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A Report by NNC Limited: August 2004

Commissioned by:

Committee on Radioactive Waste Management (CoRWM)

Disposal in Space: Cost

Adding value through knowledge

Committee on Radioactive Waste Management

Disposal in Space: Cost

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NNC Document Number	11993-TR-0001	Task No	TS 021
Issue:	1	Status:	First Issue to CORWM
Recipients	CoRWM COG Working Group		
When commissioned by CoRWM	August 2004		
Confidential	No		
Additional notes			
CoRWM Document No	629		

REVISION RECORD

DATE	VERSION	STATUS	COMMENTS
01/09/04	1	Draft	Prepared by Lynn Mulelly for checking
01/09/04	2	Draft	Checking Comments by Bob Major added
01/09/04	3	Issue 1	Approved for issue to CoRWM COG Working Group by Sam Usher

Contents

Executive Summary

The purpose of this work package is to provide a clear understanding of the cost associated with disposing of UK radioactive waste into space on the basis of current technology to assist CoRWM in deciding whether or not it foresees this option being taken forward.

On the basis that this method would only be considered for HLW and the total HLW arisings in the UK amount to about 4550 tonnes, the estimated number of launches assuming a radioactive waste payload of 5 tonnes is 910 based on a Space Shuttle type launch vehicle and 1820 launches based on an Ariane type launch vehicle. In addition approximately the same number of launches of cargo launch vehicles will be required to send the waste packages on their final journey.

The costs that may be incurred have been estimated for two possible scenarios.

The overall costs for using a Space Shuttle type launch vehicle and the associated processing plant is estimated to be around £300,000,000,000. The use of a UK system based on the ESA Ariane is similar at £330,000,000,000.

The time taken to dispose of all the HLW to space is estimated to be between 230 and 450 years to complete.

It is estimated that approximately 13 launch failures may occur if a Space Shuttle type launch vehicle is used compared with an estimated 130 launch failures expected with an Ariane type launch system.

1 BACKGROUND

The purpose of this work package is to provide a clear understanding of the cost associated with disposing each type of UK radioactive waste into space on the basis of current technology to assist CoRWM in deciding whether or not it foresees this option being taken forward.

See Ref 1 for further background information.

2 UK WASTE INVENTORY

Table 1 Current Waste

	cubic metres	**tonnes**	terabecquerels
LLW	14,700	**17,800**	11
ILW	75,400	**90,400**	5,290,000
HLW	1,960	**3,290**	57,800,000
Total	92,100	**111,000**	63,100,000

Table 2 Future Waste Arisings

	cubic metres	terabecquerels	**~ tonnes[1]**
LLW	1,490,000	609	**1,804,218**
ILW	163,000	13,400,000	**195,427**
HLW	750	278,000,000	**1,259**
Total	1,660,000	291,000,000	**2,000,904**

[Ref 2]

3 COST

Ref 3 states that the AIAA believes that a funding level of about 10 million dollars [in 1981] per year [for four years] for space disposal is required to generate sufficient data to support near-term energy planning.

This funding level would allow concentrated consideration of key problem areas related to short-term safety of waste disposal in space, such as payload survivability and re-entry following an aborted launch. It would also allow initiation of a technology development program in the key areas of deep ocean and deep space location and recovery. Finally, it would allow system preliminary design studies to proceed at a modest level so that the results of the other studies could be reflected in the baseline system design.

3.1 Transport Container

It is thought likely that a container along the lines of a Type C transport container would be required for a safe launch in all accident scenarios.
A type C transport container has not yet been produced in practice, but it is thought that it would cost around £250,000 per container including development costs.

[1] Based on average densities from values in Table 1

3.2 Space Shuttle

Ref 4 describes an 'uprated space shuttle' with oxygen/RP-1 Liquid Rocket Boosters (LRBs). This provides for a 45,400 kg payload and allows increased safety for the launch ascent phase and a lower launch cost.

Previous studies [Ref 5] have been carried out using a reference case of a reusable, enhanced, space shuttle type vehicle with a payload weight of 45000kg. Of that weight only 5000kg was conditioned radioactive waste. The remainder was made up by the packaging for the waste.

Total weight of HLW, including estimated future waste arisings is **4549 tonnes**.

Each launch can carry 5 tonnes of waste.

Therefore it would take 910 launches to dispose of predicted arisings of HLW.

Table 3 of Ref 6 gives a cost of between $100 million and $500 million per launch of the Space Shuttle. The Shuttle does not have an easily identifiable launch cost as it is not commercially available. Ref 6 concludes that $300 million is an appropriate cost estimate, and is based on eight flights a year.

Therefore the cost of launching current and future HLW arisings assuming an exchange rate of 0.55 Pounds Sterling per US dollar is:

910 * 300,000,000 * 0.55 = £150,150,000,000 (£1.5E11)

(cost of transport containers is negligible compared with the error on this figure)

The above launch vehicle will place the waste package in low earth orbit. As described in the risk paper another launch will be required to transport the cargo launch vehicle to low earth orbit. The waste will then be transferred to the cargo launch vehicle that will then transport the waste to its final destination. The total number of launches is therefore doubled and so the total launch cost is estimated to be of the order

1820 * 300,000,000 * 0.55 = £300,300,000,000 (£3.0E11)

Based on eight launches per year it would take around 230 years to dispose of HLW alone.

Based on launch statistics of the Space Shuttle (described in Ref 1) there would be 26 launch failures containing radioactive waste payloads during this time.

3.3 UK Space Program

The UK does not have an independent space programme and does not operate its own launch vehicles. Therefore ESA's Ariane 5G is used here as a representative example of what a space program developed by the UK might cost. ESA seems to have a budget of several billion pounds a year.

However, this includes scientific research and other projects apart from launching Ariane 5G. Ref 6 calculates that the cost per launch is $165,000,000.

The payload capacity is around half that of the Space Shuttle described above and also manages around eight flights a year.

1820 * 165,000,000 * 0.55 = £165,165,000,000 (£1.65E11)

As described in section 3.2 above, the payload will be launched into low earth orbit and will require a cargo launch vehicle to launch the waste package to its final destination. Assuming that this will double the required number of launches then the total cost will be of the order:

3640 * 165,000,000 * 0.55 = £330,000,000,000 (£3.3E11)

It would therefore take a total of about 3540 launches and around 450 years to dispose of the HLW.

The launch statistics for Ariane are not as good as those for the Space Shuttle, so there would be 253 launch failures containing radioactive waste payloads during this time.

3.4 Processing plant

In addition to the costs associated with the development of a fleet of suitable launch vehicle and their deployment, costs will also be associated with any process plant required to condition or purify, separate and condition the waste material into a acceptable form. If it is assumed that a plant similar to that designed for the reprocessing of oxide fuel, e.g. BNFLs THORP plant, then the costs for this plant likely to be in the range of £2 billion.

4 CONCLUSIONS

The costs that may be incurred have been estimated for two possible scenarios.
The overall costs for using a Space Shuttle type launch vehicle and the associated processing plant is estimated to be around £300,000,000,000. The use of a UK system based on the ESA Ariane is similar at £330,000,000,000.

The time taken to dispose of all the HLW to space is estimated to be between 230 and 450 years to complete.

It is estimated that approximately 26 launch failures may occur if a Space Shuttle type launch vehicle is used compared with an estimated 253 launch failures expected with an Ariane type launch system.

5 REFERENCES

Ref 1 Disposal in Space: Risk; L Mulelly; 11992-TR-0001

Ref 2 The 2001 United Kingdom Radioactive Waste Inventory; NIREX CD-ROM; October 2002

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