SRO-2014-00316-F
2nd Responsive Document 004

Transport Strategy Recommendations

Assumptions:

1. Probability for inclusion under the Foreign Research Reactor Spent Nuclear Fuel (FRR SNF) Acceptance program/Gap program is very low.
2. Shipment activities will be conducted under a new DOE authorization.
3. The EOL Enrichment values are >20%, meaning still HEU (See Comment No. 2 of the Transport Strategy).
4. Material is considered under Pu, U-233 and U-235 categorization.
5. Material is not irradiated nuclear fuel (INF) under IAEA INFCIRC 225, Rev 5 and NRC 10 CFR Part 110, Appendix M.
6. DOE Orders requires compliance with NRC categorization requirements per 10 CFR Part 110, Appendix M.
7. DOE O 474.2, Ch 2, *Nuclear Material Control and Accountability*, does not apply for shipments in transport.
8. DOE O 461.1B, *Packaging and Transportation for Offsite Shipment of Materials of National Security Interest*, do not apply to this project
9. Applicable DOE requirements:
    a. DOE G 460.1-1, Implementation Guide for Use with DOE O 460.1A
    b. DOE O 460.1C, Packaging and Transportation Safety
    c. DOE O 460.2A, Departmental Materials Transportation and Packaging Management
    d. DOE M 460.2-1A, Radioactive Material Transportation Practices Manual for Use with DOE O 460.2A

Recommendations:

1. Based on the assumptions, the following tables may apply in general terms:

Table 1 – Transportation Report Summary

Uranium total	Max 13.2kg
Uranium 235	Max 1.0kg
Uranium 233	Max 0.4kg
Plutonium total	Max 0.2kg
Pu 239 and Pu 241	Max 0.1kg
Thorium	Max 16.0kg
Activity	Max 1.5E15 Bq
Decay heat	Max 141W

Table from Transport Strategy Report

Table 2 (Ship Loading based on Pu and Uranium only)

	Pu	U-233	U-235
Max value per cask	0.2kgs	0.4kgs	1.0kgs
Cat I – IAEA/NRC	≥2 kgs	≥2 kgs	≥5 kgs
Casks per ship - IAEA	Unlimited	Unlimited	Unlimited

Prepared by: Chuck Messick

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Cat II – IAEA/NRC	<2kgs	<2kgs	>1kg & <5kgs
Casks per ship - IAEA	10	5	5
Cat III – IAEA/NRC	≤500gm	≤500gm	≤1kg
Casks per ship - IAEA	2	1	1

2. Noting the categorization requirements in Table 2, Compliance with IAEA Category I internationally can be accomplished by applying At least minimal security requirements which may be appropriate based on the existing characteristics and the robust packages involved in the transport. Compliance with this categorization in Germany will require compensatory actions and approval by the appropriate German regulator. Since a full NRC Category I transport requirements cannot be accomplish using the type transport packages to be used for this project, compliance with DOT/NRC and DOE requirements will require use of appropriate alternate security protocols. The NNSA US-origin Nuclear Remove program is actively considering an activity associated with similar materials and may be used to meet transport requirements in the United States. This recommendation assumes that appropriate approvals are obtained to conduct this project.

3. Based on the quantity of material and activity level, transportation may be most efficient by using an INF 2 (<2 x 10E6 TBq) ocean-going vessel under an IAEA Category I in international space and an NRC category utilizing approved alternate security protocols under DOE requirements within United States territory. Use of a propose 16 (max 20) Caster packages would comply with this arrangement.

4. Possible transport arrangements in the US –
    a. Use of the Joint Base Charleston – Weapons Station (JBC-WS). Upon DOE-EM acceptance to proceed, NNSA will approach the USAF regarding its use of this port of entry in the United States with an expected schedule. NNSA will authorize the use of the Wharf A crane. NNSA pays 100% of all cost of maintaining this asset. However, other costs will be required on a shipment basis for mooring, crane operation, on-base security, on-base personnel to support mooring and rigging to off-load and possibly incremental support for other low-use assets such as on-base rail. Use of this asset would require a funding mechanism such as an Interagency Agreement with DOE-EM and JBC-WS.
    b. Possible use of the South Carolina State Law Enforcement Division (SLED) and other SLED managed LLEAs to meet security requirements and acceptance within South Carolina - However, the use of a private security force may provide more flexibility, but would need to meet

regulatory and prudent security requirements acceptable by the State of South Carolina.

c. Requirement to transport by rail - CSX is the only carrier for this service from Charleston. The NNSA security escort car may be used for this service if using the JBC-WS with some maintenance and transport costs. Depending on the security organization used and the security posture required, and additional security escort rail car may be needed.

5. Possible Transportation scenario – (16 packages per shipment nominal with 3 sets of frames and impact limiters)
   a. DOE-EM conducts environmental evaluations as required for accepting this material into the United States including the Savannah River Site based on up to 20 transport packages per movement. Note: Not under the FRR SNF or Gap Acceptance program.
   b. Plan to ship the first shipment with 6 packages using existing transport frames and impact limiters unless additional sets can be manufactured and delivered in time. If using a ro/ro ocean-going vessel, it may be possible to conduct the first shipment by road with additional protocols in place more stringent that the anticipated require protocols due to necessary support equipment and resources that may be required to transport 6 packages in a single movement from Charleston to SRS.
   c. Possible use of the INS Atlantic Osprey, INF-2 certified vessel, with use of minimum necessary security force to meet IAEA Cat I security requirements, as a lo/lo load/unload operation and possible ro/ro operation for the initial shipment.
   d. In parallel with the first shipment and other prerequisite work; design, fabricate and license the remaining frames as required, total 48, plus one additional frame.
   e. For the next 8 shipments, plan for shipping 16 packages.
   f. Develop the environmental documentation to support movement of up to 20 on a single vessel, for extra capacity, if the need arises.
   g. For the last shipment, transport 17 packages.

   Other activities may proceed in parallel such as:
   - Formal material transfer contract
   - US Government coordinate with governmental agencies in the US
   - Forschungszentrum Jülich GmbH coordinate with all German governmental agencies in Germany and other countries, if required
   - Communication strategy and develop plan
   - DOE validation of the Castor packages in the US
   - Establish Joint Base Charleston-Weapons Station (JBC-WS) as the entry point into the US. Obtain agreement and develop documentation and funding source for use at the JBC-WS.
   - Establish the source of a security force and implement appropriate contracts and protocols.

- DOE coordinate with the State of South Carolina regarding movements in South Carolina and develop resulting protocols necessary to support this project such as; South Carolina Department of Health and Environmental Control (DHEC), South Carolina State Law Enforcement Division (SLED) and South Carolina Emergency Response Division.
- DOE coordinate with other US Government agencies such as DHS Coast Guard, US Customs, Immigration, Agriculture and Department of Defense.
- Forschungszentrum Jülich GmbH coordinates implementation of similar activities in Germany and other countries as required.
- Forschungszentrum Jülich GmbH coordinates with Euratom and Euratom Supply Agency regarding obligations.

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2nd Responsive Document 005

Transport Strategy Report

Executive Summary

The High Temperature Fuel Elements Group determined that a Strategy Paper detailing the issues relating to the upcoming transport of the irradiated fuel from the Jülich site to the Savannah River Site, USA should be prepared.

This Strategy Paper provides:

- An explanation of the transport concept to be pursued by the prime contractor and its subcontractors;
- Key issues that have to be addressed;
- Associated time frames and essential support activities that have to occur to ensure the transport of the full consignment of casks from Jülich will be completed by the end of June 2016;
- Critical path items for fulfilment of the proposed transports;
- A discussion of project risks and risk management; and
- Estimated costs for the envisaged transport scenarios

Shipments of irradiated fuel from foreign locations to the Savannah River Site have been conducted safely and effectively for 50 years under various US DOE programs. The difference with the Jülich irradiated fuel project is the large quantity of casks that are to be transported within a defined time frame.

As the Strategy Paper details, there are several shipment scenarios that allow ample time, including contingency periods, to complete the transport program by the deadline of June 2016.

To maintain certainty of completing the transports by the deadline, decisions need to be taken relatively quickly regarding the ideal transport scenario so appropriate regulatory approvals can be applied for and obtained in a timely manner.

Transport Strategy Report

1. Introduction

Following on from the Nuclear Summit in Seoul initiative in 2012 it was confirmed there are 152 fully loaded casks in storage at the Jülich research site in Germany. In addition, there are 305 loaded casks in storage at the Ahaus storage facility.
A project group, the High Temperature Fuel Elements Transport Group (HTG), has been formed to develop a Transport Plan for the shipment, in the first instance, of the 152 casks from Jülich to Savannah River Nuclear Complex (SRS), USA. The planned termination of the Jülich facility storage license at the end of June, 2016 is the key date for the completion of cask shipments from this site, having emptied the store.
The development of this strategy is the first step in the preparation of the Transport Plan under contract placed by Forschungszentrum Jülich (FZJ) with Edlow International Company (EIC).

2. Scope of the transports

The options range, in theory, from 1 cask per voyage to a single shipment of 152 casks. Clearly, single cask voyages would be impractical, expensive and take between six and seven years to complete. This is therefore not a viable option. Similarly, one large ship capable of loading 152 casks, even assuming such a ship could be contracted, would take an unacceptable time to load and unload in the nominated ports and be an extremely costly option with the total compliment of impact limiters and frames that would be required.

So a credible range between four casks/shipment and 36 casks/shipment is examined in detail. The procurement of the necessary assets to undertake the range of consignments under consideration poses an increasing risk to the project as the total required under the individual scenarios increases.

3. Transport scenarios

Individual consignments of casks from Jülich to a nominated port can be undertaken by road or rail, provided all the necessary licences and permits are obtained. To date this is not the case. Obtaining all the necessary approvals is a significant risk to the project.

A range of German North Sea ports lie approximately 450km from the Jülich site. The existing road transport assets (their length excludes utilising an ISO container stowage system) would facilitate transport to a candidate port provided it is served by the necessary road or rail network. An adaptor(to be designed and manufactured) would enable special ISO 20' container to a maximum gross weight of 45 tonnes to be transported in Germany by the existing tractor and trailer units or on a rail wagon with a suitable tie down feature.
A prudent plan, at this stage, would be to work towards securing two German ports and having a Dutch port as a contingent arrangement. All the Dutch ports are closer to the Jülich site than the North German ports.

Today, the number of casks that can be transferred by road in Germany are limited to four in a convoy, as permitted for previous shipments from Jülich to Ahaus. This restriction is related to the number of escort vehicles available(for land transport in Germany one escort vehicle is required for every two casks).. The number of licensed drivers has the potential to increase this to six to eight casks per convoy. If large convoys obtain a license the maximum would be eight to ten per convoy (depending on the proposed concept).

Currently, for rail transport the physical constraint of the marshalling area at Jülich is the limiting factor. The Transport Study will investigate the possibility of short term interim storage of loaded containers within a secure area of the Jülich site, on trailers or on rail wagons so as to increase the number of casks per train or convoy. Ten heavy load rail wagons have already been identified as having the capacity for the cask with either the existing or new transport frame and available for the proposed shipments. There are 10 Uaaikks 764 wagons, owned by Heavy Cargo + Service and have a declared maximum carrying capacity of 84te. A lashing system to secure the cask frame to the rail wagon has to be designed before the wagon can be utilised for the shipment of the Castor THTR/AVR cask.

For the nominated German loading port the infrastructure must be able to serve the chosen transport mode, road or rail, and provide a safe and secure berth for the selected ship. The ship will sail directly from the nominated German port to the US and be subject to a timed arrival at the selected US port for transhipment to the SRS facility. This route has been used previously for similar shipments.

The two options for the sea transport component centre around the cargo handling concept; either roll on – roll off (ro/ro) utilising road trailers or lift on-lift off (lo/lo) operation that will require new transport frames, heavy lift cranes and an efficient transfer operation so as to minimise the time the casks are stationary on the quayside awaiting loading and unloading. It is envisaged that for the lo/lo option new transport frames that are based on the 20' ISO container will be essential to provide efficient transfer of the casks during the full transport cycle. For ships of the same net tonnage, a lo/lo vessel has a much higher load factor than a ro/ro vessel.

On arrival at the nominated port in the United States the currently approved transport system is to load casks onto marshalled railcars for the onward journey into the SRS complex. The US DOE's Environmental Impact Statement (EIS) and the Memo of Understanding states the permitted maximum is 16 casks per shipment. This figure was because the US DOE never envisioning having more than 16 casks arrive within the disposition programme, so it was the limit written into the Foreign Research Reactor EIS. It will have to be a US DOE policy decision to increase that number.
A second significant issue is the predetermined arrival date at the US east coast port demanded by the receiver. For the ship to make the declared arrival date it has meant on occasions the ship has had to wait for a week before entering port. These additional days at sea (demurrage and fuel) add to the voyage costs and either puts the completion date at risk or reduces the contingency in the overall programme if days are lost in this manner.

4. Sea transport requirements.

For the transport of significant quantities of radioactive material the selected ship has to comply with the International Maritime Organisation's (IMO) Code for the safe Carriage of Irradiated Nuclear Fuel, Plutonium and High Level Wastes in Flasks onboard ships (INF Code).
The INF code (Appendix1) specifies the additional features an INF1, INF2 and INF3 ship must be provided so as to carry the designated quantities of radioactivity. The additional features across the three INF classifications requires enhancement of the stability and subdivision of the ship, additional segregated electric supplies and fire protection, specific cargo temperature control and additional structural and cargo securing arrangements. Enhanced management procedures are mandatory; encompassing radiological protection, training with reference to the onboard emergency plan and maintaining the regulatory certification for the carriage of such cargoes.

The quantities each INF category can transport, based on the activity within the casks provided by the Jülich management, is provided in Appendix 2. The after irradiation per cask can be summarised below,

Uranium total	Max 13.2kg
Uranium 235	Max 1.0kg
Uranium 233	Max 0.4kg
Plutonium total	Max 0.2kg
Pu 239 and Pu 241	Max 0.1kg
Thorium	Max 16.0kg
Activity	Max 1.5E15 Bq
Decay heat	Max 141W

The quantities of nuclear material in each consignment will demand that the shipments comply with 'The Physical Protection of Nuclear Material INFCIRC/225/Rev4 and Rev5'. Signatory countries to these requirements base their more specific security standards on this code and for obvious reasons these are not widely published or disseminated. National security arrangements are divulged by the appointed Governmental body for such security arrangements on a 'need to know' basis. However there are general principles that will enable the Transport plan to conclude, the category for the consignments and thus their general requirements. At this stage it is considered that as individual casks will not be pre-selected for a specific consignment then the shipments, dependent on the number of casks onboard will fall into the Category classification I or II (between 6-9 casks is Category II in Germany). Appendix 2 also details the categories and security requirements for a range of casks being shipped.

Against this background, it is considered that there will have to be enhanced security measures on the selected ship, onboard escorts for the voyage from Germany to the USA and advanced communication capability for real time reporting on the status of the ship, personnel and cargo, consistent with previous experience from similar shipments.

To secure a ro/ro vessel for the proposed shipments will be problematical. First, a ship has to be chartered between EIC and a ship owner so that the selected ship is available for voyages over a three year period. Secondly, a detail design of the features to enable the

ship to be classified as an INF 2 ship has to be approved by the flag state's maritime regulatory body. Then the ship has to be converted in a timely manner to the required INF categorization with the provision of the statutory security features together with additional accommodation for the necessary security personnel. The contracted party (shipowner or ship management company) must have the in-house expertise to manage INF shipments, have the flag state certification and approvals to operate the ship with an appropriate escort personnel onboard, and backed up with a military based contingency plan.

5. Time frame

The dates given are indicative at this stage with firm schedule dates being given in the Transport Plan at the end of the transport study. An INS programme has been provided (Appendix 3) detailing two shipping scenarios, one commencing prior to and one commencing after the 2014 Nuclear Security Summit (NSS) with a load factor of 16 casks per voyage. This is the current shipment limit stated in the USDOE's EIS.

The Group's goal to achieve a shipment prior to the NSS in March 2014 is ambitious but achievable. To achieve this design, testing, licensing, procurement of the associated cask hardware and additional land transport assets are on very tight schedules.

	Start date
Licensing of the Castor cask	
Contract for licensing process in US (FJZ)	15 January 2013
Validation in the US – safety report to DOE, LLNL &SRS (GNS)	15 March 2013
US validation issued	TBC

New 20' ISO based transport frame & impact limiters	
Design of frame contract (WTI)	7 December 2012
Commence fabrication of additional impact limiters (FJZ)	February 2013
Completion of frame design (WTI)	March 2013

Decision to start fabrication of prototype frame (FJZ)	March 2013
BfS and BAM validation of frame and impact limiters (GNS)	April 2013
Fabrication of prototype frame for handling trial	April 2013
Frame handling trial	May 2013
Commence full scale frame production	June 2013
Start phased delivery of hardware to meet shipment schedule	October 2013

The Transport Study will determine frames and impact limiter quantities, identify critical path items, the phasing of deliveries and where and by whom management effort must be focussed to achieve the overall project completion date.

Commercial contracts

Award of Transport Study contract	December 2012
Design of conceptual transport frame design contract	December 2012
Exchange of inter-governmental letters	March 2013
Completion of Transport Plan ahead of submission of transport frame design concept to US DOE	March/early April 2013
Presentation of findings	April 2013
Submission of transport frame design concept to USDOE	May 2013
Transport contract with EIC	May 2013
NC+S, under subcontract from EIC, for German land transports	July 2013
INS, under subcontract from EIC, for sea transport	July 2013
STS, under subcontract from EIC, for land transport in US	July 2013

Overall shipment schedule

Demonstration voyage	Beginning of 2014
Shipping programme	Spring 2014 to early 2016

Shipping schedule contingency (based on Appendix 2 programme)	Early 2016 to June 2016

(This schedule assumes assets are procured to maximise cost effectiveness and provide an operational contingency up to the closure of the Jülich storage facility.)

6. Essential support activities

Government liaison

All necessary briefings of Department Secretaries, Ministers and senior government officials is to be co-ordinated through Edlow International Company. This will become an increasingly important activity and it is imperative all personnel involved act in concert with consistent briefing material.

Communication Plan

This will provide briefing material, in full compliance with the Confidentiality Agreement, for key senior stakeholders in Germany, USA and UK.

Contingency and Emergency Response Plans

These will be classified documents, detailing comprehensive contingency arrangements for both land and sea transport sectors and detailing the emergency response plans for the entire journey from Jülich to SRS.

7. Cost base

Casks per voyage

Four casks		38 voyages
Six casks	25 voyages and 1 voyage with 2 casks	26 voyages
Nine casks	16 voyages and one voyage with 8 casks	17 voyages
Twelve casks	12 voyages and 1 voyage with 8 casks	13 voyages
Sixteen casks	9 voyages and 1 voyage with 8 casks	10 voyages
Twenty four	6 voyages and 1 voyage with eight casks	7 voyages
Thirty six	4 voyages and 1 voyage with 8 casks	5 voyages

Consignment details

Jülich to SRS	152

Ahaus to SRS	305
Total	457

Current assets

6 pairs of shock absorbers and 6 large transport frames
6 tractor and trailer units
2 escort vehicles

Cost model

This cost model details the cost of additional assets in stages so as to achieve increased payloads per voyage. For an INF3 vessel International Nuclear Services have provided conversion and voyage cost estimates. For comparison an INF2 option based on chartering a vessel is also included in the paper.

The cost estimates are based on very preliminary estimates from partners to the Transport Study. Therefore the compilation of the cost model cannot be taken as the definitive costs for the overall project but the cost comparisons could contribute to the decision making process to determine the option, or options, to be pursued.

All the quoted options are based on one complete set of transport frames for the INF3 scenarios and pairs of impact limiters for the proposed capacity for both the INF2 &3 transport options. It is recommended that the ship or ships selected operate at the higher capacities which require fewer voyages and provides sufficient time in the scheduling to wait in a US port for the transport frames and impact limiters to be returned to the vessel for the return journey to Germany.

If it is considered an additional set of frames and impact limiters for the INF3 option should be provided then project capital will be increased

Having three sets of transport frames and impact limiters per INF3 option would further increase project capital costs but provide for one set being loaded at Jülich, one set onboard ship in transit and one set being unloaded at SRS. It is considered that options of nine and above could complete the shipments by the 2016 licence deadline with an adequate level of contingency. Obviously a third set would further enhance this contingency.

Two additional escort vehicles and three tractor and trailer units are first included in the nine cask scenarios. For twelve casks and above per voyage a total of six additional tractor and trailer units are included in the capital estimate. For some loadings of the ship there would have to be repeat convoys from Jülich to the nominated German port. It is considered that providing further escort vehicles, above the additional two included, could put the project completion date in jeopardy as there is limited approved manufacturing capability for these specialised vehicles and would further increase project capital costs.

The following voyage scenarios provide an estimate on both a total cost and shared cost basis for the option together with the additional equipment that would be required.

(i) Four casks per INF3 voyage

A total of 38 voyages would be required to empty the Jülich storage facility. This option is licensed for transports by road or rail in Germany but it is not viable as campaign completion date is at least the Spring of 2017.

Four new transport frames need to be purchased and the casks could be transported by rail or road to the nominated loading port. The cost estimate includes land transport costs in Germany and US, overall project management, government liaison, provision of communication, contingency and emergency response plans and maintaining programme flexibility so as to maximise asset utilisation throughout the project period. This is included to show the project based on the current approved four cask road transport system cannot meet the completion date and that this high number of voyages generates a high overall project cost.

(ii) Six casks per INF3 voyage

A total of 26 voyages would be required to empty the Jülich storage facility.

Six new transport frames would be purchased and the casks, based on previous shipment limits, would travel by rail to the nominated loading port. The cost estimate includes land transport costs in Germany and US, overall project management, government liaison, provision of communication, contingency and emergency response plans and maintaining programme flexibility so as to maximise asset utilisation throughout the project period. This option provides no contingency to cover for any delays and is thus not satisfactory as a shipment quantity per voyage.

(iii) Nine casks per INF3 voyage

A total of 17 voyages would be required to empty the Jülich storage facility.

Nine new transport frames three pairs of impact limiters would be purchased and it is assumed the casks could travel by road or rail to the nominated loading port. The cost estimate includes provision of two additional security vehicles and three tractor and trailer units, land transport costs in Germany and US, overall project management, government liaison, provision of communication flexibility so as to maximise asset utilisation throughout the project period. This option provides a contingency of some 9 months to provide for timed arrivals in the US and voyage delays due to bad weather.

(iv) Twelve casks per INF3 voyage

A total of 13 voyages would be required to empty the Jülich storage facility.

Twelve new transport frames and six pairs of impact limiters would be purchased and to increase the efficiency of the land transport operation in Germany two additional escort vehicles and six tractor and trailer units have been included in the capital spend. The cost estimate includes land transport costs in Germany and US, overall project management, government liaison, provision of communication, contingency and emergency response plans and maintaining programme flexibility so as to maximise asset utilisation throughout the project period. This option allows 13 voyages of a minimum of a month's duration to be undertaken over a 29 month period. This is a considerable contingency period for the project.

(v) Sixteen casks per INF3 voyage

Increasing each consigment to a North Sea German port to achieve 16 casks per voyage, the authorised maximum trainload within the USA. No ship modifications would be required.
A total of 10 voyages would be required to empty the Jülich storage facility.

Sixteen new transport frames and twelve pairs of impact limiters would be purchased together with two additional escort vehicles and six tractor and trailer units. The cost estimate includes land transport costs in Germany and the US, overall project management, government liaison, provision of communication, contingency and emergency response plans and maintaining programme flexibility so as to maximise asset utilisation throughout the project period. A ten voyage schedule for an available INF3 vessel is provided in Appendix 3. The schedule shows ample contingency together with a planned statutory dry dock and third party voyages.

(vi) Twenty four casks per INF3 voyage

A total of 7 voyages would be required to empty the Jülich storage facility.

Twenty four new transport frames and eighteen pairs of impact limiters would be purchased together with the two additional escort vehicles and six tractor and trailer units. The capital spend also includes modification costs to the ship to increase onboard stowage capacity. The cost estimate includes land transport costs in Germany and US, overall project management, government liaison, provision of communication, contingency and emergency response plans and maintaining programme flexibility so as to maximise asset utilisation throughout the project period.

(vii) Thirty six casks per INF3 voyage

A total of 5 voyages would be required to empty the Jülich storage facilty.

Thirty six new transport frames and thirty pairs of impact limiters would be purchased together with the two additional escort vehicles and six tractor and trailer units. The ship would require a major conversion to an all cellular loading arrangement, to provide the additional capacity required and significantly decreases the cargo handling times. The cost estimate includes land transport costs in Germany and US, overall project management, government liaison, provision of communication, contingency and emergency response

plans and maintaining programme flexibility so as to maximise asset utilisation throughout the project period. This is the design capacity of the ship in a converted ISO 20' cellular configuration.

(viii) Four casks per INF2 voyage

As determined by the INF3 option a four cask per shipment campaign would not Empty the Jülich storage facility in time.

(ix) Six casks per INF2 voyage

A total of 26 voyages would be required to empty the Jülich storage facility. However, it is considered there is no contingency as a campaign starting January 2014 would not finish until April 2016 if you allowed time out for statutory drydocks. No additional days on planned voyages have been factored in for timed arrivals in the USA, let alone delays in specific voyages due to bad weather. This risk could be mitigated by operating two INF2 vessels.

Today, there are six tractor and trailer sets, associated large transport frames and sets of shock absorbers available. No further land transport equipment needs to be procured. Included in the cost for this option is an estimate to convert a commercial ro/ro vessel into an INF2 ship.

(x) Nine cask per INF2 voyage

A total of 17 voyages would be required to empty the Jülich storage facility. Limiting a converted INF2 ship to 9 casks would place the security requirements into Category 2, which states additional security arrangements are subject to Regulatory discretion. This is a risk to the project that is discussed in the next section of the Report. Three sets of impact limiters, two additional escort vehicles and three tractor trailer units and conversion of a standard ro/ro ship to an INF2 vessel have been included in the capital spend.

8. Project risk and risk management

(i) Project completion

This is the most significant risk to the project and bringing forward the start date is not conceivable. As with all transport projects that are time critical maximising operational contingency is the best assurance for an on time project completion. Increasing voyage payloads increase the schedule contingency but at a cost. An early decision on the amount of contingency that is considered prudent set against the cost of provision will drive the ability to manage the future risk. The selection of one option with a prudent level of scheduling contingency, then pursued by all partners is the best management strategy for reducing this risk.

(ii) Maintaining shipment schedule

The voyage from a German North Sea Port to East Coast USA port is ~ 3,600 nautical miles. Assuming a 12.5 knot service speed it crosses the Atlantic in 13 days and two days in each port gives one month per voyage; assuming no delay is unrealistic. Timed arrivals into the USA can cause a six day delay and adverse weather can create random delays, more so in the winter months. To manage this risk adequate contingency has to be included into the overall shipping schedule. From section 7 of the report planning for a maximum of 17 voyages provides an adequate contingency for the shipping schedule.

(iii) Ship reliability

An explanation of the initial design criteria for the INF3 ship is relevant to risk management being considered for this project. The design of the spent fuel carriers in the 1970's for the Japan to Europe shipments was to have a ship that had the highest degree of reliability and to achieve this both Lloyds Register of Shipping and the Salvage Association were contracted to determine the features the safest ship should contain. The resultant advice led to an immensely strong ship (withstand grounding and collision), two main engines with independent supply and control systems, duplicated and segregated electrical generation (electrical power failure results in most ship losses) and high degree of compartmentalisation to provide highest standard of damage stability. As a result of Greenpeace lobbying the IMO introduced the INF code, with INF3 based on these existing vessels which were build for the highest reliability not to further protect the cargo. It was acknowledged by IMO the cargo was more than adequately protected with packaging dictated by the IAEA transport regulations but they were responding to anti-nuclear pressure whose objective was to have more regulation and thus cost on the nuclear industry. Thus the INF3 ships have the capacity to provide the highest level of reliability. This factor is a ket risk mitigation factor and when the additional quantity from Ahaus is taken into consideration this would be of such a scale and timeframe that ship reliability will become key to completing the combined shipping campaigns.

(iv) Ship conversion and decommissioning

The paper has included quoted conversion and decommissioning costs for an INF3 vessel to increase capacity. This covers both conversion and return to a non cellular INF3 ship. Continuing in nuclear shipping negates the risk associated in the ship returning to the open market. An estimate has been used to convert a commercially available ro/ro vessel to gain INF2 registration and returning the ship to standard commercial service. Controlling costs on decommissioning a ship from nuclear transports to open commercial service is not without risk. Experience of returning vessels to open commercial use has lead to additional steel work being replaced. This is due to Health Physicists being unable to categorically state an area of steelwork is completely free of contamination. This risk is managed by comprehensive pre-hire surveys but this does not eliminate the risk entirely. A potential secondary risk is that an assurance is sought by the charter ship owner that they are financially protected for any subsequent loss if the ship is blighted in the open market having previously carried nuclear cargoes. This can be eliminated by contract but it does have the potency to close contractual negotiations with a prospective ship provider.

(v) Project fatigue

The administrative and emergency response agencies are more supportive and positive if the number of voyages are minimised, particularly if they are aware that a higher capacity system can reduce the demand on their services. This is especially true for officials responsible for law and order, security and nuclear safeguards. Manpower scheduling for occasional shipments is usually achieved with overtime working and holiday management but for long campaigns more staff are sought so they can be confident commitments can be fulfilled. Being in a position to demonstrate the best transport campaign has been selected helps to mitigate this risk.

(vi) Strength in depth of ship owners

For ship procurement the fleet size and capability of candidate shipping companies can create project risk. If additional ships are not within the shipping company's fleet and the company is therefore unable to provide a suitable substitute ship or summon an additional ship over the schedule period then timely project completion is at risk. An assessment of capability at the contracting stage can help to mitigate this risk.

(vii) Regulatory approval and certification.

This is a significant and difficult risk to manage. As the partners in this project are well aware obtaining the necessary certifications and approvals is at best time consuming and at worst unpredictable. The risk can be reduced by selecting as many elements as possible that are already certified or approved. For certificates and approvals that have to be obtained regardless of the option selected then management resources have to be allocated to monitor and maintain momentum on the relevant regulatory body. Of special concern are the security arrangements that the regulator will apply. For a category II shipment additional security requirements are subject to regulator discretion. This is the greatest risk associated with chartering a vessel for conversion to an INF2 classification. To manage this risk the Regulator has to determine well in advance the level of security, principally the level and number of onboard staff, so that both the equipment and additional accommodation can be confirmed as achievable on a candidate vessel. Recent charters that have been approved to the INF2 standard by the Danish authorities have been on a one voyage basis. This would be an unacceptable risk for a project of this magnitude and must be eliminated by obtaining an approval for the complete shipping period.
It is a real possibility that the flag state regulator may require a level of security that cannot be accommodated on the vessel. To increase the number of personnel onboard requires appropriate accommodation but less obvious is the possibility that lifeboat capacity, galley and recreational facilities increased which on some ships is just not possible or involves such a high capital reconstruction of the vessel that it is an uneconomic option. This is a real risk that cannot significantly be mitigated against by management action.

(viii) Two ship or a ro/ro, lo/lo hybrid.

Both these options add additional complications to an already major nuclear transportation project. To commence the shipping programme with a ro/ro option and then switch to a

lo/lo option is a risk. The risk being, a real reluctance by regulators, politicians and security services, and to a lesser extent the personnel directly involved, to change from one system that is working to an unproven system.
A contractual requirement for selected ship owners to be contractually obligated to provide a second ship as a contingent arrangement or to increase shipping capacity during the project period can eliminate project completion risk and therefore has merit.

9. Conclusions

The shipment of the High Temperature Fuel Elements from Jülich, Germany to the Savannah River Site, South Carolina, United States is a challenging project that nonetheless can be accomplished for a reasonable cost within the time constraint of June 2016.

The use of either Ro/Ro or Lo/Lo vessels is possible, and each has advantages and disadvantages as indicated in the report.

The selection of at least two ports in Europe and possibly two in the US with the necessary approvals is a critical issue and needs early confirmation.

In order to meet the timescale, an early determination of shipment size is necessary to ensure the necessary lead times to procure the correct equipment and have it available when required. It is possible, and perhaps desirable, to begin with one or two smaller shipments of up to nine casks using an INF2 vessel. This could also facilitate local security forces training. Later shipments could then be increased, up to as many as 36 casks although this would require the use of an INF3 vessel.

An integrated team of transport professionals is working to meet the needs of the client and the two governments involved. It is imperative that constant communications amongst all the parties be exercised in order to ensure project success.

While complicated, this project, once begun, will become a routine operation, with the necessary flexibility to meet unexpected challenges, such as weather, or other potential disruptions.

We are pleased to engage in further discussion leading to the completion of the full Transport Plan.

Appendix 1
INF Ship Criteria

Ship Class	Damage Stability	Fire Protection	Cargo Temperature Control	Structural Considerations	Cargo Securing Arrangements	Electrical Supplies	Radiological Protection	Management, Training and Plans
INF 1	1	5	8 + 9 +10	11	12 + 13	14	18	19
INF 2	3	7	8 + 9 + 10	11	12 + 13	15 + 16	18	19
INF3	4	6 + 7	8 + 9 + 10	11	12 + 13	15 + 16 + 17	18	19

Explanation;

1. The damage stability for cargo vessel has to be to the satisfaction of the relevant government bodies.
2. A damage stability requirement that applies to passenger ships only.
3. Regulations on compartment subdivision and damage stability, openings in water tight bulkheads and external openings.
4. Requirements to Code on Construction and Equipment for Ships Carrying Dangerous Chemicals in Bulk.
5. Equipment to be to the satisfaction of the relevant government bodies.
6. Accommodation, service, control and machinery spaces to be fitted forward or aft of cargo holds.
7. Water fire extinguishing system throughout the ship and a fixed system within the machinery space and a fixed cargo space cooling system. A fixed fire-detection and fire alarm system.
8. Ventilation or refrigeration of enclosed cargo spaces so ambient temperature does not exceed 55°C at any time.
9. Ventilation and or refrigeration systems serving cargo spaces shall be independent.
10. Essential equipment shall be duplicated and spare parts to satisfaction of government body.
11. Structural strength of deck areas and support arrangements to adequately withstand cargo loads.
12. Adequate permanent securing devices to withstand 1.5g longitudinally, 1.5g transversely, 1.0 upwards and 2.0g vertically down. Where packages are carried on vehicle deck to be secured as for heavy unitised and wheel based cargo and approved by government body.
13. Collision chocks where used shall not interfere with requirements under 8, 9 &10.
14. Provision of electrical supplies to satisfaction of government body.
15. Alternative source of electrical power so that damage to main supply does not affect the alternative source.
16. Alternative power sufficient to supply cargo cooling or flooding and all statutory emergency services to operate for at least 36 hours.
17. The alternative source to be located outside the extent of any damage envisaged in 1, 2, 3 &4.
18. Radiological arrangements and equipment shall be provided to the satisfaction of government body.
19. Management, training and shipboard emergency plan shall be to satisfaction of government body.

Ship	Cargo capacity based on **activity**.	Castor HTR numbers (based on example data)		**Security** Requirements (based on example data i.e. 0.2kg Pu / flask)	**Security** Requirements (based on U235 enrichment data i.e quantity >90%).	Additional **Security** Requirements
INF-1	An aggregate **activity** less than 4,000 TBq.	2 flasks.		2 flasks.	0 flasks.	No armed guard requirement.
INF-2	Irradiated nuclear fuel or high-level radioactive wastes with an aggregate **activity** less than 2 x 10^6 TBq and ships which are certified to carry plutonium with an aggregate **activity** less than 2 x 10^5 TBq	Numbers determined by physical restriction of vessel.		Max of 10 flasks = Cat1. ---------- Below 10 flasks = Cat2	To be confirmed.	Armed guard / escort required. (Cat1) ---------- Additional **security** requirements subject to regulator discretion. (Cat2)
INF-3	Irradiated nuclear fuel or high-level radioactive wastes and ships which are certified to carry plutonium with no restriction of the maximum aggregate **activity** of the materials	Numbers determined by physical restriction of vessel.		Max of 10 flasks = Cat1. ---------- Below 10 flasks = Cat2	3-10 flasks = Cat1	Armed guard / escort required. (Cat1) ---------- Additional **security** requirements subject to regulator discretion. (Cat2)

Appendix 2