Large and ASSOCIATES Consulting Engineers

UNITED STATES OF AMERICA NUCLEAR REGULATORY COMMISSION

DISPOSITION OF SURPLUS WEAPONS PLUTONIUM USING MIXED OXIDE FUEL

EUROFAB - TRANSFERS TO AND FROM FRANCE

COMMENTS AND OPINION ON THE APPLICABILITY AND SUFFICIENCY OF THE SAFETY, SECURITY AND ENVIRONMENTAL REQUIREMENTS AND MEASURES AS THESE APPLY TO THE TRANSATLANTIC SHIPMENT, EUROPEAN WATERS AND FRANCE

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1 QUALIFICATIONS AND EXPERIENCE

1.1 I am **JOHN H LARGE** of the Gatehouse, 1 & 2 Repository Road, Ha Ha Road, Woolwich, London, United Kingdom, SEI8 4BQ.

1.2 I am a citizen of the United Kingdom.

1.3 I am a Consulting Engineer, Chartered Engineer, Fellow of the Institution of Mechanical Engineers, Graduate Member of the Institution Civil Engineers, Member of the British Nuclear Energy Society and a Fellow of the Royal Society of Arts.

1.4 As an undergraduate student I attended the Borough Polytechnic (now University of the South Bank, London) being awarded a Higher National Diploma in Technology, and I read for and graduated with Honours in Engineering Science and Technology at London University. Thereafter, in the mid-1960s, I completed post-graduate research at Brunel University, London where I was appointed as a full time member of the academic research staff of the School of Engineering and Technology.

1.5 As a Research Fellow at Brunel University, I undertook postgraduate research sponsored by the United Kingdom Atomic Energy Authority (UKAEA) until the mid 1980s. Long term research projects and tasks undertaken for the UKAEA included comprehensive modelling of the aeroelastic oscillations of advance gas cooled (AGR) nuclear reactor fuel stringers during core charge and discharge transients; in-core fluid dynamics studies for gas-cooled reactor primary circuits, graphite moderator performance under long term irradiation, the development of integrated moderator/uranium ceramic fuels for a prototype HTR reactor then under development, together with a number of assignments relating to the research and development reactors and other nuclear devices.

1.6 In all, my research for the UKAEA (and other UK nuclear related agencies) spanned over 15 or so years.

1.7 From the mid-1970s I was appointed as Academic Tutor and a member of a number of Boards of Studies of the Engineering School at Brunel University; I was responsible for and taught a number of undergraduate and post-graduate courses; and I supervised postgraduate research students in a diverse range of technologically based projects, including nuclear based research. I served on the Senate of the University for a number of years, and I acted as External Examiner at a number of other UK Universities.

1.8 I now occasionally teach and tutor at a number of UK universities, regularly at Brighton, Bath and Middlesex universities.

1.9 Since 1986, I have headed the firm of Consulting Engineers, Large & Associates. Large & Associates provides engineering and analytical services relating to nuclear activities, systems failure and engineering defects.

1.10 Over the last 20 or so years, I have given evidence to a number of United Kingdom House of Commons parliamentary select committees on nuclear and related environmental topics,[1] and I have represented and provided evidence at a number of public inquiries for local authorities on nuclear issues in the United Kingdom. I have also given evidence and/or advised a number of overseas governments, states and commissions on nuclear matters, including the Government of Italy on irradiated fuel transportation; Japan on decommissioning nuclear power plants; New Zealand on MOX fuel transportation and, separately, the risks and hazards associated with the berthing of nuclear powered vessels; the Republic of Ireland on the environmental and health impact of sea discharges from the British Nuclear Fuels (BNFL) plant at Sellafield, UK; the State of Bulgaria on the preparedness of emergency plans at the Kozladuy nuclear power complex; the Oblast (state government) of Sverdlovsk (now Ekaterinburg) on decommissioning; and the government of South Africa on a confidential nuclear matter.

1.11 More recently, I acted for the Government of Gibraltar advising on the safety of the repairs being undertaken to the reactor of the Royal Navy nuclear powered submarine HMS *Tireless* whilst emergency berthed at Gibraltar during much 2000. This involved assessment of the nuclear safety case for the reactor (pressuriser pipe saddle) repairs and my role included evaluation of issues relating to security of the submarine whilst in the busy commercial port of Gibraltar.

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1 a) *Radioactive Waste and Long Term Storage* - Evidence to House of Commons Environment Committee, August 1985, b) *Corrosion of Magnox Cladding* - Evidence to House of Commons Environment Committee, November 1985; by order of the H of C Environment Committee, c) *Information on the Nuclear Industry* - Evidence to H of C Environment Committee, November 1985; by order of H of C Environment Committee, d) *Decommissioning of Civil Nuclear Power Stations* - Evidence to Select Committee on Energy, January 1987

1.12 Throughout 2001, I organised, headed and was responsible for the specialist team assessing the nuclear reactor and conventional weapons hazards of the sunken Russian Federation nuclear powered submarine *Kursk*, advising the Russian Federation government and the Dutch consortium Smit-Mammoet throughout the salvage operations, being responsible for the nuclear risk assessment and the implementation radiological protection regime on board all of the salvage vessels.

1.13 My team comprised 8 to 10 specialists in reactor technology, naval weaponry, radiation protection and submarine design, including a serving Commander from the Royal Navy's Naval Nuclear Regulatory Panel seconded to Large & Associates for the duration of operations. My team was required to negotiate directly with the submarine designers RUBIN and the Russian Federation Northern Fleet, and to approve all procedures prior to each stage of the salvage being permitted to proceed.[2]

1.14 Separately, I was appointed to advise the insurance firms and brokerages covering the equipment and crews involved in the *Kursk* salvage.

1.15 I was awarded a commemorative medal by the Russian authorities for my contribution to the successful salvage of the *Kursk*.

1.16 In a similar venture, I was a member for the working party convened by the Russian authorities to assess the risk and hazards of the two nuclear tipped torpedoes lost on board the nuclear power submarine *Komsomolets* that foundered in the Barents Sea in 1989.

1.17 I have also prepared and given evidence at the Court of Human Rights at Strasbourg relating to the blast, thermal and radiation damage of the UK *Grapple* series atmospheric nuclear test series at Christmas Island in 1958 as these related to UK Armed Forces Services personnel attending those tests; over a period of six years until 1998, I acted for and advised the UK National Fire Brigades Union (FBU) on accidents involving nuclear materials and irradiated fuel shipments (attending as an observer many exercises), and I negotiated the present system of radiation exposure limitation for fire fighters attending incidents involving radioactivity; and I have prepared and given evidence relating to bomb making and firing devices in a matter of an intended act of terrorism brought before the English criminal justice system in the late 1990s.

1.18 On general nuclear matters, I not infrequently contribute facts and opinion on international developments in the nuclear field to national and international news media, including BBC World, Sky, CNN and other such international broadcasting organisations.

1.19 Relating to the matter being considered here (the disposition of plutonium derived from nuclear weapons):

- in the mid-1990s I undertook and completed a comprehensive study of the risks and hazards relating to the transportation and storage of nuclear weapons in the United Kingdom;[3a]
- I have prepared and given evidence at a UK public inquiry on the manufacture, refurbishment and storage of nuclear weapons; which involved consideration of the dispersal of and health detriment arising from a release of plutonium in oxide form;[3b]
- I have completed a number of transport studies involving irradiated fuel and unirradiated MOX fuel on the high seas and overland by road and rail modes;[4]
- I have presented reports on emergency planning and the countermeasures necessary to mitigate the aftermath of nuclear accidents and incidents;[5]
- I have specifically studied and reported on the proposed transportation of MOX fuel from the British Nuclear Fuels plant at Sellafield (UK), travelling through France onwards to the Beznau nuclear power plant in Switzerland;[6]
- I attended the June 2003 IAEA conference of the transport of radioactive materials, at which I summarised the papers and findings of the conference.[7]

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2 *The Nuclear Risks and Hazards in the Salvage of the Kursk,* Marine Industry Challenges in the Global Market, Society of Naval Architects and Marine Engineers, October 2003

3 a) *The Hazards of Transporting Nuclear Weapons Through Urban Areas*, Large & Associates, National Steering Committee of Nuclear Free Zone Local Authorities, January 1990, b) *Atomic Weapons Establishment Aldermaston Radioactive Wastes, Discharges, Commissioning and Safety Policy*, Evidence to the AWE Community Public Inquiry, Reading Borough Council, March 1994

4 a) *The Transport of Radioactive Waste in the UK*, Large J H, Manchester Conference, Metropolitan Boroughs, January 1986 - *Transportation of Irradiated Fuel through London* - LA1712-1, Nuclear Information Unit, 5 Pts, October 1987, b) *Transportation of Nuclear and Radioactive Materials Risk, Hazard and Consequences and Insurance* - Proc GENEVA Conf, London, October 198, c) *Import/Export of Irradiated Fuel and Radioactive Waste to and From the United Kingdom.* Report for Greenpeace International, June 1990, d) *Transportation of Irradiated Fuel through the Port of Dover* - Hazard, Risk and Consequences of Severe Accidents, Seminar - Kent County Council, County Hall, Maidstone, 28 January, 1991, e) *The Transportation of Plutonium and Irradiated Fuel Products, Hazards and Risks*, Into Conf on Plutonium, Omaha Sonic City, Omaha, Saitama, Japan 2-4, November 1991.

5 a) *The Health and Safety of Firefighters* Proof of Evidence - PWR at Hinkley Point C., National Executive of the Fire Brigades Union, May 1989, b) *Emergency Response Planning for a Nuclear Weapons Accident, Emergency Planning* '91 International Conference, Lancaster University, September 1991, c) *The Role of Firefighters in Nuclear Accidents, Emergency Planning* '91 International Conference, Lancaster University, September 1991.

- With respect to the vulnerability of nuclear processes and materials in transit to terrorist attack, in 2002 I was invited to address an assembly of the Finish Parliament in Helsinki,[8] and I have published on aspects of terrorism in a number of international journals.[9]

1.20 I present myself as a Consulting Engineer with considerable experience of the nuclear industry worldwide, being qualified by education, professional standing and experience to provide expert opinion on this matter.

2 TERMS OF ANALYSIS

2.1 I have been instructed by Mr Tom Clements of Greenpeace International.[10]

2.2 Mr Clements has outlined to me his organisation's environmental, security and proliferation concerns over the proposal by the US Department of Energy (DOE) to export a quantity of fissile plutonium (PuO_2) to France for fabrication into mixed oxide (MOX) fuel for return to the United States.

2.3 This DOE proposal is referred to the *Fabrication of Mixed Oxide Fuel Lead Assemblies in Europe* or *Eurofab* program, which is a part of the larger plutonium disposition programme as reviewed in various documents.[11a,b,c]

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6 *A Review of the Risks and Hazards Relating to the Proposed Transportation of Unirradiated Mixed Oxide Fuel from BNFL UK to the Beznau Nuclear Power Plant , Switzerland*, R3095-A1, Greenpeace International, January 2003.

7 *Briefing on the Conference papers and Discussions*, International Conference on the Safety of Transport of Radioactive Materials, International Atomic Energy Agency, Vienna, July 2003.

8 *Uncertain Risks and Hazards relating to the Ordering and Commissioning of Finland's 5th Nuclear Reactor*, Finnish National Parliament, Presentation to Members of Parliament, 15 May 2002

9 a) *Nuclear Risks at Nuclear Facilities post 11 September,* 4th Standing Conference of Irish and UK Local Authorities, Tenby, Wales 21-22 March 2002, b) *Rethinking Nuclear Energy and Democracy after 09/11*, *The End of Probabilistic Risk Analysis*, International Conference, PSR/IPPNW Basel, Switzerland, April 2002, c) *The Implications of September 11th for the Nuclear Industry*, Monitor, Royal United Services Institute, London, February 2003, V2 No 1, d) *Vulnerabilities of Nuclear Plants to Terrorism*, Large J H & Schnieder M, Oxford Research Group Seminar, Rhodes House, Oxford, December 2002. d) *A Review of Local Authority Off-Site Emergency Planning under the Radiation (Emergency Preparedness & Public Information) Regulations*, Greenpeace UK, December 2002, e) *Nuclear Terrorism – The New Nuclear Threat*, 5th Conference of UK and Irish Local Authorities, Cork, 20 March 2003, f) *The Implications of 11 September for the Nuclear Industry*, J H Large, United Nations for Disarmament Research, Disarmament Forum, 2003 No 2.

10 I should state here that over the years I have provided technical and engineering opinion on a number of nuclear issues to Greenpeace International and a number of national Greenpeace organisations but, that said, I am not a member of nor do I subscribe to this non-government environmental organisation.

11 a) *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement (Storage and Disposition PEIS)* DOE/EIS-0229, December 1996) (DOE 1996a), b) *Surplus Plutonium Disposition Environmental Impact Statement (SPD EIS),* (DOE/EIS 0283, November 1999) (DOE 1999b). c) Supplement *Analysis, Fabrication of Mixed Oxide Fuel Lead Assemblies in Europe*, November 2003, US DOE/EIS-0229-SA3

2.4 I have been asked to provide my expert opinion, for both the plutonium dioxide outward consignment to France and the return of MOX fuel to the United States, on the following issues:

- First, do the physical protection and security measures specified by the IAEA INFCIRC/225, as adopted by and practicably implemented in France, meet with the standards practised in the United States for what it defines as *'strategic special nuclear material'* intended for disposal via the plutonium disposition programme?
- Second, are the INFCIRC/225 measures reasonably sufficient to protect against theft or sabotage of the plutonium, either in its dioxide powder form or as fabricated MOX fuel assemblies?
- And, third, do any shortfalls identified by the above justify that i) a further environmental impact assessment and ii) proliferation assessment be undertaken in addition to that existing in the previous Environmental Impact Statements[11] made in support of the surplus plutonium disposition program?

3 BACKGROUND

3.1 Via *Eurofab*, the DOE proposes to export about 150 kilograms (kg)[12] of plutonium dioxide to France on a one-time basis for fabrication into four MOX lead test fuel assemblies (LTAs) and, once manufactured, the MOX LTAs are to be returned to the United States.

3.2 From my research efforts, the only formal documents describing the proposed transboundary movement of this strategic special nuclear material comprise i) the US DOE's application to the US Nuclear Regulatory Commission (NRC) for an export licence dated 1 October 2003, and ii) the *Supplement Analysis*[11c] prepared by the US Department of Energy in or about November, 2003.

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12 The earlier references to the plutonium disposition programme refer to total quantity 140kg PuO_2 whereas the latest EIS in the Supplement Analysis (11c) refers to 'approximately 150kg pf plutonium oxide – I shall refer to the later quantity, 150kg, throughout this statement, although I note that the Supplement Analysis 150kg figure may derive from the total available capacity of the FS47 flasks. Of course, 10kg of plutonium is not an insignificant quantity with the IAEA stating 8kg to be a *'Significant Quantity'*[x], although less that 8kg mass of weapons grade plutonium elemental metal could be used for the fissile pit components of a modern, plutonium cored nuclear weapon. That said, the memo to L W Camper from Nancy Osgood of NMSS, date 29 May 2003 specifically refers to 140 kg plutonium

3.3 The DOE's application is quite brief and provides very little detail. The *Supplement Analysis* (SA) gives somewhat more information, being drawn from the DOE's previous environmental impact statements (EIS)[11a,b] of 1996 and 1999.

3.4 Essentially: The proposal is to transfer about 150kg of weapons grade plutonium dioxide (PuO_2) powder from storage at the Los Alamos National Laboratory by road to an east coast military port, from there by sea on board one of two Pacific Nuclear Transport Limited (PNTL) ships to Cherbourg, France, and thereafter overland by road to Cogema's ATPu MOX fabrication plant in Cadarache in Provence.

3.5 At Cadarache the plutonium is to be blended with uranium, and formed into pellets loaded into fuel pins. These pellets will be transferred to the MELOX plant for fabrication into four MOX fuel assemblies. The assemblies are to be returned, first, by road to Cherbourg and then by PNTL ship(s) to an east coast port in the United States. Archive and scrap material containing residues of the original PuO_2 batch are also to be returned with the completed fuel assemblies.

3.6 Outward and homebound journey distances to and from the United States dispatching/receiving ports are each approximately 3,300 miles by sea and about 500 miles overland in France. According to the export license application, DOE's contractor for the plutonium disposition programme, Duke Cogema Stone & Webster (DCS), will make all contractual arrangements with PNTL for the shipments.

3.7 For both outward and return sea legs, the PNTL ships sail together, each providing an armed escort for the other. It is not known whether the entire consignments of PuO_2 (outward) and MOX (homeward) will be carried in just one ship or spread between the two.[13]

3.8 Outward and return consignments of are to be made in two different types of IAEA Type B(U) flasks:[14]

3.9 For the outward transit, the (assumed weapons grade) plutonium dioxide powder is carried in double cans each containing 3.4kg PuO_2, with 5 cans stacked in a sleeved jacket

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13 In previous shipments of fissile materials by theses two PNTL ships, it is believed that only one vessel actually carried the fissile material cargo with the other ship running empty but acting as an armed escort.

14 Type B(U) in accordance with IAEA 1996 Regulations, TS-R-1 – see also *Regulations for the Safe Transport of Radioactive Material, Safety Standards Series No. ST-1* Requirements, Edition, Vienna (1996)

that in turn is held in a FS47 flask, giving about 17kg PuO_2 per flask. In total, 9 FS47 flasks with about 150kg PuO_2, are to be loaded to one or two PNTL ships for the sea journey to the French port of Cherbourg, where the offloaded flasks will be transferred to unspecified vehicles for the short journey to the COGEMA reprocessing works at La Hague. At La Hague, the FS47 flasks are transferred to three 'SIFA'[15] vehicles, each carrying three FS47 flasks, which are to haul the consignment to Cadarache.

3.10 For the return journey, the fabricated MOX fuel assemblies, archive and scrap material are to be carried in FS65 flasks with four flasks containing fuel assemblies and two flasks with the archive and scrap material temporarily sheathed in fuel pins. The FS65 flasks would be carried to La Hague in SIFA vehicles[16] where the flasks are transferred to unspecified vehicles for the short haul to Cherbourg. At Cherbourg the flask are fitted with overpacks prior to loading into the hold of one or both of the PNTL armed ships.

3.11 The DOE's export application of 1 October 2003 states that applications for *'Certification of Competent Authority'* for both the FS47 and FS65 shipping packages *"will be filed with the Department of Transportation and the NRC by DCS."*, although I understand that this has yet to be done for either flask design.

3.12 The assessment of the environmental impact for the entire Eurofab program is, essentially, in two parts.

3.13 For the 1st part, the United States has undertaken the EISs[11] in respect of the handling and transportation phases in US territory and for the sea legs out of the dispatching port and across the Atlantic Ocean – much of the assessment for the US <u>overland</u> transportation has been openly published.

3.14 However, the US EISs do not include assessment of the approaches to the receiving port of Cherbourg in France, nor for any aspect of the transportation, handling and

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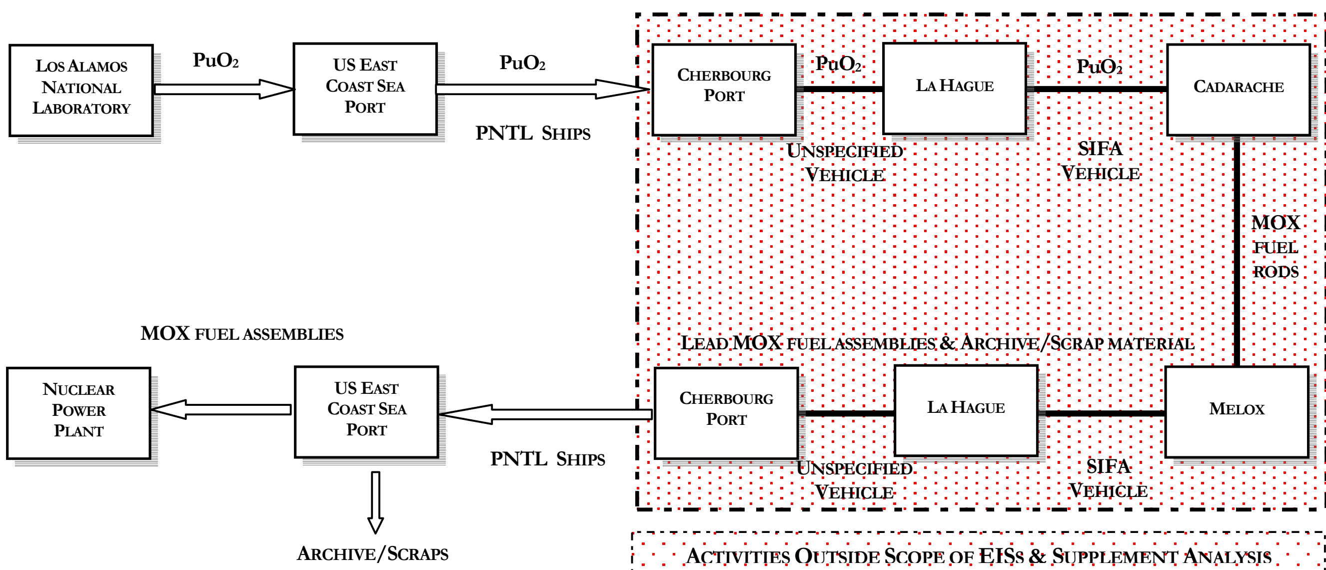
15 The tractor-trailer unit involved is referred to as a safety vehicle or 'SIFA' carrying a Siemens manufactured fuel flask, with the delivery convoy comprising transport, escort and communications control vehicles, all of which are armoured and fitted with vehicle tracking systems. Both driver cabin and load compartment of the SIFA trailer unit are armoured, with the load compartment being 2050 x 2300 x 6070mm dimension, and of maximum payload of about 14 tonnes. This type of vehicle for hauling French sourced PuO_2 to two French and single Belgium MOX fabrication plants – about 90 such shipments were made in 2001.

16 A number of fabricated MOX unirradiated fuel shipments to Germany have been completed since October 1996 and six or more road/sea/road shipments have been undertaken since. Because the SIFA is not custom designed solely for MOX cargoes it was expected to be replaced with a MOX dedicated unit sometime around 2000 – see *The Transportation of MOX Fuel,* Christ R, 23rd Annual Symposium, Uranium Inst, 1998

fabrication, etc., processes for the MOX lead assemblies that are to be undertaken in France.

3.15 This 2nd part, relating to the Cherbourg port reception of the PNTL ships, the road transfers to and from Cadarache, and the Cherbourg port loading and embarkation, together with the fabrication processes undertaken in the French MOX plants, is the responsibility of the French authorities (and PNTL for the maritime aspects).

3.16 The (geographical) areas of demarcation of these two parts are shown schematically as follows:



Scope of the Most Recent Supplement Analysis (after 11c)

4 US Standards for Safeguarding Strategic Special Nuclear Material

4.1 For the United States, the two EISs[11] relating to the disposition of weapons grade plutonium[11] have had to, essentially, consider the impacts of normal operation and the outcome of abnormal events. For the latter, both accidental and contrived situations apply, although here I shall only comment upon what I consider to be the inadequacy of the approach to contrived events, that is acts of sabotage and terrorism.

4.2 The underlying conclusions in the Storage and Disposition PEIS[11a] and the SPD EIS,[11b] which are carried through to the SA, are that *"adequate safeguards are in place to meet such a [terrorist] threat"*, that *"the candidate ports analyzed in this SA are military ports that provide a heightened level of security"*, and that *"the chance of success [of a terrorist act] is judged to be very low, particularly in light of the transport methods to be deployed by DOE . . . which are specifically designed to afford security against sabotage or terrorism"*. [p23 SA]

4.3 In other words, the existing facilities in the United States are considered to be sufficiently terrorist proof.

4.4 Indeed, for the US and Atlantic sea transport phases (the latter statement of para 4.2 above), in referring to special transport methods suggests there to be some other standard applied to achieving a satisfactory level of security for the consignments in transit, that is in addition to and over the IAEA INFCIRC/225[17] which is internationally adopted for *Category I* materials. This seems to be the so-called *'Stored Weapons Standard'* that is referred to in SPD EIS[11a] in the most general of terms that *"high standards of security and accounting . . . should be maintained . . . for weapons-usable fissile materials throughout dismantlement, storage and disposition."*.[18]

4.5 My point here is that in addition to the security requirements of IAEA INFCIRC/225, the United States US Department of Energy requires its contractors to take <u>additional</u> safeguards and security measures for handling weapons-grade plutonium, or what is also referred to as *strategic special nuclear material*.[19]

4.6 I consider this requirement for such additional measures to be consistent with the legal determination made by DOE in the SPD EIS.[11b]

4.7 In fact, this is a key issue because the draft *Public Notice of Intent*,[20] circulated within DOE and to Belgium and France, although never formally released, in respect to the to the Eurofab project, states:

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17 IAEA Information Circular INFCIRC/225.Rev 4, Physical Protection of Nuclear Materials

18 See also G Bunn who claims to provide an authoritative outline of the US Stored Weapons Standard in the Appendix of *US Standard for Protecting Weapons-Usable Fissile Material Compared to International Standards*, Non-Proliferation Review/Fall 1998

19 The Code of Federal Regulations, Part 73, S73.1 and 73.2 defines this to be more than 5kg of U-235 enriched to 20% or more and/or 2.5kg or more of plutonium.

20 DOE, Pre-Decisional Draft – Draft No 1, Notice of Intent to Prepare a Supplement to the Surplus Plutonium Disposition Final Environmental Impact Statement (Lead Mixed Oxide Fuel Assemblies), March 6, 2002 (Q\NIGAM\SEIS LTA\Draft NO1-LTA2.1,doc)

"...

The European fabrication option would be viable only if supported by the interested European government(s) and only if there were mutual agreement on such aspects as cost and schedule, transportation, security and safeguards arrangements . . . key activities include:

- *Issuing a Public Notice of Intent and evaluating the environmental impacts of this approach as required by the US National Environmental Policy Act*

. . ."

[my truncation . . .]

4.8 Given decisions already taken by DOE concerning the Stored Weapons Standard, for Eurofab to proceed the NRC has to be satisfied that the overseas states involved in the transportation (and fabrication) have in place additional measures that are superior to IAEA INFCIRC/225 – the two overseas states involved are France and the United Kingdom.[21,22,23]

4.9 Neither of these states publicly claims to adopt the US Stored Weapons Standard.

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21 The two lightly-armed PNTL vessels involved, Pacific Pintail and Pacific Teal, are both British registered vessels operated by a British registered company (James Fisher & Sons) so, unless some artful dodge is to be introduced, the IAEA defined *Shipping State* is the United Kingdom which has responsibility for ensuring safety of the consignment.. In the UK the Competent Authority that approves radioactive material in transit is the Radioactive Materials Transport Division (RMTD) of HMG Department for Transport (DfT). More specifically, the RMTD generally reviews the nuclear safety arrangements, although matters relating to security are undertaken by arrangement with the HMG Department of Trade and Industry's Office of Civil Nuclear Security (OCNS). These departmental responsibilities and jurisdictions mean that, in effect, the UK approves the nuclear and security safety aspects of the consignments to and from the United States and French ports of entry and dispatch.

22 In previous shipments of PuO2 and MOX to Japan and in which the United States had an interest under the US-*Japan Agreement for Peaceful Nuclear Cooperation,* the two PNTL ships were considered by the US State Department to be on *'[UK] Government Service'* because the shipments will be carried *'on government service because the shipments will be carried out by BNFL which is a corporation wholly owned by the British Government, and because the armed guards on board each vessel will be officers of the United Kingdom Atomic Energy Authority Constabulary'*, see *Japan's Transportation Plan for Shipment of Mixed Plutonium/Uranium Oxide (MOX) Reactor Fuel from Europe* t Japan, US DOE, April 99.

23 There is some resistance by the British Government to classify the PNTL ships as being on 'Government Service'. For this HM Government is reluctant to admit to these ships, albeit that PNTL is largely owned by the state-owned entity British Nuclear Fuels Ltd., are 'Government Ships' instead considering them to be civilian vessels engaged in commercial cargo operations – see Memo for Andrew Hutcheon, Watson, Farley & Williams, London 7 July 2000 and written House of Commons Parliamentary Answers Written Answer 29 November 2000 from Stephen Byers [Secretary of State for Transport] to Mr Chayter [Member of Parliament] . . . (2) *"what assessment he [Secretary o State for Transport] has made of the compliance of the shipments of MOX fuel from Sellafield to Japan with US requirements concerning safety and physical protection; and if the vessels concerned were classed as engaged in commercial cargo operations."* [140601] Mr. Byers, Secretary of State for Transport: "*The United States Government has confirmed, after careful scrutiny by all the relevant agencies, that the arrangements that were put in place for the shipment of MOX from Europe to Japan fully satisfy the physical protection provisions of Annex 5 of the 1988 US-Japan Nuclear Co-operation Agreement. PNTL vessels involved in MOX shipments are civilian vessels engaged in commercial cargo operations.",* see also *The Shipment of Ultrahazardous Nuclear Materials in International Law*, b Duncan E. J. Currie and Jon M. Van Dyke, in Review of European Community & International Environmental Law (1999). The significance of denying that the ships are on 'Government Service' is that the present UK licensing legislation is based on commercial trade with the the commerical operator being responsible for security and, particularly, emergency planning whilst at sea via the non-government RADSAFE voluntary code of practice.

4.10 Alternatively, if they each have their own equivalent standards these are not available for public scrutiny, with the French going so far as to state that any arrangements for transportation would be 'secret'.[24]

4.11 If these two states solely rely upon IAEA INFCIRC/225 then this would not be sufficient for the US DOE which, in 1999, *'showed that the US [Stored Weapons] standard was much higher [than INFCIRC/225]'.*[25] Indeed, doubts continue to be expressed that the latest revision (Revision 4) of INFCIRC/225, although higher than before, is not as high as the DOE's Stored Weapons Standard.[26]

4.12 Of course, if asked, France and the United Kingdom would, in all likelihood, assert that the safeguards to be put in place, for their respective parts of the transits, will be sufficiently robust to render the chance of success of an act of sabotage or terrorism to be very low.

4.13 On its part, the US DOE's SA[11c] acknowledges that the likelihood of an attempted act of sabotage or terrorism occurring *"is not precisely knowable"*, although the inclusion of the *'transport methods to be employed'* or directed by the DOE are designed *"to afford security against sabotage or terrorism, as well as safety in the event of an accident."*.

5 IAEA &FRENCH STANDARDS FOR PROTECTION OF CATEGORY 1 MATERIALS

5.1 The IAEA standard INFCIRC/225 defines the plutonium as a *Category 1* material.[27] In this respect both the outward PuO_2 and MOX Eurofab consignments are *Category 1.*

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24 The senior French civil servant responsible for defence affairs in the industry ministry (HFD), Didier Lallemand, said the details of the shipments would remain secret but that the administration intended to organize more general information about the operation for the media and the public at an appropriate time – Nuclear Fuel, 24 November 2003.

25 According to George Bunn in the *Nonproliferation Review/Summer 2000,* and *Management and Disposition of Excess Weapons Plutonium*, National Academy of Sciences, 1994

26 *Raising International Standards for Protecting Nuclear Materials from Theft and Sabotage*, Bunn G, The Nonproliferation Review/Summer 2000 – here Bunn also seems to imply that the latest draft Revision 5 of INFCIRC/225 still falls short., although it is believed that discussion has begun for strengthening this guideline in Revision 5 of INFCIRC/225. In fact, in October 2003 the IAEA convened a meeting to *"Address Guidance for Security in the Transport of Nuclear Materials"* (TM-25898) with the am of producing a revised version of the IAEA Technical Document *"Security in the Transport of Radioactive Material – Interim Guidance for Comment"*, which is now under preparation for review by Member States.

27 IAEA INFCIRC/225/Rev 4 gives the primary factor for determining the physical protection measures against unauthorized removal of nuclear material to be the nuclear material itself, categorized in accordance with the following table which gives a categorization of the different types of nuclear material and with the considerations given below:

Categorization of Nuclear Material

Material	Form	Category I	Category II	Category III
Plutonium[a]	Unirradiated[b]	2 kg or more	than 2 kg but more than 500 g	00 g or less but more than 15 g

onium except that with isotopic concentration exceeding 80% in plutonium-238

l not irradiated in a reactor or material irradiated in a reactor but with a radiation level equal to or less than 1 Gy/hr (100 rad/hr) at one meter unshielded

5.2 For *Category 1* material a number of security safeguards have to be in place, including for arrangements at the transfer of responsibility for the consignments at the international border, either between the dispatching and receiving states (US to France) or, as is probably the case here, from the shipping state (UK to France)[22] to the receiving state.[28]

5.3 The IAEA INFCIRC/225 standard sets out protection and security measures in general terms, essentially that [my comments enclosed thus]:

- The physical protection system should be based on the evaluation of the threat and account should be taken of the emergency response capabilities.

  [Nothing is available from the French La Direction Generale De La Surete Nucleaire Et De La Radioprotection (DGSNR) on evaluation of the threat and emergency response capabilities than a Decree with sets out radiation exposure limits for attendees of incidents.] [29]

  [For the sea transport phase, which applies in the approaches to and entering the harbour at Cherbourg, the emergency response arrangements for PNTL ships are the responsibility of PNTL and not any Government agency, and are not openly published – these plans, known as RADSAFE are not publicly available.]

- A design basis threat (DBT) developed from an evaluation of the threat of unauthorized removal of nuclear material and of sabotage of nuclear material is an essential element of the physical protection system.

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28 IAEA INFCIRC/225/Rev 4 recommends a number of security measures, for example:

Security Guards: A 24-hour guarding service should be provided. Guards should be trained and adequately equipped for their function in accordance with national laws and regulations. When guards are not armed, compensating measures should be applied. The objective should be the arrival of adequately armed response forces in time to counter armed attacks and prevent the unauthorized removal of nuclear material.

Transfer of Responsibility: In contracts or agreements between shippers and receivers involving international transport of nuclear material, the point at which responsibility for physical protection is transferred from the shipper to the receiver should be clearly stated. During international transport of nuclear material the responsibility for physical protection measures should be the subject of agreement between the States concerned. The shipping State should consider, before allowing the international transport, if the States involved in the transport, including the transit States:

- are Parties to the *Convention on the Physical Protection of Nuclear Material* (INFCIRC/274 Rev.1); or
- have concluded with it a formal agreement which ensures that physical protection arrangements are implemented; or
- formally declare that their physical protection arrangements are implemented according to internationally accepted guidelines; or
- have issued licences which contain appropriate physical protection provisions for the transport of the nuclear material.

In the case of a Category I nuclear material international shipment transiting international waters, the shipping and receiving States should establish specific measures to ensure the maintenance of communication regarding the continued integrity of the shipment and to ensure that responsibility for response planning and capabilities is defined and fulfilled. When the contract or agreement involving international transport provides for delivery to a destination in the receiving State in a vehicle of the shipping State, this contract or agreement should provide that information be supplied in time to enable the receiver to make adequate physical protection arrangements.

29 Décret N° 2003-295 du 31 Mars 2003.

[In France, the role of the DGSNR does not include matters of security which is dealt with by the senior official, un haut fonctionnaire de défense (HFD), appointed from within the French industry ministry regulation. It is believed that HFD considers security on a case-by-case basis and it not known what, if any, design based threat scenarios are nominated. Indeed, nothing has been published on previous *Category 1* transits in France and when referring specifically to Eurofab, HFD stated *"transport measures will be confidential*".[30]]

[In the UK the situation is confused insofar that Government ministers consider the DBT to be based on *'intelligence about the motives, intentions and capabilities of potential adversaries'*,[31] which seems to imply that there is sufficient confidence to detect the intent of terrorist act before such are carried through. In fact, the UK nuclear safety regulator, the Nuclear Installations Inspectorate of the Health & Safety Executive, has concocted the quite absurd reasoning for why it is unnecessary to include assessment of terrorist attack on the basis that *". . .that if a threat to the plant is judged by the operators, to fall below the limit of reasonable foreseeability then it does not need to be included in its submission to HSE. Given that there is no substantive evidence that a terrorist threat to a specific plant* (or transport mode) *and in a specific manner is reasonably foreseeable, HSE considers that it is quite correct that the reports of assessment do not need to consider this."*.]

- Emergency plans for any needed response to unauthorized removal and subsequent unauthorized use of nuclear material or sabotage of nuclear material to support and supplement, when needed, those emergency plans prepared by the carriers.

[Other than a somewhat limited decree on emergency radiation exposure limits, nothing further is available from the French authorities.]

[The claim in the UK is that the emergency plans (RADSAFE) prepared by the Carrier (here PNTL) are sufficiently flexible to be extended to cover acts of terrorism, although nothing is available in the public domain to substantiate this. However and in general, prior to the transport being undertaken the Carrier is required to submit a *Summary Transport Plan* detailing the modes of transport, routes, ports, vehicles and packages involved. In the UK this summary is reviewed by the security authority the Department of Trade and Industry's Office of Civil Nuclear

30 Nuclear Engineering, No 24, November 24, 2003

31 a) Letter, Sunil Parekh, APS to John Denham, Home Office Minister to Large & Associates, 10 May 2002, b) Letter, Mike Smith, Manager Nuclear Security, Department of Trade and Industry to Large & Associates, 28 February 2003, c) The Office of Civil Nuclear Security 1st Annual Report, October to March 2002, d) E-mail Graham Holder, HSE to Large & Associates, 26 February 2003.

Security (OCNS) details of the Summary *Plan* for the Eurofab voyages, if that is it exists, are not publicly available.][32]

- o During international transport of nuclear material the responsibility for physical protection measures should be the subject of agreement between the States concerned and the following should be in place:[33]
  - have concluded with a formal agreement which ensures that physical protection arrangements are implemented; or
  - formally declare that their physical protection arrangements are implemented according to internationally accepted guidelines; or
  - have issued licences that contain appropriate physical protection provisions for the transport of the nuclear material.

  [Nothing is available in the public domain suggesting that both France and the UK have complied at this with this requirement for Eurofab.][34]

- o To ensure that physical protection measures are maintained in a condition capable of effectively responding to the design basis threat (DBT), the competent authority should ensure that evaluations are conducted by the Carrier (BNFL) of the transport, with these evaluations including administrative and technical measures, such as testing of detection, assessment and communications systems and reviews of the implementation of physical protection procedures and should also include exercises to test the training and readiness of guards and/or response forces.

  [Nothing has been published on whether the transportation flask (the FS47 or FS65 and the road vehicle - SIFA or similar) has been subject to trials to demonstrate its resistance to terrorist acts.

  Also, the road routes to be adopted are not published, nor apparently are the local emergency services (fire brigades) notified in advance, although the main road route seems to be common knowledge.][35]

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32 Large J H, *A Review of the Off-Site Emergency Plans under The Radiation (Emergency Preparedness & Public Information) Regulations, 2001* – see also *The Radiation (Emergency Preparedness & Public Information) Regulations, 2001*

33 The International Maritime Organisation (IMO) Conventions also apply and for radioactive materials these adopt much of the IAEA recommendations - see a) *The Transport of Radioactive Materials by Sea - Role of the IMO,* Hesse. H, Int. J. Radioact. Mat. Transp. 7(4), pp 295-297 (1996), b) *IMO Requirements Relating to maritime Transport of Hazardous Materials in General and Nuclear Materials in Particular - Development, Current Status & Future Activities,* Hesse H, Malaysia Conference October 1999

34 In the case of Japanese plutonium sea transports carried out under the US-Japan Nuclear Cooperation Agreement, transport plans were submitted in advance of shipment to the US State Department, which determines if they are adequate to protect the material in transit.

35 Greenpeace France recently published the routes and the registration number plates of the road tractor (truck) units deployed for the plutonium oxide shipments from COGEMA La Hague, going so far as to adapt a complete SIFA-like vehicle and run this along the route in a hail of publicity.

5.4 I can now **summarise** a response to the first question in para 2.4, which is do the material protection and security measures specified by the IAEA INFCIRC/225, as practicably implemented in France, meet with the standards practised in the United States for what it defines as *'strategic special nuclear material'*?

5.5 For the following reasons, I do not believe there to be any basis for such a conclusion:

5.6 Very little information is available regarding the means by which the French government implements INFCIRC/225 for the protection and security of present (French sourced) consignments of plutonium.

5.7 For the Eurofab consignments the French regulator, DGSNR, has only recently (18 November 2003) received the safety file application from COGEMA[36] and the security aspects, dealt with by HFD have yet to be submitted, being expected within *"the next few weeks"*.[30]

5.8 Similarly, the United Kingdom authorities responsible for licensing the PNTL ships and for overseeing security (RMTD and OCNS) have declined to respond to my enquiries on this issue, including whether the US Stored Weapons Standard was adopted, so I must assume that the vetting/licensing/approval processes are not yet underway.

5.9 The US-EURATOM Nuclear Cooperation Agreement, under which DOE asserts that the plutonium will be protected in France, is based on the physical protection standards of INFCIRC/225. However, the US DOE has committed to apply the Stored Weapons Standard, which is acknowledged to provide a higher level of protection and security for strategic special nuclear material.

5.10 It follows that this higher Stored Weapons Standard must be applied throughout all phases of the handling of US weapons grade plutonium whilst it is in the possession of foreign governments but, that said, it is entirely unknown what arrangements DOE has made with France and with the UK for the carriage by the PNTL vessels.

36 It is assumed that the COGEMA safety file submission will also account for the fact that certain of the Cadarache plutonium and MOX processes and equipment were closed by DGSNR in July, 2003 and that these are required to fabricate the Eurofab LT assemblies. Also, it is not at all clear whether the MELOX plant has been adapted to handle weapons grade plutonium, since it was designed for the lower Pu-239 content French source plutonium from the La Hague reprocessing works.

5.11 I find and am of the opinion that, in the absence of additional measures such as the US Stored Weapons Standard, application of the IAEA INFCIRC/225 alone falls short of the levels of physical protection and security sought by the United States.

5.12 I consider that before the Export Licensing decision is taken, the means and arrangements by which this higher Stored Weapons Standard is to be applied by these overseas governments should be spelled out in the license application and/or associated documents.

5.13 I can now **summarise** a response to the second question in para 2.4, which is are the INFCIRC/225 measures reasonably sufficient to protect against theft or sabotage of the plutonium, either in its dioxide powder form or as fabricated MOX fuel assemblies?

5.14 In drafting its standards, including INFCIRC/225, the IAEA has to verse these in such a way that each co-signatory state (under INFCIRC/224) may adopt and adapt these into its domestic legislation. In my opinion, this universality weakens the application of the standard, so much so that regularity and harmony is not achieved between one state and another.

5.15 In terms of whether INFCIRC/225 alone is sufficient to prevent to theft and/or sabotage of the Eurofab consignment(s), even with stringent application by a particular state within its own territory, I doubt that any such standard would be sufficient to deter would-be saboteurs and terrorists, particularly during the transportation of such consignments.

5.16 In the absence of any vetting of the adequacy of any additional French security measures for the Eurofab consignments, it is difficult to evaluate whether France's measures for implementation of INFCIRC 225 are sufficient to provide a level of security that is a) comparable to the level of security provided in the United States to strategic special nuclear material, and b) sufficient to protect the consignments against sabotage or theft.

5.17 In the absence of such vetting, I do not believe that the NRC has a sufficient basis for finding that the Eurofab material (both PuO_2 and MOX LTAs) will be adequately protected against sabotage and theft while it is in the possession of the French government. On this basis, I strongly recommend postponement of the export licensing decision until the adequacy of the physical protection and security issue has been established, including preparation of a proliferation assessment as required by Section 131 of the Atomic Energy Act.

6 ACCOUNT OF TERRORISM IN THE EISS AND SUPPLEMENT STATEMENT

6.1 According to the Storage and Disposition PEIS,[11a] the accident analysis in the PEIS addresses the consequences of accidents and incidents resulting from a breach of security during transportation of the plutonium oxide and MOX fuel consignments [PEIS, pG-7], with this notion being implicitly carried forward in the SA.[11c] Closer scrutiny of the DOE studies relied upon[37] for this claim show that for the plutonium dioxide consignment the EIS excludes malicious acts, and MOX the relevance to such acts is somewhat tenuous and not at all substantiated.

6.2 In this way the SA fails to specifically account for the environmental impacts of sabotage and terrorist acts when formulating the EIS to be a significant failing.

6.3 I consider this failure to account for the outcome of malicious acts to be a very significant deficiency in the environmental impact assessments.

6.4 This is particularly because sabotage and terrorism are intentional acts, intelligently driven by behavioural factors that do not conform to the probabilistic (almost mechanistic) reasoning adopted by the nuclear industry to predict and defend engineered systems against accidental situations.[38] Moreover, as recent past terrorist incidents quite ruthlessly lay bare, terrorists will seek out the vulnerabilities of the system under attack and, moreover, their actions are likely to obstruct and hinder countermeasures and emergency plans, all to maximize the human and environmental consequences.

6.5 It follows that the outcome of a maliciously motivated act could be very different from that of an accidental event, and the nature of the consequences could be planned ahead.

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37 In fact the PEIS draws upon a previous study which includes assessment of the damage of a terrorist attack (although limited to a shaped charge modus operandi), *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Fuel*, DOE/EIS-0218 which it considers, but does not technically substantiate, equally applies to MOX fuel, noting that the results are *"relevant to the shipment of MOX fuel"*. Thus there is no consideration of plutonium dioxide nor, with respect to the claim of relevancy for MOX, to the entirely different characteristics of research reactor fuel compared to MOX fuel and, indeed, for the very much more substantial fuel flasks required to ship irradiated reactor fuel than the FS65 flask proposed for the Eurofab LTAs..

38 *The Implications of September 11th for the Nuclear Industry*, Large J H, Monitor, Royal United Services Institute, London, February 2003, V2 No 1

6.6 The modus operandi of the attack by be chosen to outwit or outflank the security measures: For example, it might be delivered by small boat during the berthing and unloading operations of the PNTL ships; or remotely with the use of infantry weaponry (RPG or similar) on the road convoy; or in confined space, such as a road tunnel where access could be tightly controlled by a few individuals; and so on.

6.7 The attack might be deliberately timed and located at a place of maximum population: For example, the density of population might be contrived, by first creating a road traffic jam ahead of the planned attack; or by hijacking the consignment vehicle and taking it to a concentration of population, say a football stadium or similar; and so on.

6.8 The environment under attack might be selected to best effect: For example, small quantities of the plutonium might be dumped in water reservoirs treated with chlorine, with the chlorine increasing the human gut transfer factor of the plutonium significantly; or by introducing and spreading an aerosol in a confined system, such as an underground train network, or in the air conditioning system of an office complex; or by dispersing the material in a city centre as a 'dirty' bomb; and so on.

6.9 The physical circumstances of the attack might be 'engineered' to optimise a release to maximize the consequences: For example, the particulate size of the plutonium dioxide might be reduced to maximise respiratory uptake by the first of a two stage release process by introducing an incendiary;[39] it might be rendered into a plutonium-

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39 There is now an emerging field of literature on the response of irradiated uranium dioxide fuel and fuel transport flasks when subject to explosion, although these relate generally to irradiated uranium dioxide fuels across a variety of flask designs.

Following events of 11 September, terrorist attack against any nuclear consignment in transit cannot be discounted and, in recent months, the threat has heightened in Europe (apparently from the ongoing number of arrests). Certainly, some national and international terrorist groups have the knowledge and skills to manufacture powerful ordnance sufficient to breach the carrying vehicle and the flask itself. Also, there is a variety of anti-tank and armour piercing weapons available in the military domain (and supposedly on the international arms black market) with virtually all of these weapons capable of breaching the typically carbon steel flask walls. Certain armour piercing rounds comprise two stages, first a high brisance armour piercing stage and, once that the armour has been pierced, a second stage firing an explosive intended to obliterate the internals of the target. Most anti-tank weapons and their rounds are portable and capable of being handled by one or a few individuals in urban environments.

More recently, there is one specific research paper that quantifies the release fraction of irradiated fuel following breach of the containment flask by an explosive charge, working on the basis of the quantity of respirable spent fuel aerosol that might be produced by a terrorist attack. The experimental-based work yields two relevant source terms that lead to values of 6×10^{-5} to 8×10^{-4} g of respirable surrogate spent fuel aerosol released from the cask per gram of surrogate fuel matrix disrupted by a sabotage attack using high-energy device acting on the exterior surface of the flask. That the explosive charge was not in physical contact with the fuel assemblies and the aerosol/particulates given off primarily derive from the shock and blast loading and the release fractions relate only to the quantity of fuel that was expelled from the flask (ie excludes fragments and particles of fuel remaining in the flask). The surrogate fuel used in this work comprised unirradiated U^{238} sintered oxide pellets sheathed into fuel pins and arranged as fuel assemblies for which the results were then factored up (x3) to model spent or irradiated fuel.

nitrate for dispersion into a potable watercourse; or the flask itself might be adapted, with the introduction of a shaped explosive charge, to form a crude criticality device; and so on.

6.10 My point here is that it is most unlikely that a terrorist would be content with a crude detonation to damage the flask and disperse the material. Like the atrocities of September 11, such an act would be expected to be meticulously planned and resourced to maximize its impact and consequences.

6.11 Obviously, openly speculating about the ways and means by which the Eurofab consignments might be attacked or hijacked in any greater detail here would not be in the public interest. That said, it has to be recognized that the knowledge and means are available to would-be saboteurs that could pose a serious threat to the Eurofab consignments – there is no rationale that somehow excludes strategic special nuclear material from this threat.[40]

6.12 I would expect to be able to address my concerns on the modus operandi and other sensitive aspects of the potential for nuclear terrorism in greater detail in a future Hearing held in part camera.

6.13 This leads me to **summarise** a response to third question in para 2.4, which is do any shortfalls identified above justify that i) a further environmental impact assessment and ii) proliferation assessment be undertaken in addition to that existing in the previous Environmental Impact Statements made in support of the surplus plutonium disposition program?

6.14 The principal and principled weakness of the DOE approach of not performing a complete analysis of environmental impacts related to sabotage or terrorist acts is the assumption that the nominated worst case accident scenario will cover the worst possible outcome of any contrived malicious act.

40 Indeed, some observers would note hat this US-sourced material might be considered an attractive target whatever its location, that is both in the United States or overseas.

6.15 My previous studies[6,41] indicate that this is not the case and that malicious acts of sabotage and terrorism have to be specifically addressed in terms of the most likely environmental impact and human health consequences.

6.16 My strong recommendation is that until full assessments of the environmental impact drawn from a range of sabotage and terrorist actions are undertaken, then the decision on the granting of an export licence should be postponed.

7 POTENTIAL FOR SUCCESS OF SABOTAGE/TERRORIST ACTS ON THE US PORTS

7.1 Finally, as an aside to the main issues presented in this report, I previously referred to the assertion in the SA that the existing facilities in the United States were terrorist proof (see para 4.3) and, in particular, I noted the underlying conclusions in the SA included the assertion that *"adequate safeguards are in place to meet such a [terrorist] threat"*, and that *"the candidate ports analyzed in this SA are military ports that provide a heightened level of security."*.

7.2 I am very cautious about accepting the validity of this assertion, particularly when I recall the al-Qaeda terrorist attack against the *USS Cole* in the Yemini port of Aden in October 2000 with the tragic loss of 17 Navy services personnel lives. Indeed, in the same year, my involvement with the Royal Navy nuclear powered submarine *HMS Tireless*, then under repair at an established Royal Navy base at Gibraltar, gave me a personal insight into the very demanding challenges that the military face in securing an open commercial trading port.

7.3 For these reasons, I suggest that the Eurofab candidate ports of Charleston, Yorktown and Norfolk should not entirely dismiss the threat of terrorist attack, but instead prepare and put in place specific plans and countermeasures to mitigate the radiological consequences in the public domain should an attack occur.[42]

7.4 The human health risks and consequences presented in the SA for these ports are drawn from accident circumstances which, as I previously explained, are likely to be less severe

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41 a) *Review of the Sea Transportation of Mixed Oxide Fuel: i) Transportation Risks and Hazards , ii) Physical and Dispersion Characteristics of MOX Fuel, iii) MOX Fuel, a UK Perspective*, Evidence to the New Zealand Government Foreign Affairs, Defence and Trade Select Committee, May 2001, b) *Transportation of Mixed Oxide Fue*l, Greenpeace International, May 2001, c) *Dispersion Characteristics of Mixed Oxide Fuel*, Greenpeace International, July 2001

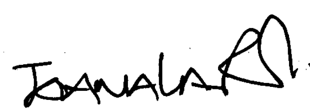
42 Modelling the extent and dispersion of radioactivity from the source of a release is determined by a number of factors, particularly the height of the lofting plume, terrain factors and the prevailing metrological conditions. For example, a release incident at Charleston NWS, given sufficient lofting energy (a high temperature fire) could certainly extend the 10 to 15km to impact upon the urban communities of Summerville, Goose Creek, Hanahan and North Charleston, and beyond depending on the prevailing

than those yielded by a carefully planned and executed terrorist attack. This is why I reach my conclusion of para 6.16 that the environmental impact assessments should fully account for acts of sabotage and terrorism and, of course, equally apply to United States facilities, including each of the candidate ports.

8 FURTHER WORK FOR A FUTURE HEARING TESTIMONY

8.1 In preparing this report I have referred to a number of past studies that I have extrapolated to apply to the proposed Eurofab activities. Although this is a valid approach it is incomplete, so given sufficient notice it should be possible for me to undertake a study that relates directly to the Eurofab activities in France. I could prepare and present the results of such a case-specific study in Testimony to a future Hearing.

8.2 In fact, I am presently instructed by clients to advise on safety and security issues relating to the transport arrangements for the French-sourced plutonium dioxide transits from La Hague to Cadarache – this study is presently examining dispersion and human health impacts using the European Union developed and approved software COSYMA, which is seeded with a Europe-wide population data base. With the permission of the clients, which I believe would be forthcoming, this information would form a strong basis for a case-specific study for Eurofab activities, applied to both plutonium oxide and the MOX LTA transits.



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CEng, FIMechE, GradMICE, MBNES, FRSA

wind direction which, if to the south-east, could present difficulties evacuating the population (if necessitated) from the Charleston peninsular with its restricted exit routes.