Large and ASSOCIATES
Consulting Engineers

# REQUEST FOR FURTHER INFORMATION

## ANNEX A & B

## DEPARTMENT FOR TRANSPORT LETTER OF 4 MAY 2006

## REF RMT 002/003/0001

# FORMAL RESPONSE BY JOHN H LARGE

## CLIENT: HARRISON GRANT, SOLICITORS

## REPORT REF N$^{O}$ R3146-DFT ANNEX A&B

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**RESPONSE TO THE DEPARTMENT FOR TRANSPORT'S REQUEST FOR FURTHER INFORMATION**

## 1 INSTRUCTIONS

1.1 I am John H Large of the Gatehouse, 1 & 2 Repository Road, Ha Ha Road, Woolwich, London SEI8.

1.2 I was instructed on 11 June 2006 by Ms Kate Harrison of Harrison Grant, a firm of solicitors acting on behalf of Greenpeace UK, to prepare an appropriate response to the annexes of the Department for Transport letter of 4 May 2006.

## 2 QUALIFICATIONS AND EXPERIENCE

2.1 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 Society and a Fellow of the Royal Society of Arts.

2.2 From the late 1960s through to the late 1980s I was employed as a full-time member of the academic research staff at Brunel University on behalf of the United Kingdom Atomic Energy Authority (UKAEA) and other government agencies undertaking postgraduate research in the nuclear area.

2.3 In the early 1990s I established the firm of Consulting Engineers Large & Associates which provides specialist analysis and advice in nuclear related activities.

2.4 During the course of my career I have been involved in fundamental and applications research connected with the development and analysis of a number of technically demanding nuclear projects, including aspects of nuclear fuel reprocessing, nuclear power generation, nuclear propulsion and nuclear weapons. On these topics I have given evidence to several House of Commons Select Committees; I have advised a number of overseas governments on nuclear power and nuclear propulsion, the nuclear fuel cycle, and nuclear weapons related matters; and I have given evidence at the Court of Human Rights, Strasbourg on the effects of nuclear weapons atmospheric testing on British armed services personnel stationed on the sites of nuclear weapons atmospheric testing (Grapple Thermonuclear Series - Christmas Island).

2.5 Specifically relating to the transportation of irradiated spent fuel, the associated risks and hazards, I have undertaken a number of studies including an assessment for the Greater London Council in the late 1980s on the risks and hazards of spent nuclear fuel transportation through London; I provided evidence to the House of Commons Environment Committee on aspects of fuel transportation studies in the mid-1980s; in the mid-1990s I reported on the risks of the sea movements of irradiated fuel imports; throughout the 1990s I acted as consultant to the National Fire Brigades Union, in this role I attended a number of irradiated transport emergency planning exercises, and I negotiated the incident radiation dose limitation system presently

adopted nationally for firefighters involved in nuclear incidents; and, more recently, I attended and reported upon an international conference of the transportation of radioactive materials, including irradiated fuel;[1] and I completed an assessment of UK movements of irradiated fuel for Greenpeace UK[2] which is the subject of the Department for Transport request (hereafter referred to as the *Subject Report*).

2.6 On the vulnerability of nuclear facilities to terrorist attack I have published a number of papers[3] and participated at international conferences presenting on this topic.[4] Specifically relating to the vulnerability of nuclear cargoes in transit to terrorist attack, particularly to consignments under transit in IAEA Type B compliant flasks;[5] I have given evidence to the United States Nuclear Regulatory Commission (NRC) on the risks incurred during the transportation of plutonium dioxide powder;[6] completed an exhaustive assessment of the transportation of plutonium across France by road as part of the United States plutonium disposition program;[7] I have submitted evidence to the International Atomic Energy Agency (IAEA) on plutonium-based or mixed oxide (MOX) fuels in transit;[8,9] and I have given evidence to and been examined by the New Zealand parliamentary Foreign Affairs, Defence and Trade Select Committee[10] on the maritime movements of plutonium dioxide, MOX and irradiated fuel.

2.7 My experience relating to the forecasting of fuel and other particle/aerosol dispersion in the immediate, short and interim terms is considerable. I have used both fundamental analysis and software package modelling to project radioactive and other forms of aerosol release from single sources for a range of release scenarios, including puffs and streams. As well as the studies cited above, which include work with the COSYMA

1 Report on the International Conference on the Safety of Radioactive Materials, International Atomic Energy Agency, Vienna, July 2003 - http://www.largeassociates.com/Vienna2003.pdf

2 Risks and Hazards arising the Transportation of Irradiated Fuel and Nuclear Materials in the United Kingdom, R3144-A1, March 2006 - http://www.largeassociates.com/3144%20Spent%20Fuel/R3144-A2%20FINAL.pdf

3 *The Implications of 11 September for the Nuclear Industry*, J H Large, United Nations for Disarmament Research, Disarmament Forum, 2003 No 2, pp29-38 - http://www.largeassociates.com/terrorismUNDisarmament.pdf - see also *Vulnerabilities of Nuclear Plants to Terrorism*, Large J H & Schneider M, Oxford Research Group Seminar, Rhodes House, Oxford, December 2002 - http://www.largeassociates.com/TerrorismLargeSchneider.pdf

4 Rethinking Nuclear Energy and Democracy after 09/11, The End of Probabilistic Risk Analysis, International Conference, PSR/IPPNW Basel, Switzerland, April 2002

5 Type B flasks as specified in the *International Atomic Energy Agency* (IAEA) recommendations TS-R-1 the *Regulations for the Safe Transport of Radioactive Materials*

6 NRC Hearing Disposition of Surplus Weapons Plutonium Using Mixed Oxide Fuel, US Nuclear Regulatory Commission Hearing, 2004: *i) Comments on 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 ii) The Role of PNTL Ships in the Atlantic Transit Phases, United States of America Nuclear Regulatory Commission, 26 November 2003, iii) Summary of the Findings of the French-sourced Plutonium Dioxide Transportation, 23 March 2004 - http://www.largeassociates.com/NRC1.pdf*

7 *Potential Radiological Impact and Consequences Arising from Incidents Involving a Consignment of Plutonium Dioxide Under Transit from Cogema La Hague to Marcoule/Cadarache*, March 2004, Large & Associates - http://www.largeassociates.com/PuFrance.pdf

8 Joint Assessment, WISE-Paris / Large & Associates Safety and Security Concern / FS47, PLUTONIUM TRANSPORTS IN FRANCE, *Safety and Security Concerns over the FS47 Transportation Cask*, Yves Marignac, Xavier Coeytaux, John H. Large, 21 September 2004 - http://www.largeassociates.com/JointAssessmentFS47.pdf

9 Large J H. Marignac Y, Submission to the International Atomic Energy Agency - Convention on the Physical Protection of Nuclear Material (CPPNM) – IAEA InfCirc/274 & InfCirc/225/Rev.4 - *IAEA Requirements on Design Basis Threat Assessment - Non Compliance of Eurofab LTA shipment from US to France on UK Vessel: Security and Physical Protection Issues*, IAEA 20 September 2004 - http://www.largeassociates.com/JointAssessmentIAEA.pdf

software package, I worked with Russian Federation personnel on modelling the potential dispersion from a propulsion reactor or weapon fault during the salvage recovery operations of the nuclear propelled submarine *Kursk* undertaken in 2001. I was ultimately responsible for this work, reporting my satisfaction with and approval of this and other aspects of the salvage operations the insurers covering the salvage.[11] For this project I was jointly engaged by the salvers (Smit-Mammoet) and the Russian Federation government, and I was awarded a commemorative medal by the Russian authorities for my contribution to this world-first successful salvage of a nuclear powered submarine.

2.8 I consider myself adequately qualified and experienced to appropriately respond to the Department for Transport's request for further information on the Subject Report that was independently prepared by Large & Associates at the instruction of Greenpeace UK.

## 3 RESPONSE TO ANNEX A & B OF THE DEPARTMENT FOR TRANSPORT LETTER 4 MAY, 2006

3.1 The Subject Report provides assessment of irradiated fuel flask performance when subject to accidents (ie as chance would have it events) and incidents arising from intent (ie terrorist acts).

3.2 The Subject Report contends that both accidents and well planned and implemented terrorist acts could severely damage the fuel and flask containments and, as a result, the general public could be placed at radiological risk. In other words, the issue raised by the Subject Report fundamentally relates to the potential consequences so, in making this response, I shall not distinguish between safety and security which I understand are dealt with by different Justifying Authorities (Department for Transport Department and the Department for Trade and Industry respectively).

3.3 Referring to the annexes of the Department for Transport letter, seriatim:

3.4 Under A:

3.5

*1. Details of the version of the software used and the platform it is run on.*

3.6 The PC COSYMA software is version 2.01 EUR 16240 EN. Serial N$^{o}$ 196 running on DOS.

3.7 The COSYMA software package and its user guide[12] were purchased from the then National Radiological Protection Board (NRPB) in or about 2003.

3.8 My understanding is that this is the most recent edition of COSYMA with meteorological and population seeding data appropriate to its date of issue.[13,14] I am unaware of any recently

10 *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 - http://www.largeassociates.com/R3063-MOX1.pdf

11 *Risks and Hazards in Recovering the Nuclear Powered Submarine Kursk*, Warships - Naval Submarines 8, Royal Institution of Naval Architects, Conf, London, 23-24 June 2005.

12 PC COSYMA V 2.0, *User Guide*, National Radiological Protection Board, Forschungszentrum Karlsruhe GmbH, NRPB-SR280, November 1995

published information that would substantially modify either the operation and/or results of the COSYMA software.

3.9

2. *The validation status of that version and the verification of this installation.*

3.10 COSYMA is self-validating software via the executable file SAMPLE.SAV.[15]

3.11

3. *Details of the training and experience, relevant to the operation of this code, of the person carrying out the calculation.*

3.12 I have previously listed my experience in the dispersion modelling situations involving the release of aerosol and I consider myself to be adequately experienced and competent in such matters.

3.13

4. *A listing of the input data for each calculation.*

3.14 I consider there to be adequate explanation and information in the text of the Subject Report to provide a sufficient introduction to the range of input data. This information is present in the form of a description of the type and burn-up of the fuel under consideration, the severity of damage to the flask and fuel containments, and the assumptions made and derivation of the release term fraction of the fuel consignment under consideration.[16]

3.15 Of course, it may be that the Department for Transport Radioactive Materials Transport Division (RMTD) is simply, but not particularly judiciously to my mind, adopting the same interrogation protocol as it would apply to operators (consignors) seeking permission to transport radioactive material. This I consider to be inappropriate for the justification process because it is likely to result in too much emphasis being placed on the COSYMA analysis alone, whereas the Subject Report raises a number of important issues that should be considered paramount by the Justifying Authority(ies) and not be put to one side as at present.

3.16 In terms of justifying the existing practice of transporting irradiated fuel on the public railway, I believe that the following primary issues are salient in that:

a) severely damaging situations, such as the flask(s) being subject to a prolonged tunnel fire are not but should be taken into consideration, particularly when the condition and circumstances of actual rail tunnel fires that have occurred in the past have been very much more severe, in terms of

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13 NRPB (1995) PC COSYMA Version 2.0 User Guide. EUR 16240 EN.

14 Ehrhardt, J. and Jones, J.A. (1991) *An outline of COSYMA, A New Program Package for Accident Consequence Assessments*, Nuclear Technology No. 94, pg. 196 -203.

15 This and other aspects of the Department for Transport request suggests to me that the person framing the requests of the Annex does not entirely understand the COSYMA software package and its installation – see also other errors and misunderstanding in Annex A such as referred to in Footnotes 21 and 22 – and this, in itself, raises my concern and any evaluation of the of the dispersal modelling results and trends included in the Subject Report will not be properly evaluated, in both applied context and results, in the justification process.

16 It is not clear to me why this information is required and, again, it suggests to me that the person framing the request does not fully understand the use of the COSYMA dispersion modelling software unless, that is, it is simply an intentionally time wasting ruse.

temperature and duration, than the test conditions specified by IAEA TS-R-1 for the Type B flask category;

b) the exemption of the flasks, apparently and solely on the basis of the IAEA Type B category, from the *Radiation (Emergency Preparedness & Public Information) Regulations 2001* (REPPIR) or similar regulations, means that there is no requirement for local authorities to put in place and test specific off-site emergency plan and arrangements;

c) contingent on b), it should be demonstrated that the absence of locally organised and resourced REPPIR arrangements will not result in greater exposure to ionising radiation exposure to members of public than if the post incident measures were solely RADSAFE;

d) on the basis of the exemption from REPPIR and the public not being informed in advance of the nature of the risk and hazards of irradiated fuel in transit or even at those locations,[17] the absence of such advance information and knowledge will not result in a greater radiological risk; and

e) there should be recognition that the transportation of irradiated fuel in the United Kingdom could be identified as a potential target for terrorist attack in light of recent evidence to suggest that nuclear sites and activities have been considered in this way.

3.17 The Subject Report introduces these and other issues to be very influential on the practice and potential radiological consequences of irradiated fuel transportation on the public railway and, accordingly, this evidence should be taken into account in the justification process.

3.18

5. *Where assumptions are made in the input or the analysis, details of those assumptions.*

3.19 My comments of the two preceding paragraphs 3.14 and 3.15 apply.

3.20 The assumptions made for the Subject Report analyses are all well argued, explained and endorsed by source references of past work undertaken by competent and/or informed authorities in the field of i) dispersion modelling; nuclear fuel, its irradiation and composition; ii) the compliance of the fuel flasks deployed in the United Kingdom; and iii) the robustness of the flask designs and fuel when subject to extremes of accidents and/or terrorist act.

3.21 I note here that the requests of Annex A are entirely related to the COSYMA analysis presented in the Subject Report. In this way, I consider the RMTD to skirt around the paramount issues that I have raised in paragraphs 3.16 and 3.17 above and which are much more germane to the justification of the practice. That is the

17 Such as at Bridgwater in Somerset, where the flasks are transferred to railway flatrols in close proximity to a school and residential properties

RMTD's approach seems to be completely preoccupied with the arithmetic detail of COSYMA whilst turning a blind eye to issues that I consider to be absolutely fundamental to public safety.

3.22

*5 & 7.* *… Outputs…*

3.23 In framing the request annex RMTD should be aware, again I am doubtful of this, that the COSYMA results[18] reproduced in the report have been summarized to illustrate the overall findings of the Subject Report which is not solely concerned with the dispersion modelling of a radioactive release from a fuel flask of irradiated fuel subject to accident and/or terrorist act.

3.24 In other words, and as clearly emphasised in the summary of the Subject Report, the COSYMA (and other techniques) arithmetic and results are used to illustrate the nature the trends of how a radioactive release from a spent fuel flask might be expected to develop. Put another way, the principal finding of Subject Report is that under certain accident situations or when the target of a terrorists act, the fuel flask(s) could fail giving rise to a radioactive release of significant radiological impact (consequences) than hitherto considered for this existing practice.

3.25 It is this finding of the Subject Report that is the substantive reason why the practice should now be subject to the justification process.

3.26 I consider the request for unspecified outputs, ie the request for *'any other results generated'*, to be misdirected and entirely time wasting, particularly so when the effort should be directed at the information and evidence that should properly form the core of the justification process.

3.27

*8.* *A comparison of MARC and COSYMA…*

3.28 In the absence of further explanation of what and why this comparison is required, I consider this to not to relate to the justification process.

3.29 Also, it is not for the Department for Transport to specify how an independent assessment should be undertaken and, in this respect, the suggestion of the assumption *(6E11Bq Cs137 instantaneous release)* is entirely inappropriate[19] and further illustrates, in my opinion, a lack of understanding of basis and derivation of the severely damaging and terrorist act scenarios considered for the Subject Report.[20]

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18 In addition to the COSYMA analyses a US-sourced code has also been applied to the terrorist act scenarios.

19 *Entirely inappropriate* on two counts: First, technically flawed as discussed in the following Footnote and, second, it is not for the Justifying Authority to specify and dictate the terms of the 'evidence' that is to be considered in the justification process.

20 Once again this suggests a poor understanding of the person compiling the RMTD annex: The suggested 6E+11Bq Cs release fraction is entirely at odds with the magnitude of the release fraction expected for both explosive and severe fire events. For example, for a LWRE flask containing 7 fuel assemblies cooled for 5 years post reactor, the Cs-137 content for 33MWd/tU fuel is ~1.E+16 so the suggested instantaneous release is a (6/(1.E+5)=) $6.10^{-5}$ release fraction is x10 and x100 the release fractions of the fire and explosive scenarios respectively adopted for the NRPB R147 study of Footnote 23 – even so, it is generally accepted that the release fractions used in R147 were too low as shown by the recent empirical trials referred to in Footnote 9 and the later Sandia work cited in the Subject Report.. Of

3.30 The purpose of making such a comparison with what is now an obsolete MARC program is not at all clear to me, particularly since COSYMA[21] is a standalone program which has no dependency upon MARC.[22] Indeed, if I had access to the MARC software I am not at all certain that the hardware platform to run it continues to be available

3.31 Moreover, I suggest that if the Department for Transport's RMTD requires such a comparative risk to be made then it, itself, should undertake a COSYMA re-analysis of the previously published MARC transportation incident analysis (eg rerun NRPB R147 with COSYMA modelling).[23]

3.32 Under B):

3.33

*1. Provide a marked up copy of the report clearly identifying the evidence included that you believe to be new and important.*

3.34 So far as it is practicably possible, I have conducted a thorough search and review of the work published by the Department for Transport RMTD, particularly in the topic areas of i) irradiated fuel transportation, ii) atmospheric dispersion, iii) COSYMA and similar modelling, and iv) the resilience of flasks to extremes of accident (ie tunnel fires) and acts of terrorism (explosives, shaped charges, etc).

3.35 These are all topics that I consider should be included in the justification of the practice of irradiated fuel transportation.

3.36 Other than some unspecified involvement in a committee study reported in the form of a press release for flasks in use in the United States,[24] together with papers of a regulatory nature and guidance notes for operators applying for permission to move radioactive materials, I cannot find any significant work that specifically relates to the Magnox and AGR designs of irradiated flask accident performance, resilience against terrorist attack of either the flask and/or its transport system in the UK; the formation of Magnox and AGR irradiated fuel aerosols in accident and incident conditions; the source term release fraction; and the dispersion thereafter.

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course, if a Magnox fuel flask were to be involved in a prolonged and damaging fire then ignition of the magnesium alloy cladding and, then, elemental metal fuel itself, would be expected to lead to much higher release fractions.

21 My understanding is that COSYMA derives from the **MARIA** (Methods of Assessing Radiological Impacts of Accidents) project being that COSYMA is **CO**de **SY**stem from **Ma**ria, thus MARC is not it's (sic) predecessor as claimed by the RMTD.

22 **MARC** - ***M****ethodology for* ***A****ssessing* ***R****adiological* ***C****onsequences* of accidental releases of activity, 1981 – the NRPB withdrew MARC from use about 15 years or more ago – similarly aged dispersion modelling software CONDOR might still be available from the Ministry of Defence if a comparison with yesteryear is required.

23 Shaw K, *The Radiological Impact of Postulated Accidental Releases during the Transportation of Irradiated PWR Fuel through Greater London*, NRPB-R147, 1983 – commissioned by the GLC.

24 http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=11538 - National Academies' National Research Council (United States) – Clive Young was the committee member from the RMTD but this study only related to PWR/BWR flasks that are physically quite different to the UK Magnox and AGR flasks.

3.37 In fact, the most recent paper of what I consider to be of any significant substance relating to the UK regulatory position in the UK by a member of the RMTD was published in 1984,[25] there being nothing readily available from the RMTD (in the public domain at least) on the topics I have identified. I could find nothing whatsoever on the dispersion (COSYMA or otherwise) of radioactive aerosols, etc., in the aftermath of an accident or terrorist incident involving an irradiated fuel flask in transit, other than the early (1983) NRPB analysis of a PWR flask subject to and explosive charge.[23,26]

3.38 In fact, other than some very early flask development programme carried out by the UKAEA in the 1950s and 1960s, I have not found any published work dealing with the containment resilience of the Magnox and AGR flask designs when subject to abnormal accident/incident conditions.[27, 28]

3.39 Thus, my finding is that the RMTD itself, or via commissioned work, could never have assessed the radiological consequences to members of the public arising from the failure of the containment of a flask. Instead, the RMTD seems to assume that the Type B compliance guarantees flask surety in all reasonably foreseeable incidents (ie the Titanic is unsinkable) and that this, in itself, has been sufficient to justify the practice.

3.40 This leads me to reach four conclusions:

3.41 First, I can find no evidence that either the Department for Transport or the Department for Trade and Industry have undertaken a justification exercise in respect to either the safety and/or security of spent fuel transportation since the introduction of the justification regulations.

3.42 Similarly, there is nothing available in the public domain, so far as I can reasonably determine, to suggest that an equivalent form of 'justification' was undertaken prior to the introduction of the justification regulations.

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25 R O'Sullivan, *The Regulatory Framework in the UK*, The Urban Transportation of Irradiated Fuel, MacMillan Press, 1984

26 Here I provide just one of several examples of the failure of the RMTD to publish, or at least explain and be accountable, for its regulatory approach to the transportation of irradiated fuel. This being that for the REPPIR exemption there is no explanation whatsoever in the regulations or the guide, why Type B flask are actually exempted that is even though the REPPIR guide was published post 9/11 2001, there is no account given to the vulnerability of the flask containment to accident and incident conditions (ie to terrorist act) that could by far exceed the conditions imposed (and supposedly representative) of real incidents as prescribed by IAEA TS-R-1. and, indeed, when specifically asked about this following the London tube bombings of 7 July 2005 the HSE, and presumably, the RMTD, made no change to its previous declared line of argument.

27 Here I exclude the 1980s trials on a Magnox flask by the CEGB (the train crash demonstration) because these trials did not consider severely damaging circumstances and any subsequent release and dispersion from the flask.

28 There is also the set point in time of 1990 when the International Commission on Radiological Protection (ICRP) introduce the ICRP 90 recommendations that replaced the 1977 ICRP 27 with a four fold increase in the risk factor relating the incidence of cancer fatality to exposure. Obviously, any existing evidence predating 1990 relied upon would require account of this change for a reassessment of the radiological consequences.

3.43 Second, the Subject Report includes a clear reference citation that identifies and dates all so-called *'new'* material that I have relied upon and, in this respect, there is no need to provide a marked-up copy as requested by the RMTD.

3.44 Third, it seems to me, that since the RMTD has published nothing substantial on its regulatory approach to the transportation of irradiated fuel since 1984 then almost the entire Subject Report is based on *'new'* information.

3.45 Even if I relax this timeline to post-9/11, I can still find nothing from the RMTD that takes into account the acknowledged threat from international terrorism, more so when I consider that the London bombings of July 2005 were targeted and successfully implemented against a public railway system, not that dissimilar to the national rail network upon which irradiated fuel continues to be moved.

3.46 And, Fourth, since I understand that the purpose for which the 'new' information is required is so that 'justification' of the practice of transporting irradiated fuel by rail might be determined,[29] it seems to me that because this practice has never been previously justified then all of the issues and facts raised in the Subject Report should be considered to be 'new' information.

3.47 Indeed, I consider that the Subject Report to be based upon new and important evidence that shows the consequences of severe accident and/or terrorist act to be intolerable and that, in this respect, the existing practice of transporting irradiated fuel on the public railway should be subject to the justification process.

**JOHN H LARGE**

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29 *Justification of Practices Involving Ionising Radiation Regulations 2004*