ANNEX H - COMPARISON OF OPTIONS - PEST ANALYSIS

INTRODUCTION

1. The PEST analysis which follows compares the four viable options which have been derived from the Annexes F and G after other options have been eliminated. These four options are:

a. Intact Afloat Storage. It is assumed that 4 Basin in Devonport would be the future afloat storage site, other locations being less viable and probably more costly. (See Annex F).

b. Land Storage of Intact Reactor Compartment. Land storage of the separated RC as described in Annex G.

c. Land Storage of Reactor Pressure Vessels/Primary Shield Tank (RPV/PST). Storage of the RPV plus PST combination in a standard Intermediate Level Waste (ILW) store such as RD66 in Rosyth, as described in Annex G.

d. Land Storage of Packaged Waste. As described in Annex G, complete dismantling of the whole submarine with all remaining ILW stored in packaged form ready for disposal in the Deep Waste Repository* (DWR) when available.

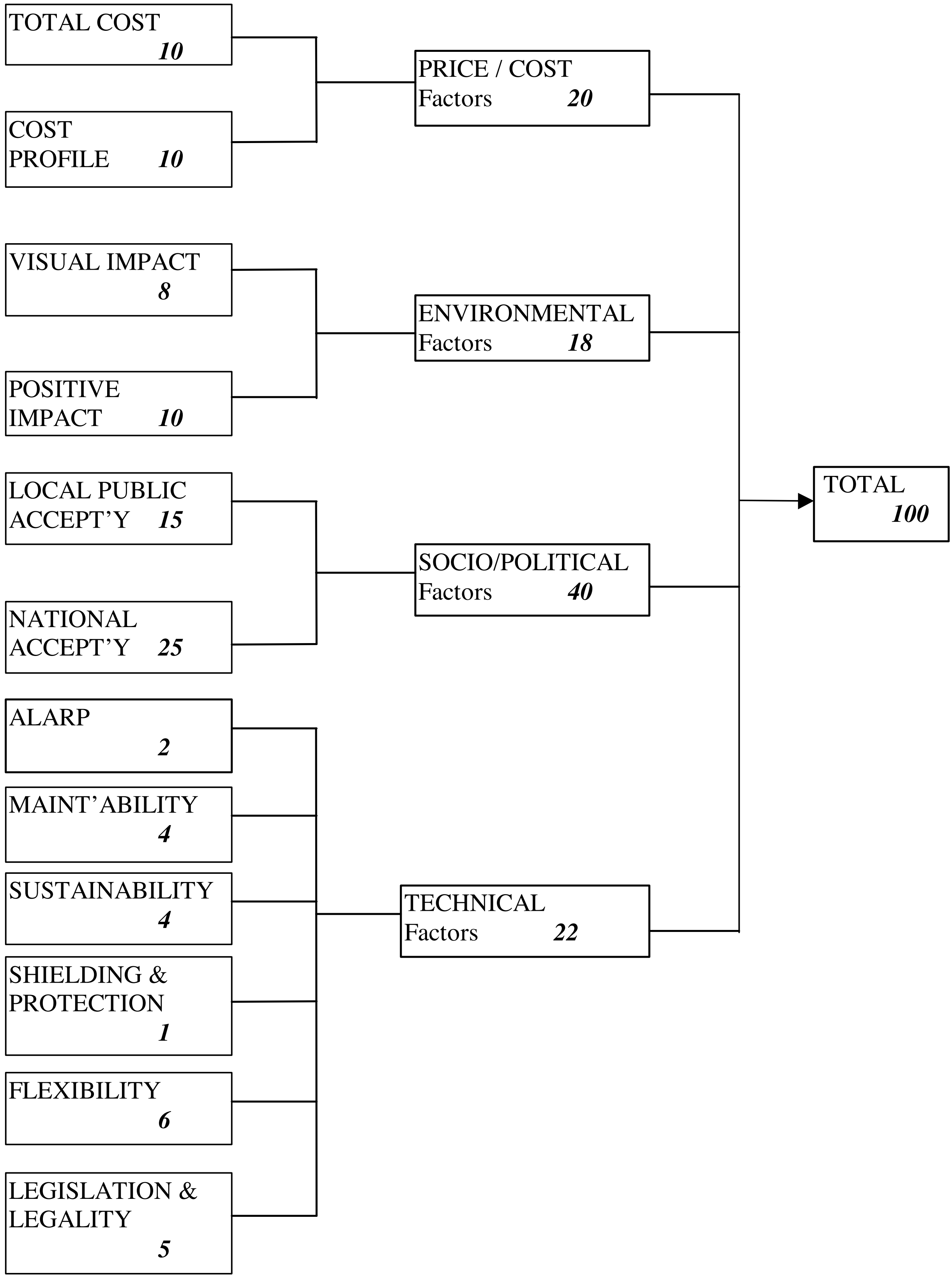
2. Each of these viable options is assessed under the PEST criteria:

a. **P** – Price, or in this analysis COST.
b. **E** - Environmental Issues.
c. **S** - Socio/Political Issues.
d. **T** - Technical Issues.

3. Critical success factors are derived under each of the above headings, as described in Annex C, and the options are then assessed against these factors. A quantitative weighting is allocated to each of the four PEST headings, and the Critical Success Factors contributing to each PEST heading is weighted accordingly (shown in brackets alongside title). Each option is marked out of a total of 100, see Figure H1 below. Other important Success Factors also are discussed but are not allocated a quantitative mark.

Note - A low weighting does not necessary mean that an impact factor is not important, it simply means that for the particular situations under consideration it does not greatly differentiate between the options.
FIGURE H1 - PARAMETERS IN COMBINATION WITH REFERENCE WEIGHTS.

ANNEX H – PEST ANALYSIS (CONTINUED)



4. On completion of the initial PEST analysis, consideration is given to the **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats of each option. This SWOT analysis further aids the process which leads to the conclusions and recommendations detailed in the Main Paper.

5. The analyses in this paper are based on submarines being withdrawn from service to a programme shown in LTR extant in late 1998. This programme is summarised in Appendix H1. The data used to build the cost models which support this PEST analysis is summarised in Appendix H2 where the source of the data is summarised. *It should be noted that the costs given take no account of risk, growth, profit or VAT.* The results of the cost comparisons themselves are summarised in Appendix H3.

CRITICAL SUCCESS FACTORS

PRICE/COSTS (weighting factor 20/100)

Must be affordable. (10/100)

6. Table H1, below, compares the total cost of Afloat Storage with that of Land Storage of Intact RCs, assuming both immediate implementation and delayed implementation. Net Present Value (NPV) is shown for a range of discounting rates around the current treasury rate of 6%, to provide sensitivity, expressing low, medium and high risk to the Land Store option illustrated.

7. Costs of the other two land storage options are not included because they are based on innovative proposals from Industry the costs for which have not been examined in sufficient detail for their use in this comparison. However, the relative costs of these two options are as follows:

a. The maintenance costs of all three Land store options would be similar;

b. Undiscounted, the total cumulative costs also would be similar, but the effect of discounting will be to make storage of RPV/PST and of Packaged Waste higher than that of storing intact RCs because the cost of break-up and packaging would be incurred earlier.

/ Table H1

Table H1 - Summary of Cumulative Total costs to 2049

[Information deleted to allow public release of this Report.]

Cost profile should be manageable. (10/100)

8. Comparative Cost Profiles at a discount rate of 6% are shown in the following tables and charts. Table H2 and its accompanying chart, below, compares Afloat Storage with immediate implementation of Land Storage of Intact RCs. Table H3 and its chart is a similar comparison but with implementation of Land Storage delayed to 2012. The higher capital cost of land storage in the early years is offset by lower running costs so that Land storage becomes cheaper than Afloat Storage at the cross-over point shown in the charts.

/ Table H2

Table H2 - Cost Profile - Afloat Storage vs Urgent Land Storage (implemented from 2000) - NPV, Discounted at 6%

[Information deleted to allow public release of this Report.]

Table H3 - Cost Profile - Afloat Land Storage vs Delayed Land Storage (implemented from 2012) - NPV, Discounted at 6%

[Information deleted to allow public release of this Report.]

9. Increasing or reducing the discount rate would defer or bring forward the cross-over point as shown in the following table.

Table H4 - Effect of discount Rate on Cross-over Point (when cumulative cost of Land Storage becomes less than that of Afloat Storage)

	Date of Cross-over point	
Discount Rate	Urgent Land Storage compared with Afloat Storage	Delayed Land Storage compared with Afloat Storage
Undiscounted	~2020	~2025
3%	~2023	~2027
6%	~2032	~2031
9%	No cross-over	~2037

10. When costs are discounted, deferring expenditure reduces NPV if no other costs are incurred. However, Tables H2 - H4 above illustrate that, for discount rates up to about 6%, the costs of continued afloat maintenance more than offset the advantage which would otherwise be gained from delaying the implementation of land-storage, thus favouring the early-land-store option. At 9%, the effect of discounting over-rides these savings making delayed land storage more attractive. The importance of selecting an appropriate discounting rate is discussed further in Annex I.

ENVIRONMENTAL IMPACT (weighting factor 18/100)

Visual Impact (8/100) - *the visual impact of the chosen option should be acceptable.*

Afloat Storage

11. The Afloat Storage Option under consideration utilises the continued use of the Main Basin at Rosyth for the 7 vessels already laid up, 3 Basin in Devonport followed by 4 basin as

the recommended future site. In these areas the visual impact in considered to be minimal, nuclear submarines whether decommissioned or not do not stand out in a Naval Dockyard. Although Rosyth will cease to be a nuclear refitting dockyard, providing its ship refitting business remains, the visual impact should remain manageable.

Reactor Compartment Land Storage

12. The visual impact will depend largely on the venue for the store, if the "Dutch barn" storage facility is in a brown field site the visual impact will be minimal. Green field sites would have a greater impact and therefore the choice of site should be carefully considered.

RPV/PST Storage and Packaged Waste

a. The visual impact of this option would be minimal, initially it would utilise existing ILW stores and as the numbers increase extensions to these facilities would be the most likely way forward.

Positive (10/100) - *The option should give a positive environmental outcome.*

13. This is a subjective area and some assumptions of what the general public/media/pressure groups perceive as a positive environmental impact has been drawn from academic research, the conclusions of which are largely covered in the Pressure Groups Annex D.

14. Metal recycling is generally perceived as being eco-friendly, it reduces the requirement to extract and refine the primary ore from the earth, thereby reducing the negative environmental impact caused by scaring the earth with open cast mines, polluting the atmosphere with the excavation and transportation vehicles exhaust (which also results in more oil excavation) and using up valuable resources which would otherwise be available for future generations.

Afloat Storage

15. Although afloat storage would eventually recycle the non radioactive elements of the vessel, this positive element would not occur until at least 2038, the earliest date when the repository can be available. The sooner recycling occurs the more positive the benefits are perceived to be, therefore the positive environmental aspects of this option will be diminished by the delay. In addition, a promise to conduct recycling eventually, leaves the MoD open to ridicule, actual recycling would have a far more positive impact.

Reactor Compartment Land Storage

16. This option would allow the immediate recycling of a large percentage of the residual hull and structure of the nuclear submarines.

RPV/PST Storage and Packaged Waste

17. These options would also result in the recycling of much of the RC and Primary Plant.

SOCIAL / POLITICAL ISSUES (weighting factor 40/100)

Acceptable to Local Population (18/100) - *the option must be linked to positive outcomes for the local population if it is to be generally accepted and the level of objections are to remain at a manageable level.*

Afloat Storage

18. The actual option does not generate a great deal of extra work or revenue in the storage area, therefore the positive economic consequences of storing laid up submarines for the local population is negligible. If the option is to be accepted in an area within manageable limits it needs to be linked to wider economic benefits gained from nuclear submarine operation and maintenance, whilst in service.

19. This makes Devonport the obvious choice as an afloat storage venue, with the imminent cessation of nuclear refitting work in Rosyth, the only Dockyard conducting nuclear submarine refits will be Devonport, it is also an important operational base and becomes the only dockyard capable of conducting a DDLP.

20. For this reason there is a strong probability that Rosyth will see increasing levels of protest, which could reach a level where they cease to be manageable. The Dockyard will cease to gain benefit from the refitting and decommissioning of nuclear submarines in the near future, when this happens it is likely that demand for their removal will grow. [Information deleted o allow public release of this report.] Contingencies should be put in place to limit this risk, either by planning for the movement of the vessels to another location or early break up and storage of the waste in another form (Annex G). It should be noted that if it became necessary to move the vessels to Devonport the available storage space in 3 Basin would be exhausted immediately.

Reactor Compartment Land Storage

21. The work involved in this option would provide some economic benefits to the local population, cut-out and preparation of the RC for land storage, if combined with the dismantling is a reasonable package of work and could make the option palatable.

22. A storage site remote from the cut-out area would provide only marginal economic benefit. It could be linked to future break-up and packaging work on completion of the storage period, although it is debatable whether the promise of future revenue would have an appreciable positive affect. It may be possible to store the RCs in areas already used for the storage of radioactive waste, storage at Sellafield or an existing MAGNOX site may not attract the same level of criticism as that levelled at a site with no nuclear storage history.

23. As with afloat storage, a site in an area which gains major benefits from nuclear submarines in general such as Devonport, VSEL, and the Clyde would attract less protestations than other sites.

RPV/PST Storage and Packaged Waste

24. These options have already attracted an unsolicited bid from a commercial company and therefore it can be assumed that the economic benefits will sustain a permanent workforce. This economic benefit to the local area will make them more acceptable and less prone to criticism that the other options, however, in areas without a history of nuclear work or experience of nuclear submarines, the level of protest could still prove to be unmanageable.

Acceptable to General Population ***(22/100)*** *- For the option to be sustainable the level of media criticism and protestations from Environmental Pressure Groups particularly Greenpeace must be at a manageable level.*

Afloat Storage

25. With the deferment of the NIREX DWR the period of time laid up boats will be in afloat storage has increased substantially, this has given rise to the perception that afloat storage is the final solution; branding the policy as the MoD's "do nothing" option. Criticism from a number of sources on this theme has been levelled and show no sign of abating.

26. The SSA receive a number of questions on the subject of laid up submarines, it appears that the general perception is that afloat storage is far more costly than it actually is, and may have an environmental impact. As the number of vessels in afloat storage continues to grow and the period an individual vessel has been in afloat storage increase, it is probable that criticism of the strategy will continue to increase and with it the dissatisfaction of the general public.

27. Research has found little evidence of any group or individual projecting positive views on the afloat storage option outside.

Reactor Compartment Land Storage

28. The land storage of radioactive waste on land seems to find some favour with many Pressure Groups including Greenpeace, who appear positively disposed to a store and monitor strategy on land.

29. The actual dose up take involved in the option is relatively low and certainly compares favourably with the present afloat storage strategy, indeed the lack of a maintenance requirement may well result in lower dose accumulation over total storage period. As the pressure groups are critical of any exposure to radioactivity this option again should be relatively well received.

RPV/PST Storage

30. This option would have similar advantages to RC land storage in that it is broadly in line with the store and monitor strategy proposed by Greenpeace.

31. The option could receive some criticism from the dose up take resulting from the cut-up of the RC and the decontamination process, it unlikely that this would be unmanageable providing an acceptable ALARP case can be made.

Packaged Waste

32. Again this option has similar positive qualities in this regard, it may be seen as unnecessary to packaged the waste at this early stage, when the repository is still a long way off, but providing a successful case can be made under the principals of ALARP, criticism of the option should not present major difficulties.

33. The Pressure Groups have thus far opposed the creation of a deep waste repository*, therefore packaging waste ready for disposal in the facility may provoke extra attention and criticism from these groups, who may see this option as premature.

TECHNICAL ISSUES (weighting factor 20/100)

Maintainability (4/100) - *Maintenance facilities and trained personnel available to conduct maintenance appropriate to sustaining the specific option.*

Afloat Storage

34. The Afloat Storage option has the highest maintenance burden. The vessel will require daily checks in order to ensure securing arrangements are correct and draft marks are unchanged, an annual and 5 annual maintenance package will also require to be completed. In addition a dry dock with an appropriate nuclear licensed[66] will be required to conduct the 10 yearly dockings. The dockings are necessary to conduct surveys and re-preservation of the submarines ballast tanks, these items are manufactured from relatively low quality steel which is much thinner than the pressure hull as they see only limited differential pressure during operation.

35. As the numbers of laid up submarines continues to increase the impact of the 10 year dockings on the rolling docking programme becomes increasingly significant, dry docks and associated infrastructure are often in short supply, and usually operate at full capacity in support and maintenance of the fleet. (See Appendix F1 - Docking Histogram).

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[66] Whether or not the dry dock needs to be licensed is the subject of some debate, at time of writing the views of a number of regulators were sort and the general conclusion was that this would be the case.

[*] Refer to statement on long-term management of radioactive waste on front cover of this report

Reactor Compartment Land Storage

36. An RC stored in a relatively simple weatherproof building would be virtually maintenance free. The Reactor Systems contained within the RC are of necessity very high quality low corrosion steels, consequently deterioration would be infinitely slow.

RPV/PST Storage

37. The package its-self would be virtually maintenance free.

Packaged Waste

38. As above.

Sustainability (4/100) - *The NIREX Deep Waste Repository*will not be available until 2038, it is possible that it may be delayed beyond that date or cancelled altogether. The option must therefore be sustainable in the long term.*

Afloat Storage

39. Afloat storage is time sensitive, as the length of time in storage increases the maintenance costs will increase. In this context, any delays to the DWR availability date, currently 2038, will increase the maintenance costs per vessel. Additional Afloat Storage Space will need to be allocated and pressure on the availability of suitable dry docks to conduct the 10 yearly dockings will increase.

Reactor Compartment Land Storage

40. Provided that suitable sites can be allocated for the provision of additional RCs this option should provide indefinite storage, without an increase in the cost per unit overtime. Update of the storage facility would be necessary in the long term, however, its relatively simple construction should keep costs relatively manageable.

RPV/PST Storage

41. As with the previous option this storage strategy should be sustainable indefinitely without an increase in storage costs per unit. The space occupied would be less than the RC land storage option although the cost of maintaining and building additional Intermediate Level Waste Stores are likely to be higher.

Packaged Waste

42. Storage should be possible indefinitely with this option. In addition it should be possible to store the package less expensive facilities as the radioactivity decays and requirement for shielding decreases. The time interval before this benefit could be realised will depend on the amount and type of shielding used in the waste package.

Protection and Shielding (1/100) - *The radioactive waste must be contained and shielded such that it does not present a hazard to the environment or the General Public and dose rates to maintenance personnel is acceptable under ALARP.*

Afloat Storage

43. With this option the shielding is provided by the steel of the Primary Systems, Primary Shield Tank; the lead and boronated polythene blocks of the RC bulkheads, Pressure Hull[67] and Tunnel; the thick high quality steel of the pressure hull and bulkheads themselves and the sea water in which the vessels float. This shielding is extensive and results in negligible increases in radiation external to the hull and in compartments adjacent to the RC. Radiation dose increase to the general public, due to the presence of laid up submarines is so small as to be immeasurable. It should be noted that the RC contains shielding designed to allow a crew to live and work in adjacent compartments, whilst the reactor is at power, therefore it is more than adequate to shield and protect when containing only residual Intermediate Level Waste.

44. The submarines hull is built to withstand the pressures and stresses associated with operating at high speed whilst at great depth, the pressure hull which surrounds the compartment could remain an effective enclosure for radioactive waste for many hundreds of years.

Reactor Compartment Land Storage

45. The Reactor Compartment alone would provide essentially the same standard of shielding and containment as the whole vessel, providing a suitable canning plate was welded to each end of the separated RC. The lack of sea water, which provides additional shielding around the bottom of the Hull will result in higher radiation readings immediately under the RC. Access to this area would, therefore, have to be controlled especially in the early years of storage, similar measures to those put in place during the dry docking of commissioned vessels would be necessary. The implications of this are considered minor.

46. The Reactor Compartment (RC) which houses the radioactive elements of the Naval Nuclear Steam raising Plant, is extremely well shielded and robust. This combination of strength and high quality shielding combine to make the RC an excellent container for the storage of radioactive waste.

47. If housed in a basic weather proof store the pressure hull, canning plates and RC bulkheads could provide containment to the radioactive waste for many hundreds of years if required.

RPV/PST Storage

48. The radioactivity of the waste contained in this package increases in intensity nearest the centre of RPV (closer to the area which once contained the core). The radioactive waste is

[67] Pressure Hull Shielding (lead and polythene) does not extend below the waterline.

therefore self shielding to a degree, although radiation levels will still necessitate storage in shielded ILW store.

49. Shielding could be increased by replacing the Potassium Chromate solution held within the Primary Shield Tank with a substance which attenuates gamma more effectively, although the benefits would have to be balanced against the increased radiation dose received by the workforce. The RPV is manufactured from high quality low alloy steel and is over 4 inches thick. Containment could be maintained indefinitely.

Packaged Waste

50. Shielding would be provided by arranging the packaged waste to maximise self shielding and by surrounding the waste with a suitable shielding material such as high density concrete. A cost balance will need to be made between the amount of external shielding required and the packaging costs. It is highly likely that this option would utilise the NIREX 4 metre box, this is a combined transport and disposal container which is robust and offers corrosion resistant. It would provide shielded containment indefinitely if stored in a weather proof building. It is likely that this option would only require a rudimentary storage facility similar to that envisaged for the RC land storage option.

Flexibility (6/100) - *The option should be able to adapt to new storage methods and/or disposal strategies - the storage option should allow transportation to new storage or disposal sites.*

Afloat Storage

51. Only minor modification is necessary to prepare the vessels for interim storage afloat, therefore, it remains able to adapt to any innovative options which may arise in the future. Transportation to an alternative site would be relatively straightforward, and could be achieved by a number of methods. The vessel could be towed to its new destination after some minor alterations, alternatively a barge or lift ship could be utilised for the task. A safety case would be required for the move but this should be a low risk item as commissioned nuclear submarines have been successfully towed in the past and Dreadnought was towed from Chatham to Rosyth on completion of its DDLP.

Reactor Compartment Land Storage

52. Storage of the intact RCs retains the flexibility to adapt to lower cost alternatives in the future[68]. As this option will allow interim storage to be continued until the optimum benefit[69] from natural decay is gained, final break up and packaging costs will be lower due

[68] Radiation dose, and the costs involved in RC break-up and waste packaging have not yet been incurred. Safer and cheaper processes may become available.
[69] The point at which the benefits from further radioactive decay are negligible in the medium term.

to the simplification of the process[70]. It is also possibility that the RC will constitute the final disposal package without the requirement to break up and package the individual radioactive items, this would be very advantageous both in terms of cost savings[71] and preventing radiation dose to a break-up work force.

53. The RC package weighs up to 850 tonnes and measures approximately 10 metres x 8 metres, transportation outside the cut-out area would therefore necessitate sea transportation either by barge or lift ship. Transportation by Land would be possible over short distances. Transport regulations specify activity levels and container requirements for the shipment of radioactive waste, the strength and high quality shielding of the RC should make compliance with the regulations relatively straightforward.

RPV/PST Storage

54. Unlike the previous options, much of the preparation for final disposal has been completed and therefore flexibility to adapt to other initiative has been diminished. The cut-up work force have already been exposed to radioactivity and would have accumulated some radiation dose, it is still possible that savings can be made with respect to the final ILW packaging phase.

55. The RPV/PST combination would require an additional shielded sleeve or container to be manufactured before it could comply with the transport limits for radioactive waste. Although the package would be smaller and lighter than the complete RC, it would still weigh up to 100 tonnes, therefore, unless further dismantling was carried out long distance transport by sea would still be necessary.

Packaged Waste

56. With this option all flexibility to adapt to new storage or disposal strategy has been lost.

57. Transportation of the packaged waste should not present major difficulties, additional shielding may be required in order to meet transport regulations. The quantity of shielding will be dependent on the method used to package the remaining radioactive waste, and the storage time elapsed (allowing natural decay to reduce radioactivity to allowable levels).

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[70] Lower radiation levels would simplify the break up process and reduce the requirement for biological shielding of the final waste package. In addition, the machining of the RPV cladding would no longer be necessary after an interim storage period of 60 years.

[71] break up and packaging costs would be saved

Legislation and Legality (5/100) - *The option must comply with current legal and legislative requirements governing the storage of radioactive waste. It should be sustainable against probable future changes to the legislative requirements.*

Afloat Storage

58. A number of problems exist for the Afloat Storage option in this area. At present for the vessels already in afloat storage we are covered by Crown exemption, and act as if the Act applied, however, possible future changes concerning Crown exemption from NIA65 and RSA93, could cause a number of difficulties:

a. NIA65 states that "*a nuclear site licence shall not be granted to any person other than a body corporate and shall not be transferable*". The MoD has never applied for a nuclear site licence and at present there is no mechanism for creating a body corporate within the organisation. It is likely, therefore, that the MoD would prefer to pass control of the submarines to a contractor, who would then need to apply for a nuclear licence. For the Afloat Storage option it may be difficult to find a contractor willing to undertake this commitment at an acceptable cost to MoD.

b. De-licensing the site is also costly and would be complicated by the fact that an area covered by a body of water has been licensed.

c. Consultation with a number of nuclear regulators has indicated that the 10 year dockings will need to be conducted in a dock holding an appropriate nuclear licence. As the number of vessels continues to grow this will increase pressure on existing dock space and may impact on the upkeep of the commissioned submarine fleet.

Reactor Compartment Land Storage

59. In the RC land store option, the control and management of the site would almost certainly be contracted to a private company, this would simplify the act of licensing and allow existing expertise in the private sector to be utilised. Licensing in this instance should be relatively straightforward; the *body corporate* will hold liability making the option relatively low risk in terms of the effect which crown exemption changes would have upon the strategy.

60. If this strategy was adopted, the cut out, storage, cut up and packaging would be conducted on licensed sites allowing the entire process to be legislated under NIA65 and regulated by the NII. A single regulator would simplify and streamline the policing of the process which would reduce the overall legislative risk to the programme. Only transport and final waste disposal will be legislated by RSA93 with regulation by the EA/SEPA.

RPV/PST Storage and Packaged Waste

61. With these options the management and control of the stored radioactive waste would almost certainly be contracted to a private company[72]. This would make the licensing of the storage area under NIA65 relatively straightforward and as a consequence the risks associated with possible future changes in Crown exception from NIA65 would be considerably reduced.

ALARP (2/100) - *The dose rate associated with the option must be able to put forward an acceptable case under the principals of ALARP.*

Afloat Storage

62. Afloat Storage allows the levels of radioactivity within the RC to reduce by natural decay, before RC is cut-up and preparation of the remaining radioactive waste for packaging is commenced. Store and decay is currently the nuclear industries accepted strategy, it is difficult to see how cut-up after this period, providing that best practise is used during the process, would not be acceptable under the principals of ALARP.

Reactor Compartment Land Storage

63. Reactor compartment land storage would not cause an appreciable increase in dose uptake against the present afloat storage option. The majority of the preparation work carried out on the RC for land storage is outside the boundary of the biological shield and therefore the additional dose intake by the workforce would be minimal.

64. As with the afloat storage strategy, it is difficult to see any circumstances under which this option could be unacceptable under the grounds of ALARP.

RPV/PST Storage

65. Immediate cut up of the RC following defuel and decontamination, will result in a higher dose rate to the break up workforce than would be incurred after a period of interim storage.

66. In order to make this option viable aggressive decontamination of the primary circuit would have to be carried prior to cut-up and disposal of the primary plant for this option to be acceptable under the ALARP principals. The decontamination process its-self would create exposure and dose up take by the break up work force, it would also result in contaminated resin which would have to be stored alongside the RPV/PST package. This option does stray from the nuclear industries 3 phase disposal strategy, in that it prepares and disposes of radioactive waste inside the biological shield, before a period of store and decay has been completed.

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[72] At present the ILW stores are under the control of DML and BRDL in Devonport and Rosyth respectively.

67. Not withstanding the above, the option remains viable providing a successful ALARP case can be made. As long as Industry are confident that this can be achieved and will take any financial risks associated with any failure to make a successful case, the option should not be penalised in the analysis under the ALARP principal.

Packaged Waste

68. Cut-up and packaging of the RPV/PST immediately after the DDLP process would necessitate the need for remote process and packaging facilities in order to make dose rate up take acceptable.

SUCCESS FACTORS

Option broadly in-line with that adopted by Nuclear Industry. *If the chosen option is broadly inline with strategies used and approved by the nuclear industry in general, it is likely to be less contentious and more likely to be acceptable to all concerned and reduce any Socio-Political risks associated with the option.*

69. The decommissioning policy currently adopted by the nuclear industry is 3 phase decommissioning:

a. Stage 1 is defuelling and transfer of fuel off site;

b. Stage 2 is dismantling and removal of outer superstructure and buildings external to the reactor's biological shield. This stage is normally followed by the "*safestore"* period of up to 135 years depending on the type of reactor[73];

c. Stage 3 is final clearance of the biological shield, internal plant and reactor island, packaging of remaining radioactive waste, and shipment to repository.

70. The 3 phase decommissioning strategy adopted by the UK Nuclear Industry, is similar to that proposed for the land storage of Reactor Compartments. The *safestore* of the RCs being conducted after the removal and scrapping of the forward and after ends of the vessel, is comparable to stage 2. By devising a strategy which follows similar principals the Socio-Political risks should be reduced. The RPV/PST & Packaged waste options differs because it breaks up the reactors biological shield[74], prior to the interim storage period.

[73] National Audit Office - The cost of Decommissioning Nuclear Facilities 4 Jun 93, Part 2 Decommissioning Practice.
[74] The biological shield is provided by the shielded bulkheads and pressure hull of the RC.

Optimum Storage Period - *A storage period of 60 years has been recommended in the Main Paper . This would double the storage time of the current strategy and have a significant impact on the 4 options chosen for analysis if this time period was adopted as an integral part of a future storage strategy.*

Afloat Storage

71. Afloat Storage would not adopt well to this length of time, Dreadnought would be the first boat to be broken up and disposed of and this would take place in 2043, by this time a total of 32 will be laid up in afloat storage, and even if 4 Basin Devonport has been utilised for storage, an additional storage venue will still be required.

72. This number of vessels will cause difficulties:

a. The effect on the rolling docking programme will be considerable, over 3, 10 yearly dockings will be required per year by this time.

b. The cost of the dockings will rise 18 submarines will have conducted their 30 year docking by this time, [Information deleted o allow public release of this report.].

c. The visual environmental aspect will increase and the Social/Political problems associated with this option will be exacerbated as the numbers continue to grow.

d. General maintenance on the vessels will create a ever increasing strain on existing dockyard resources.

Reactor Compartment Land Storage

73. This option is not "time sensitive" in that the cost and maintenance burden per unit does not increase appreciable overtime. This option has low ongoing maintenance costs and providing the initial site has sufficient space for additional units, storage could continue virtually indefinitely without an appreciable increase in costs per unit.

74. As this store and monitor strategy is favoured by Environmental Pressure groups (Supported recently by their opposition to a DWR - In reply to the findings of the HOLSC on radioactive waste - Reference Radio 4), it is unlikely that an extension to the storage period would unduly affect this option.

RPV/PST Storage

75. Storage for an extended period would be relevant to this option because the reduction in radioactivity would simplify the final packing of the remaining ILW (Main Paper).

76. The existing ILW stores would need to be extended, additional stores would need to be built.

77. Overall, as for the RC land storage option, extension to the storage period should not unduly affect this option.

Packaged Waste

78. The length of time the packaged waste is kept in storage should only be governed by the availability of the repository and the ability of the package to meet the transport regulations external activity levels.

PEST MARKS AWARDED FOR EACH OPTION

79. Quantitative marks for each of the four options were derived from the foregoing analysis, in accordance with the marking structure shown in Figure H1 above. The following Figures indicate how the total marks are derived:

a. Figure H2 – Afloat Storage of Intact Hull;

b. Figure H3 – Land Storage of Intact RC;

c. Figure H4 – Land Storage of RPV/PST;

d. Figure H5 – Land Storage of Packaged Waste.

/ Figure H2

FIGURE H2 - AFLOAT STORAGE OF INTACT HULL - AWARDED MARKS

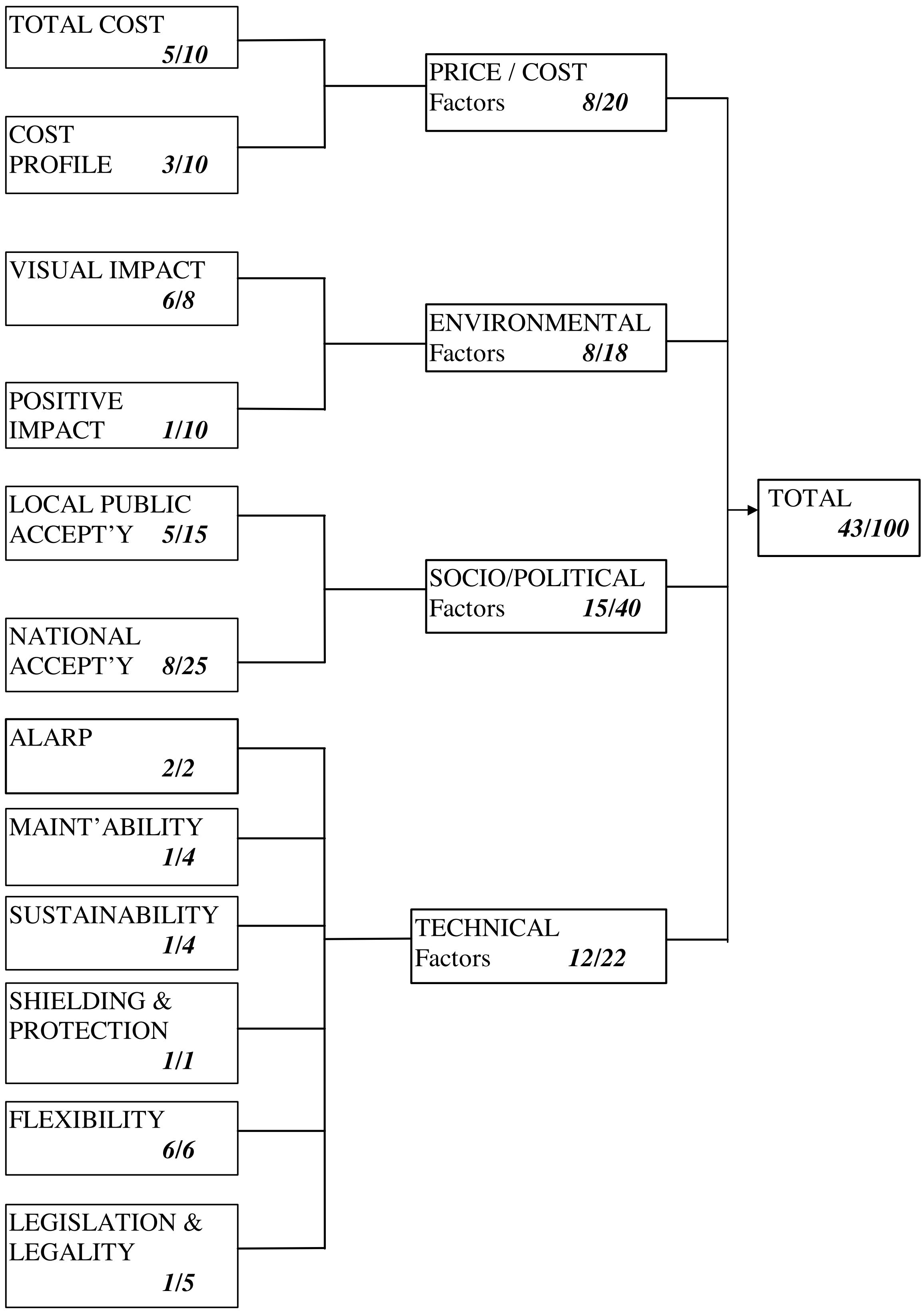


FIGURE H3 - LAND STORAGE OF INTACT RC - AWARDED MARKS

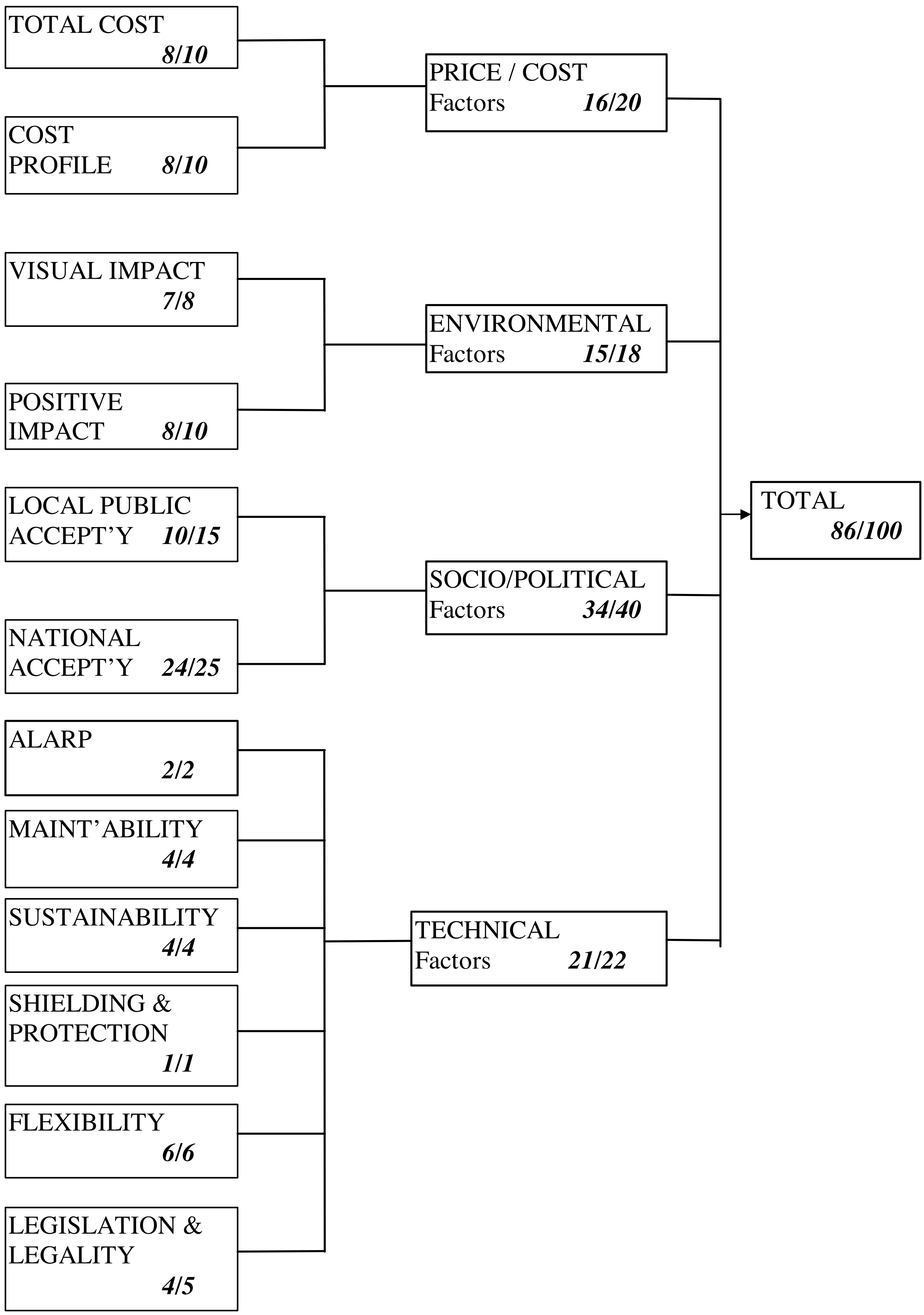


FIGURE H4 - LAND STORAGE OF RPV/PST - AWARDED MARKS

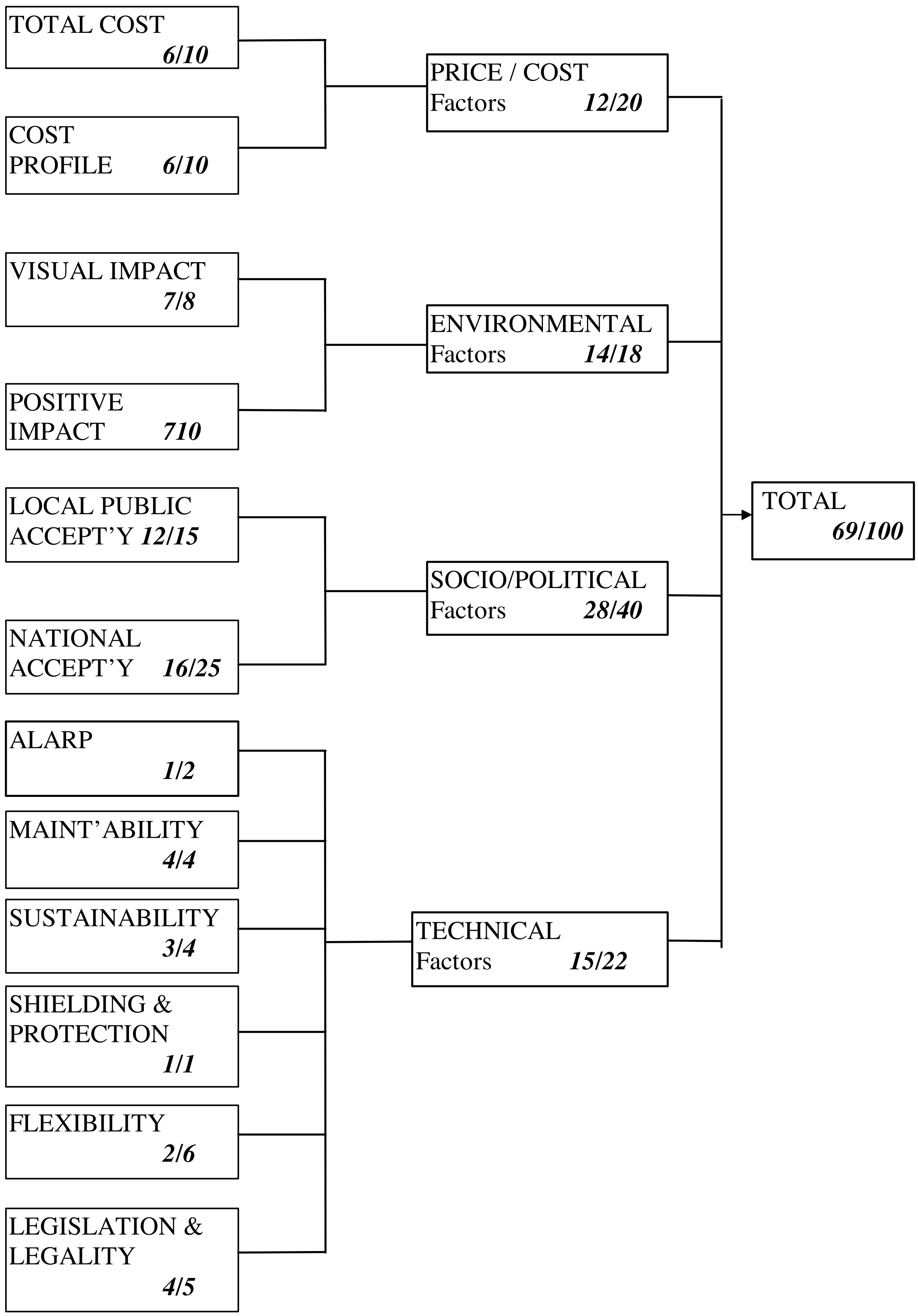
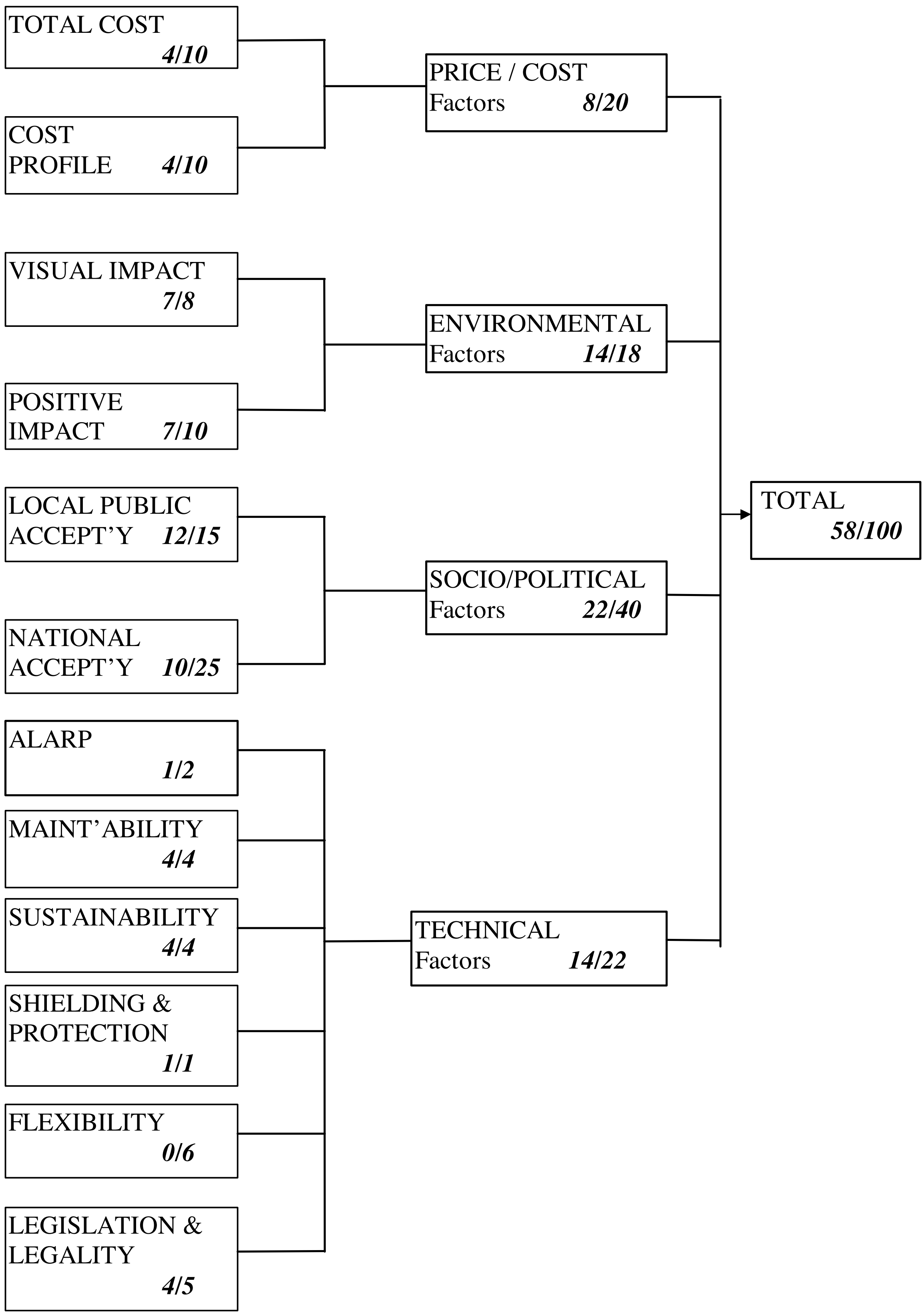


FIGURE H5 -LAND STORAGE OF PACKAGED WASTE - AWARDED MARKS



S.W.O.T. ANALYSIS

80. The "SWOT" analysis in the following seven pages summarises the inherent **S**trengths and **W**eaknesses of each of the four options, the **O**pportunities they present, and how they would respond to possible **T**hreats. This analysis complements the foregoing PEST analysis and contributes to the conclusions and recommendations in the main report.

OPTION	STRENGTHS	WEAKNESSES
Afloat Storage of Intact Vessel	1. Already Established and largely accepted strategy	1. Criticised as "Do nothing" option.
	2. Low start up costs - Ex defuelling, the cost of preparing a submarine for continued afloat storage is about 1/3 of the current DDLP workpackage cost.	2. Storage space until 2012 - new storage space will be required after this date if strategy is to continue.
	3. Low environmental impact.	3. Rising maintenance costs - as the period in storage increases the maintenance burden per vessel will increase.
	4. Defers break up costs - financial gain	4. No early recycling benefit.
	5. Store and decay - gains benefit from natural radioactive decay.	5. Berthing Cost -occupation of the berths result in an opportunity cost i.e. It could be used for another purpose.
	6. Flexible - The storage strategy can change to a favoured option in the future.	6. Docking requirement -a licensed dry dock is required for each vessel every 10 years.
	7. Transportable - As the vessel its-self is the storage container it can be moved by tow/barge or lift ship.	

OPTION	STRENGTHS	WEAKNESSES
Land Storage of Reactor Compartments	1. Positive initiative - This option would counter the "do nothing" accusation.	1. New - This is a new storage option, which will attract attention.
	2. Early recycling - Environmental pressure groups will attach value to early recycling of the forward and after ends of the submarines.	2. Suitable storage venue will need to be identified.
	3. Low maintenance - The ongoing maintenance costs of this option are low. 4. Low Environmental impact. 5. Broadly in line with store and monitor policy favoured by Greenpeace. 6. Similar strategy carried out successfully in USA and France. 7. Transportation - The RC is a suitable transport container for the radioactive matter stored inside. 8. Flexible - The storage strategy can change to a favoured option in the future.	3. Transportation - transport remote from cut out venue will require a barge or lift ship. 4. Significant set up costs.
	9. In line with 3 phase disposal strategy adopted by the nuclear industry.	

OPTION	STRENGTHS	WEAKNESSES
Land Storage of RPV/PST	1. Positive initiative - As for RC storage.	1. Dose intensive - may have difficulty justifying under ALARP.
	2. Early recycling of the entire vessel.	2. Requires a shielded ILW store.
	3. Can utilise existing ILW store in Rosyth for the first 3 - 4 vessels.	3. Transportation out of the cut up location will require the manufacture of a shielded container.
	4. Store and monitor strategy - strength as for RC storage.	4. High initial costs, financial benefit from deferring RC cut-up lost.
	5. Maintenance of actual waste package will be virtually zero.	5. Flexibility to change storage option diminished.
	6. Inspection and monitoring straightforward	6. Requirement to decontaminate
	7. Positive initiative - As for RC storage.	7. Dose intensive - may have difficulty justifying under ALARP.
	8. Early recycling of the entire vessel.	8. Requires a shielded ILW store
	9. Can utilise existing ILW store. The number of vessels able to processed using existing space will be increased	9. Transportation out of the cut up location will require the manufacture of a shielded container.
	10. Store and monitor strategy - strength as for RC storage.	10. High initial costs, financial benefit from deferring work is lost
	11. Maintenance of actual waste package will be virtually zero.	11. Flexibility to change storage option ended.
	12. Inspection and monitoring straightforward	12. Will require investment in underwater cutting or remote processing techniques early.
	13. MoD could transfer liability for radioactive waste early.	13. Requirement to decontaminate.

OPPORTUNITIES	AFLOAT STORAGE	LAND STORAGE		
	Complete Vessel	**Reactor Compartment**	**RPV/PST**	**Packaged ILW**
Technological Advances.	- As the majority of the disposal work is deferred, it can take advantage of any future advances in technology or disposal methods	- Although the non-nuclear disposal work has been completed benefits can still be gained via disposal of the radioactive matter.	- Benefits can be gained in the cut up and packaging of the remaining ILW.	- Further benefits unlikely.
Public Sector Initiatives.	- The low revenue streams involved in this option and deferral of major works make it potentially unattractive as a business opportunity.	- The early work requirement should make it an attractive business opportunity.	- Already a possible Public Sector Initiative.	Already a possible Public Sector Initiative.
New / Innovative Storage and Disposal Opportunities.	As the vessel remains substantially intact, this option remains and could adapt to any new storage / disposal strategy.	Although only the RC remains, radiation dose to this point has been low. The radioactive waste remains untouched and therefore the option remains highly flexible.	Majority of dismantling work is complete; this option has far less flexibility to adapt to any new storage / disposal strategy.	No flexibility.

THREATS	AFLOAT STORAGE	LAND STORAGE		
	Complete Vessel	**Reactor Compartment**	**RPV/PST**	**Packaged ILW**
1. Economic Changes. Lower interest rates.	- The Financial savings gained by delaying all break up and disposal costs will be reduced.	- The savings made from delaying break-up and disposal of the RC will reduce.	- The saving resulting from delaying the cut up and packaging of the remaining ILW will be reduced	- The effect will be low.
2. Dockyard Closure.	- Alternative docking facilities would have to be found, vessels stored in yard may need to be moved.	- If dockyard Security is being utilised, separate arrangements may be required.	As previous -	As previous -
3. Cancellation/ changes to submarine programme.	- New storage space would need to be found. Total maintenance costs would increase, significant impact on rolling docking programme.	- Negligible impact.	As previous -	As previous -
4. Loss of Crown Exemption - NIA65	- Area of water holding decommissioned submarines will need to become a licensed site. The MoD organisation would need to identify a body corporate unless control of the	- Negligible impact if contractor in control of storage.	As previous -	As previous -

THREATS	AFLOAT STORAGE	LAND STORAGE		
	Complete Vessel	**Reactor Compartment**	**RPV/PST**	**Packaged ILW**
	vessels could be transferred to contractor.			
5. Legislation changes (Nuclear).	- If rules become more severe higher break up and packaging costs may be incurred, a longer decay period may be required.	As previous - although a longer decay period would not present a significant problem.	Less impact as a larger percentage of the nuclear work would have been completed.	Potentially less impact from future changes.
6. Legislation changes (Non Nuclear).	- If environmental legislation is tightened higher break up and disposal costs will be incurred.	The cost of the break up and disposal of the RC will be higher.	negligible impact.	negligible impact.
7. Sudden cost increases.	At present there is no charge made for the berths in Rosyth, this could change in the future. It could bear the complete nuclear overhead.	The costs involved in this option should be stabilised by contractual agreements.	As previous - although if costs increase it should be possible to negotiate an alternative storage venue.	As previous -
8. Opportunity cost increase.	Berthing space occupied by decommissioned submarines may be required for another use.	Purpose built store so not applicable.	Will use up space in ILW store although the impact is unlikely to be significant.	As previous -
9. Pressure Groups opposition.	Opposition currently manageable, although this is	Believed to broadly favour this store and decay policy.	As previous - possibility of some objection re -	As previous - Although more dose intensive.

THREATS	AFLOAT STORAGE	LAND STORAGE		
	Complete Vessel	**Reactor Compartment**	**RPV/PST**	**Packaged ILW**
	likely to increase as more vessels are laid up.		ALARP principals.	
10. DWR delay/ cancellation	Major impact in terms of increasing maintenance cost, also social/political problems likely to increase.	negligible impact	negligible impact	negligible impact - although dose received during packaging may prove to be unnecessary.
11. Changes to DWR packaging requirement.	No impact.	No impact.	No impact.	Repackaging will be necessary.

CONCLUSIONS AND RECOMMENDATIONS

81. The conclusions and recommendations derived from the above analysis are detailed in the Main Paper.

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APPENDIX H3 - COMPARISON OF THROUGH-LIFE COSTS

1. Using a PC spreadsheet, cost models have been developed for a number of illustrative scenarios. These have been used to compare the through-life costs of various afloat and land storage options considered in this investigation. The scenarios are based on programme and cost assumptions detailed in Appendixes H1 and H2 of Annex H. They embrace afloat storage at berths and at moorings, and land storage of separated Reactor Compartments. In addition, the effect of continuing the SSN programme beyond Astute Class has been modelled.

2. Other land storage options were not included, either because they are ruled out for reasons other than cost, or because they are based on innovative proposals from Industry the costs for which have not been examined in sufficient detail for their use in this comparison. However, the relative costs of such options are discussed in qualitative terms in the text where appropriate.

3. The results of the cost comparisons may be summarised as follows:

a. Tidal Berthing vs Tidal Mooring. The cumulative cost of using moorings rises increasingly above that of using berths, largely because of the additional annual cost of maintenance and security. The difference is marginal however, and could be eliminated or even reversed by an increase in the "opportunity-cost" of berths.

b. Land Storage vs Afloat Storage. Despite greater initial costs for capital investment and while the backlog of afloat hulls is being cleared, the total cumulative cost of land storage falls below that of afloat storage in the long-term. The actual cross-over point depends on the implementation programme, the duration of storage and on the discounting rate used in the analysis. However, *provided the implementation programme is not too long delayed* (see sub-paragraphs c and d below), the cross-over point should be well before the planned availability date of the national Deep Waste Repository*. This is discussed further in the PEST Analysis at Annex H, and the importance of selecting an appropriate discounting rate is discussed further in Annex I.

c. Mixed Land Storage / Afloat Storage. The costs of "all-land-store" or "all-afloat-store" may be compared with the cost of a mixed scenario of continuing with afloat storage for the hulls which have undergone full DDLP, but adopting land storage of separated RCs for later vessels. In this mixed scenario the initial rise in expenditure associated with preparing the existing laid-up hulls for land storage would be avoided. However, the continued cost burden of keeping these laid-up vessels afloat substantially erodes the future savings which otherwise would result from the investment in land storage.

* Refer to statement on long-term management of radioactive waste on front cover of this report

d. Varying the duration of interim storage. Increasing the duration of interim storage increases the long-term cost of afloat storage but reduces (marginally) the discounted long-term cost of land storage. This brings forward the cross-over point and increases the difference between the total cumulative costs.

e. Urgent implementation of land storage. The potential advantages in early implementation of a land-store programme include minimising long-term cost. (The others are reducing cost and legislative risks, reducing environmental impact and allaying public criticism.) The initial rise in cost of this scenario, compared with others, could be offset significantly by the saving the cost of the lay-up element of the planned DDLPs of Renown, Valiant and the twelfth vessel, and by the cost of the 20-year docking of Dreadnought, and the 10-year dockings of the eight other vessels. In the long term, this scenario becomes cheapest overall as discussed further in Annex H.

f. Varying implementation programme for land storage. If land storage cannot be implemented immediately, nugatory costs would be incurred for laying-up vessels temporarily, and for continued dockings and maintenance afloat. There also could be a risk of other additional costs for processing the Rosyth hulls after cessation of planned nuclear work there (see main report, under "Development of an interim storage strategy"). A further step increase in cumulative cost would result if the delay were continued beyond 2012, the date when the current afloat storage space at Devonport is filled, and Dreadnought at Rosyth is due its 30-year docking. This is discussed further in Annex H.

g. Afloat storage of cropped hulls (vs land or intact afloat). As stated in the main paper (under "Afloat Storage of cropped submarine hulls"), the additional costs associated with preparing all submarine hulls (after Valiant and Renown) for lay-up in a "cropped" condition are such that the savings on subsequent maintenance in later years are largely negated. Cropped afloat storage is therefore no cheaper than Intact afloat storage.

h. Terminating or Continuing Nuclear submarine programme beyond Astute Class. The cost modelling has demonstrated that the cumulative cost of afloat storage exceeds that of land storage by an increasing margin once the cross-over point is reached, and by 2050 the difference is quite large. Thereafter, *when discounted at 6%*, cumulative costs increase quite slowly whether or not the requirement for nuclear submarine disposals continues beyond lay-up of the last Astute Class in … [information deleted to allow public release of this Report]. Up to about 2050, terminating or continuing the SSN programme beyond Astute Class has negligible effect on any option, whatever the discount rate. For simplicity, the PEST analysis in Annex H (which examines costs up to 2049) ignores any disposals beyond Astute Class.

ANNEX I - USING ACCOUNTING AS AN AID TO DECISION MAKING[75]

INTRODUCTION

1. Whenever a review into alternative methods of achieving a final project goal is conducted, a number of credible options will inevitably be produced. The choice of the final option to be taken forward is the most important decision a project team will make; each option must be considered against the others and the methods used in determining the best choice are fundamental to the success of the analysis and thus the project. In order for the ISOLUS project to be successful the decommissioning process must be acceptable against a number of criteria. Each criterion will vary in importance and will require different "weights" to be given by the project team in order to arrive at the best overall choice of project. A number of tools are available in matrix form to aid managers in the decision making process. One such tool is the PEST matrix where **P**rice/ Cost, **E**nvironmental Impact, **S**ocial and Political issues and **T**echnical viability are considered in varying degrees. The analysis tool provides management with a basic format with which to conduct the analysis, this can then be tailored to individual projects helping to ensure that the decision making process is structured and consistent for each option.

2. When considering the options available, the overall cost of each option will be extremely important. Less obvious, however, is the time element of the costs. The time at which outgoings will be incurred will have a considerable effect on the present-value price of each choice under consideration. This is due to the standard accountancy practice of discounting. The standard method of discounting the provision is to use the risk-free-rate (a government bond rate) as laid down in Financial Reporting Standard 12, Provisions, Contingent Liabilities and Contingent Assets (Reference A). HM Treasury (HMT) currently require a 6% discount rate to be used. However, the validity of using a 6% rate has been questioned (Reference B).

APPLICABILITY OF DISCOUNTING

3. Discounting the provision is standard practice throughout both the public and private sectors, and is used whenever future liabilities exist in a company or Agency balance sheet. The annual accounts of companies and agencies, although used by directors and managers, are not provided primarily for their information. They are intended to provide information to the stakeholders of the company. In the case of a private company these would be shareholders, creditors, employees etc; in the case of an Agency the tax paying public and Parliament would wish to ensure that the Agency is being run on sound financial grounds.

[75] Based on, Accounting, Edinburgh Business School - By Professor Niall Lothian and Professor John Small.

4. The discount rate to be used in order to reflect the time value of money is clearly laid down in the MoD Resource Accounting Policy Manual (RAPM). It states " If the cash flows to be discounted are expressed in current prices, a real discount rate will be used". It is therefore present practice for the SSA, in line with other Agencies within the MoD, to use the risk-free-rate (Government bond rate), which is currently 6%. Whether it is prudent to use this relatively high discount rate when calculating the provision has been the subject of some debate; accountants within the SSA have questioned its applicability within the public sector (Reference B). At present its use is, however, mandatory when preparing and producing the SSA's annual accounts although the policy of applying discount rates within the financial accounts is under review within MoD CAPITAL on the applicability of discounting the provision in the public sector. Indeed the latest version of the RAPM, issued as JSP 472, states that the policy of applying discount factors to provisions is still under review by the Centre.

5. When considering future direction or analysing different ways to conclude a project, discounting should also be used. Within the MoD, there are a number of rules and guidelines which apply to Investment Appraisal (IA). In particular, HMT have specified that a discount rate of 6% shall be applied to all IAs and this is reinforced in the new IA guidelines in the public mail folders (Reference C).

DISCOUNTING FOR THE ISOLUS STUDY

6. However, the subject of decommissioning and disposal of nuclear submarines has a major difference from normal MoD projects, in that the forecast cash flows are spread over a much longer period. Projects of this type which span many decades are substantially influenced by the practice of discounting, possibly to a far greater extent than originally intended. For example, discounting at 6% over 50 years reduces the value of £1 to a Net Present Value (NPV) of 5.4p. This huge distortion of the total project cost will militate disproportionately against any proposals which require funding early, compared with options which delay expenditure for several years. In these circumstances it would be reasonable to conduct further sensitivity analysis, in order to highlight the considerable impact that lower discount rates would have on the final Net Present Value (NPV) cost of the proposed option. Sensitivity analysis could include rates used in the Private Sector for decommissioning projects, which are in the region of 2 - 3%.

CONCLUSION

7. On the specific question of whether or not the risk-free-rate should be used when estimating the total cost of differing ISOLUS options, team members should recognise that the HMT 6% (discount rate) directive is mandatory. However, in order to highlight the effect that different discount rates would have on the individual project options, sensitivity analysis should be used, it may be prudent to include the risk-free-rate minus the inflation rate, or a lower rate still if macro economic indicators suggest that a lower rate would be more appropriate.

REFERENCES FOR ANNEX I

A. Financial Reporting Standard 12 - Provisions, Contingent Liabilities and Contingent Assets.
B. LM SSA/RAB/36/107/11 dated 22 January.
C. Investment Appraisal and Post Project Evaluation in the Ships Support Agency.

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