35	8.95
Accidental Radiological Discharges	Subjective	Low	2	3	3
Radioactive Discharges	Subjective	Low	1	2	1
Vulnerability	Subjective	High	4	5	6
Regulatory Compliance / Statutory Approvals	Subjective	High	2	3	7
Other / Non-radiological environmental impacts	Subjective	Low	3	2	1
Industrial Submarine Experience	Subjective	High	4	6	6

Table 5: - Identified “Best” Scoring Criterion

Figure 7 shows the overall outcome, applying the scoring and weightings agreed during the workshop. Packaged Waste emerged with the highest preference value of 69, compared to RPV storage with 35 and RC storage with 32 points.

The major contributing criteria for Packaged Waste were:

- Intergenerational Equity;
- Flexibility of Location;
- Technical Challenges;
- Volume of LLW to Central Repository; and
- Regulatory Compliance.

In interpreting the outcome, it is important to appreciate that the absolute values of the scores have little meaning, since the multi-attribute value function approach deals only with the differences between options. The correct interpretation of the scores is that the difference in performance between packaged waste and RC storage is 12.3 times that between RPV storage and RC storage.

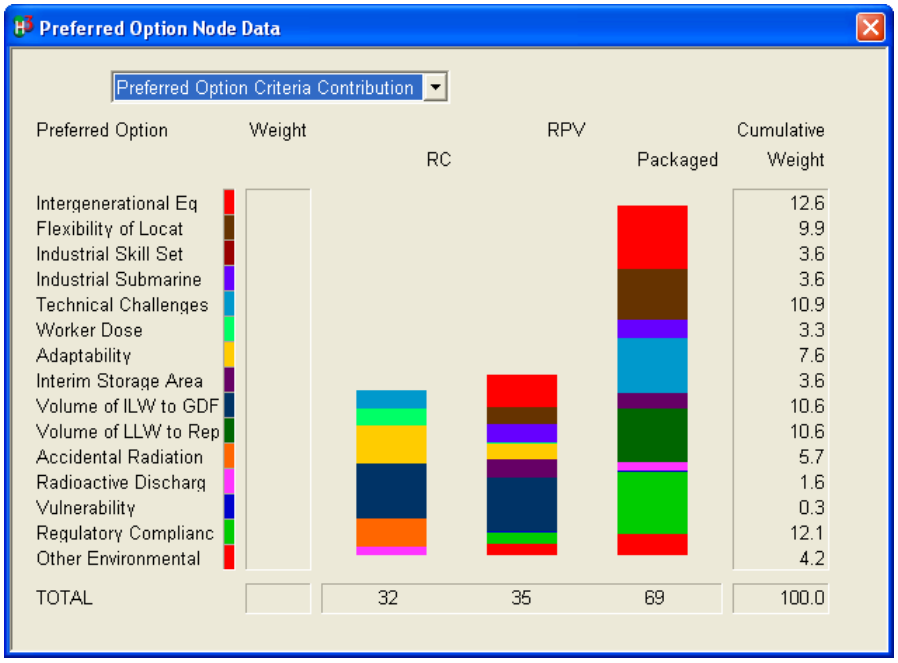

Figure 7: - Overall Outcome.

6. SENSITIVITY ANALYSIS

6.1 INITIAL SENSITIVITY ANALYSIS

The initial sensitivity analysis indicates this decision to be robust as illustrated in Figure 8.

The figure identifies those criteria against which an increase or decrease in weighting could alter the preference order of the options. A mark in the "Decrease cum wt" column indicates that a sufficiently large decrease in weight on that criterion would change the overall outcome. A mark in the "increase cum wt" column indicates that a sufficiently large increase in weight on that criterion would change the overall outcome. In this case, there are marks only in the "increase cum wt." column, and hence only increasing the weight on the marked criteria could change the decision.

The letters to the right of this column identify which option would be preferred if the weight on that criteria were increased sufficiently to change the overall outcome. In four instances this would be RC storage, in the other four instances this would be RPV storage.

The marks in this diagram can be red, amber or green. Since all the marks in figure 8 are green, this indicates that a large increase in weighting (greater than 15% of cumulative weighting) would be required to alter the outcome. To set this in context, the highest weighted criterion (intergenerational equity) was ascribed a cumulative weight of 12.6%.

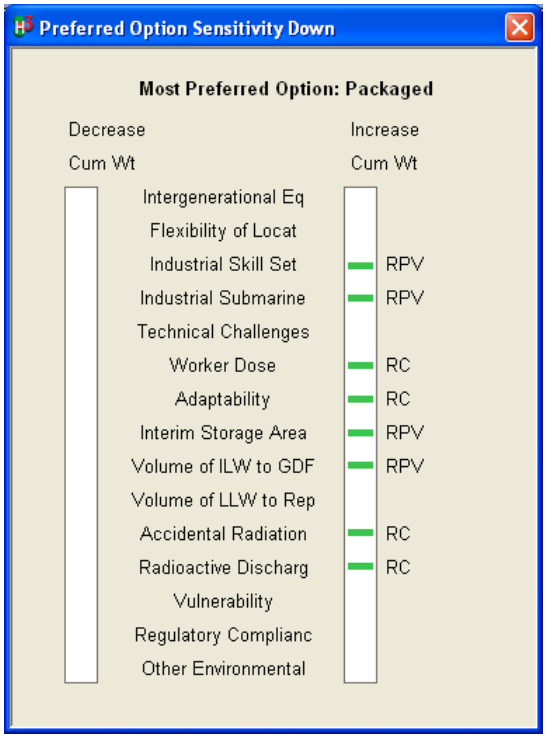

Figure 8: - Initial Sensitivity Analysis

6.2 SENSITIVITY TO SCORING

During the workshop the panel sometimes did not reach a consensus on the scores for one or more options against a particular criterion. These cases were recorded, and are presented here

as sensitivity studies. In each study, the alternative scores offered by the panel are presented, substituted into the MCDA model, and the results presented and discussed.

6.2.1 Sensitivity to the Relative Volume of ILW and LLW

If the volume of waste produced by each of the options is equal (8 boxes of ILW and 8.95m3 LLW), the result becomes more profound, as illustrated in Figure 9.

Study 1			Option		
			1	2	3
Criteria	Scale		RC	RPV	Packaged
Volume of ILW to GDF	No of boxes		8	8	8
Volume of LLW to central LLW repository	m^3		8.95	8.95	8.95

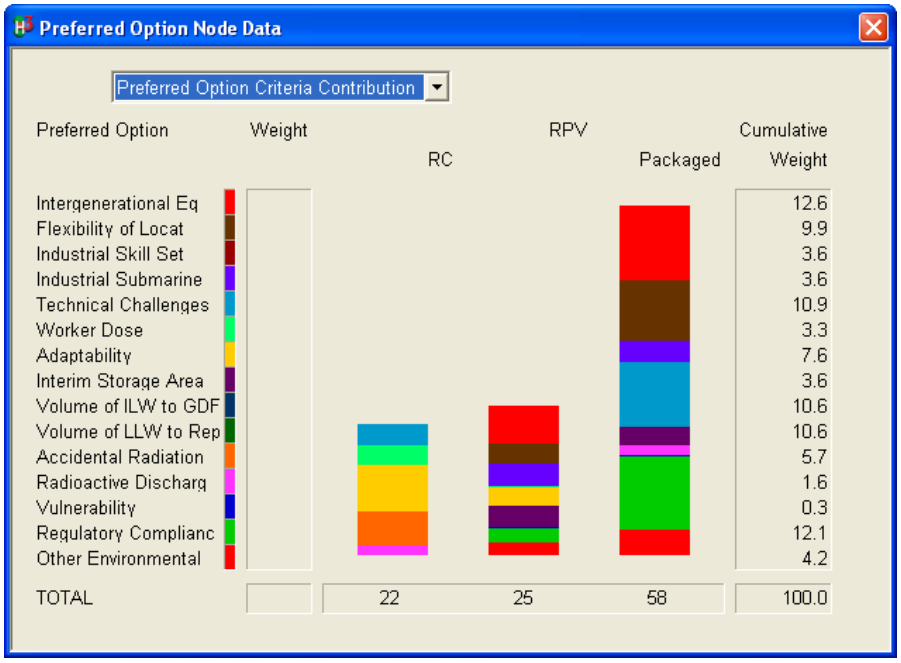

Figure 9: - Result if equal volumes of ILW and LLW produced by all options.

6.2.2 Sensitivity to the Loss of a Workforce with Skills in Operating and Maintaining Nuclear Submarines

Some participants in the decision conference felt that RC storage should score 3 on industrial skill set rather than 7. In this instance, the result becomes more pronounced as shown in figure 10.

Study 2			Option		
			1	2	3
Criteria	Scale		RC	RPV	Packaged
Industrial Skill Set	Subjective	1 to 9	3	7	7

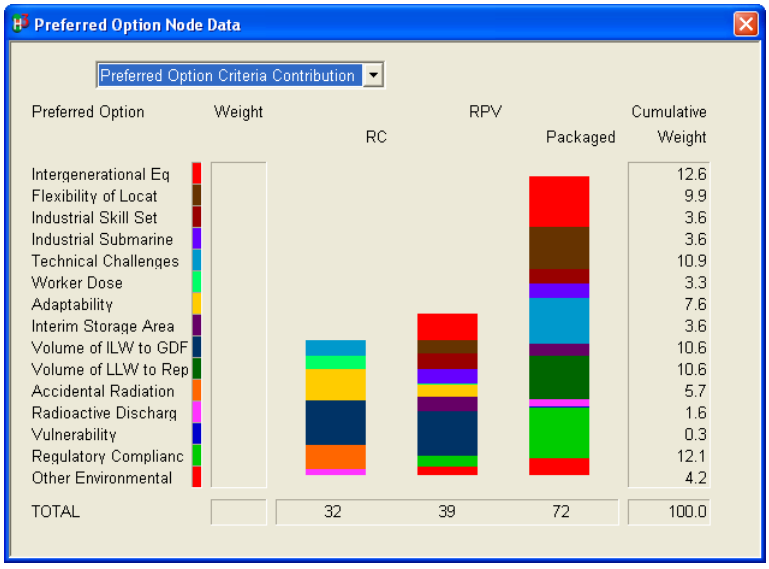

Figure 10: - Result if industrial skill set diminishes before cut-up of RC

6.2.3 Sensitivity to the Difficulty of Transporting the RC Intact

If the difficulty of transport of reactor compartments intact is rated 8, rather than 4, the scores for technical challenges become:

Study 3			Option		
			1	2	3
Criteria	Scale		RC	RPV	Packaged
Technical Challenges	Subjective	81 to 0	16	14	8

The criteria contribution for this case is shown in figure 11.

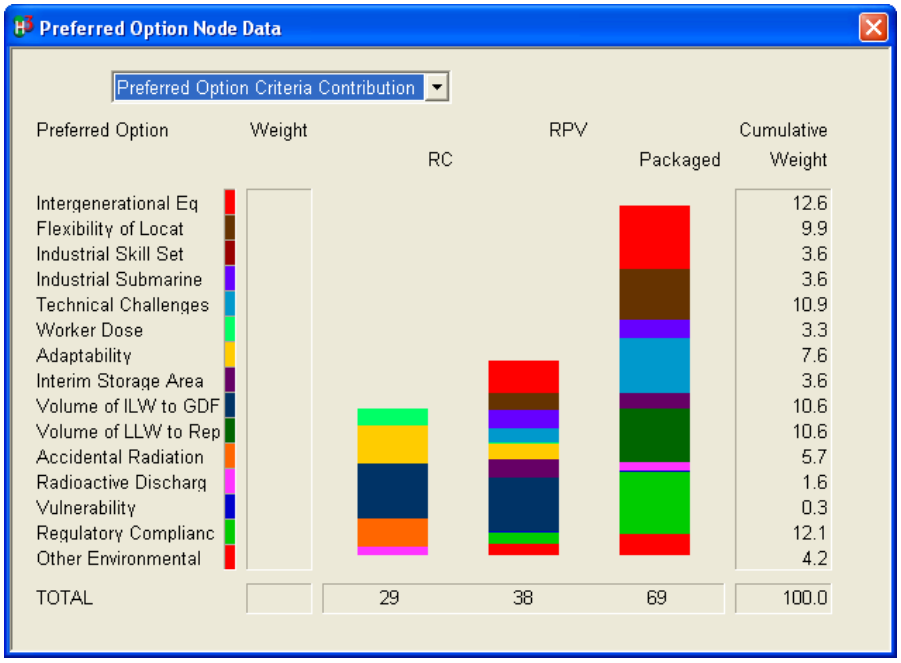

Figure 11 – Criteria contribution for increased difficulty of intact RC transport.

6.2.4 To The Effect of More Straightforward Approvals for Packaged Waste

Some conference participants wished to score packaged waste as “8” rather than “7” on the Regulatory Compliance / Statutory Approvals criterion.

Study 4			Option		
			1	2	3
Criteria	Scale		RC	RPV	Packaged
Regulatory Compliance / Statutory Approvals	Subjective	1 to 9	2	3	8

Since packaged waste is already the most preferred option against this criterion, increasing its score makes little difference to the overall outcome. Indeed when the scores are rounded to integer values, as in figure 12, there is no difference in overall score in this sensitivity case.

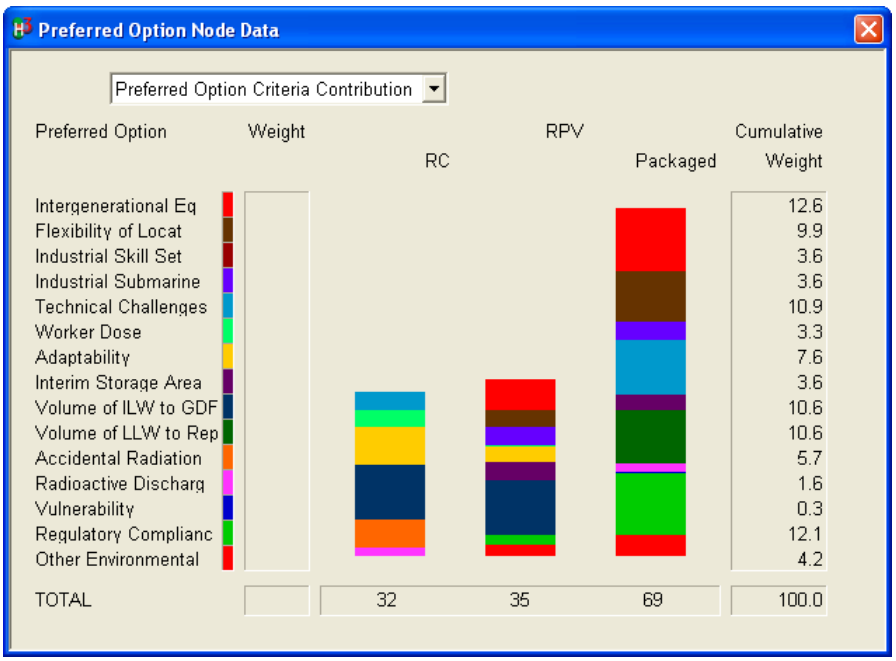

Figure 12: - Sensitivity to Ease of Approval of Packaged Waste Option

6.2.5 To RC Storage Creating Equal Non-Radiological Environmental Impact to RPV Storage

Some participants wished to explore the effect of scoring Options 1 and 2 equally on the criterion “Other / Non-radiological environmental impacts.”

Study 5			Option		
			1	2	3
Criteria	Scale		RC	RPV	Packaged
Other / Non-radiological environmental impacts	Subjective	1 to 5	2	2	1

In this case, the overall spread of scores remains the same, however the difference between options 1 and 2 is reduced as shown in figure 13.

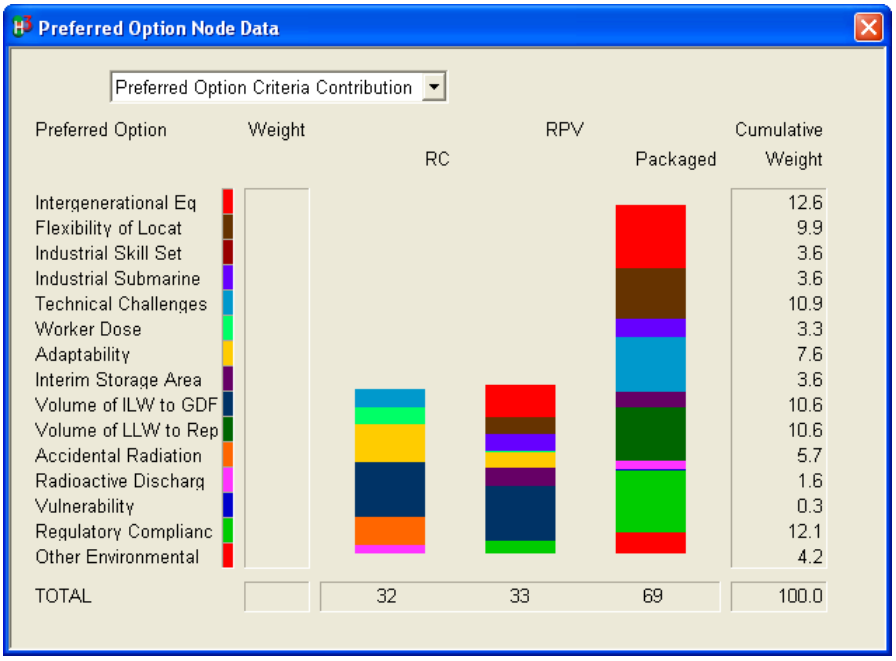

Figure 13: Sensitivity to Reduced Non-Rad Impact of RC Storage

6.2.6 To an Increase in the Volume of LLW Produced

Alternative scores were not recorded for this case during the workshop; however the panel expressed concern that the levels of LLW were not known with certainty. Sensitivity analysis showed that if the volumes for all three options increase in proportion, then the outcome does not change (i.e. the scores remain as Option 1: 32; Option 2: 35; Option 3: 69).

If the volume of LLW produced by RC or RPV storage increases, but that produced by packaged waste does not, then packaged waste is the preferred option by a greater margin.

However, if the volume of LLW produces by option 3 increases, but that produced by options 1 and 2 does not, then the margin of preference for option 3 is reduced as shown in figure 14. In this case the volume of LLW produced by option 3 was increased by 50%. This value was chosen to ensure that option 3 now produced more waste than options 1 and 2. The scores applied were:

Study 6			**Option**		
			1	**2**	**3**
Criteria	**Scale**		**RC**	**RPV**	**Packaged**
Volume of LLW to central LLW repository	m^3		11.59	11.59	13.43

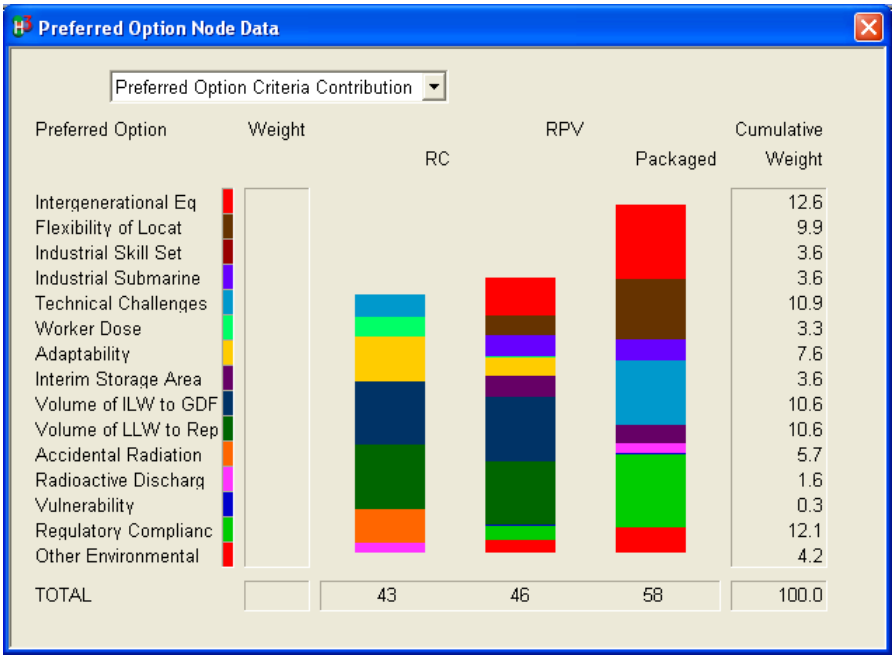

Figure 14 – Outcome if LLW produced by option 3 increases by 50%

6.3 SENSITIVITY TO WEIGHTINGS

Sensitivity to weightings examines the effect of changing the relative weighting assigned to any particular criterion. During the workshop, the panel had differing views regarding the weighting to be applied to the criterion “volume of ILW to the GDF”. The effect of changing this weighting has been explored using the tools provided within the HiView software for this task.

6.3.1 Sensitivity to the Effect of Reducing the Weighting on “Volume of ILW to the GDF”

The decision is insensitive to a reduction in weighting on the volume of ILW to the GDF.

Figure 15 shows the scores of the three options (red, green and blue lines) as the weight on “Volume of ILW to the GDF” is varied from 0 to 100% of cumulative weight. The vertical red line denotes the current weight of 10.6%, which determines overall scores of 32 (Option 1), 35 (Option 2) and 69 (Option 3) as in section 5.17.

The figure shows that a reduction in weight from the current level will only increase the preference for Packaged Waste. A very significant increase in weight to well over 30% of total weighting would be required to make one of the other two options score more highly than packaged waste. In this instance, RC storage would never be preferred to RPV storage, though the difference is small and reduces to zero as the weight on this criterion increases.

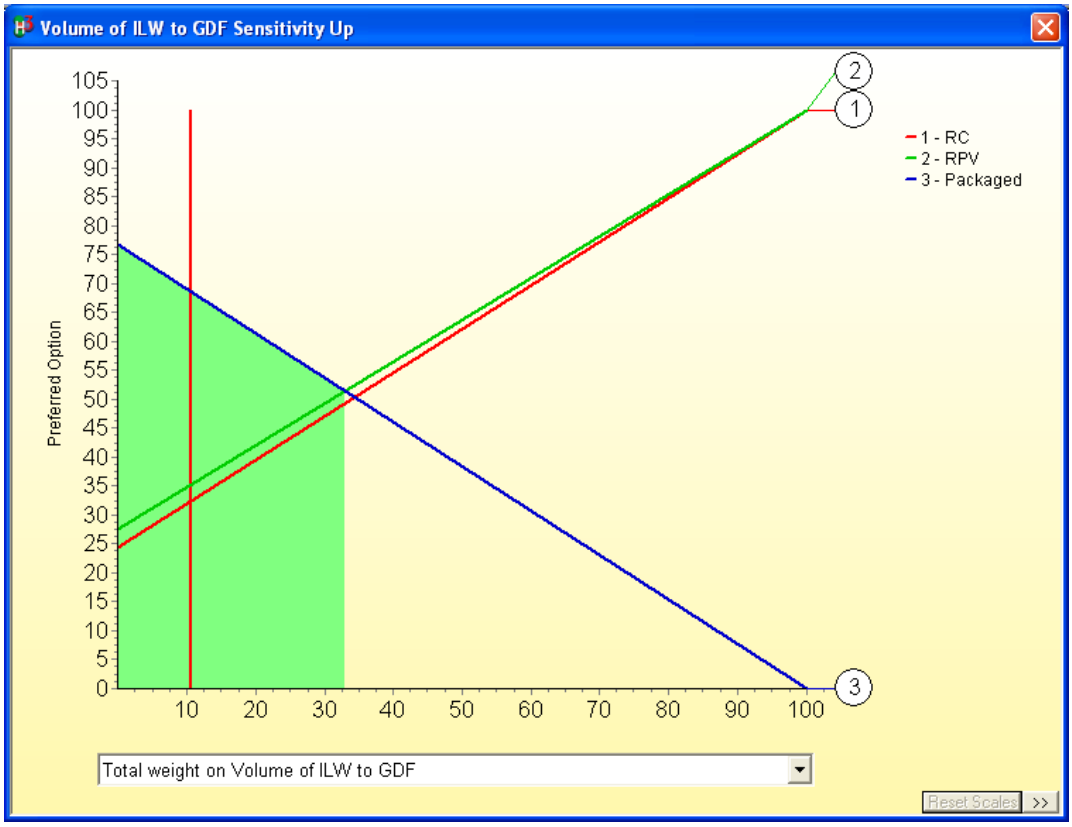

Figure 15: - Sensitivity to Weighting on Volume of ILW to GDF.

7. OUTCOME

Based on the MCDA study conducted during the desk-officers MPOS conference, packaged waste storage was positively differentiated from RC and RPV storage by a significant margin. This particular outcome from the workshop appears robust and was neither reversed, nor the margin of preference significantly eroded in any of the sensitivity studies conducted.

It was also noted that this outcome is unchanged whether weighted or raw scores are considered.

ANNEX A - ASSUMPTIONS

A.1 ASSUMPTIONS RECORDED DURING THE MPOS DESK OFFICERS' CONFERENCE

1. No facility is currently available to the MoD for the disposal of ILW
2. The project assumes that the submarine hull is radiologically "clean" outside of the Reactor Compartment.
3. Decisions need to be made based on today's policy, and hence the assumption is that the definition of ILW will not change between now and entry into the GDF.
4. The packaged waste option would require the waste to be divided into ILW and LLW on the assumption of the GDF criteria for the definition of ILW, since this definition will not exist at the time of packaging the waste.
5. The size of the storage area for option 3 is based on the assumption of 8 boxes of ILW per submarine
6. The storage facilities themselves would not be considered as secondary waste unless there was an escape of radioactive material or additional "radioactive" work was carried out in the store.
7. That all of the options would require the construction of one "hot cell" to undertake the cut-up of the RPV and to package the material into the NDA packages. Additionally, option 2 would require a second hot cell to prepare the RPV for storage.
8. It was deemed unlikely that foreign nationals would be permitted to work on dismantling of UK submarines.
9. It was assumed that there is a viable succession planning policy in the context of this programme.
10. The UK will continue in the business of operating nuclear powered submarines.
11. Transportation to the storage site was assumed to represent a transportation movement between sites, whilst transport to dismantling facility was assumed to be on the same site as the interim storage.
12. A single transportation over-pack will be developed for option 2, which would be re-used for each RPV to be transported.
13. The RC would be drained and hence there will be no increased risk of radiological discharge compared to the other options.

ANNEX B - GLOSSARY AND ABREVIATIONS

B.1 GLOSSARY AND ABREVIATIONS

Term	Definition
A	
ALARP	As Low As Reasonably Practicable
B	
BAT	Best Available Technology
C	
COEIA	Combined Operational Effectiveness and Investment Appraisal
D	
DfT	Department for Transport
DNSR	Defence Nuclear Safety Regulator
E	
F	
G	
GDF	Geological Disposal Facility
H	
I	
ILW	Intermediate Level Waste
IAEA	International Atomic Energy Agency
ISOLUS	Intermediate Storage of Laid-Up Submarines
ISM	In Service Submarines
J	
K	
L	
LLW	Low Level Waste
LL-ILW	Long-Lived Intermediate Level Waste
M	
MPOS	MoD Proposed Option Study
MCDA	Multi Criteria Decision Analysis
MoD	Ministry of Defence
N	
NDA	Nuclear Decommissioning Authority
NP	Nuclear Propulsion

O	
OSPAR	Oslo-Paris Convention
P	
Q	
R	
RPV	Reactor Pressure Vessel
RC	Reactor Compartment
RPA	Radiological Protection Advisor
S	
SDP	Submarine Dismantling Project
SL-ILW	Short-Lived Intermediate Level Waste
T	
U	
V	
W	
X	
Y	
Z	

Frazer-Nash Consultancy Ltd
Stonebridge House
Dorking Business Park
Dorking
Surrey
RH4 1HJ

T +44 (0)1306 885050
F +44 (0)1306 886464

www.fnc.co.uk

Offices at:
Bristol, Burton-on-Trent, Dorchester,
Dorking, Glasgow, Plymouth and
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