DECOMMISSIONING – OPENINGS FOR THE TERRORIST THREAT

John H Large
Large & Associates, Consulting Engineers, London, United Kingdom

After the events of 11th September, 2001 perhaps it is a short and logical step for terrorists to latch onto how highly hazardous plants might be triggered into releasing their energy and toxins. It is just another step to apply this logic to operational nuclear plants and then to realise that decommissioning nuclear plants might well be more vulnerable targets that could still have a significant radiological, health and economic impact.

This paper examines how a decommissioning nuclear plant, together with the movement of the irradiated fuel and radioactive wastes from the plant site, provide opportunities to would-be terrorists.

The conclusions are that the terrorist threat is present and will most likely persist over the decades that the United Kingdom's present generation of nuclear plants will be undergoing decommissioning; it reasons how the risk of successful terrorist attack might be quantified; it explores the almost symbiosis that could develop between defender and attacker; it examines how the UK regulatory system assesses the risks and consequences behind closed doors in an unaccountable way; and it concludes that opening up a nuclear plant in the course of its decommissioning and dismantling is likely to create openings for the terrorist threat.

The Terrorist Threat

In her public address earlier this month the head of Britain's Security Service,[1] Dame Eliza Manningham-Buller, not only told of the existing terrorist threats but foretold her vision the future.[2]

Five years on from 9/11, there are some 30 major plots being planned by 1,600 or so individual terrorists currently under investigation, comprising at least 200 British-based networks involved in terrorism here in Britain today. Dame Manningham-Buller went on to describe the existence of resilient networks, some directed from al-Qaeda in Pakistan, others loosely inspired by it to scheme mass casualty suicide attacks here in the UK, and she concluded that whereas today we see the use of home-made improvised explosive devices; tomorrow's threat may include the use of chemicals, bacteriological agents, radioactive materials and even nuclear weapons technology.

In October the Lord Chancellor reported there to be 99 defendants awaiting trial in 34 cases, and as these progress through the courts we are learning that some of these cases involved targeting, or the desire to target, nuclear facilities or to obtain radioactive material for a radiological dispersive device.[3] In fact, recent opinion polls suggest that more and more people are moving from passive sympathy towards active terrorism through

1 The Security Service more commonly referred to as MI5.

2 Dame Eliza Manningham-Buller, *The International Terrorist Threat to the UK* , Queen Mary College, 9 November 2006 - http://www.mi5.gov.uk/output/Page568.html

3 For example, in the trial of *Dhiren Barot*, an acknowledged al-Qaeda operative (sentenced on 10 November 2006), it was admitted that he planned to use a radioactive dirty bomb and explosive devices in a series of synchronised attacks in London.

being radicalised or indoctrinated in the UK and overseas. Even if the opinion polls conducted in the UK since July 2005 are only broadly accurate, over 100,000 of UK citizens consider that the July 2005 bombings in London were justified.

State *-v-* Terrorist

Obviously, any terrorist group cannot match the resources of an advanced nation State but, in face of an imbalance of military assets, the adaptability of even a small terrorist cell can, and has been shown to, win over. Dispersed across the globe, al-Qaeda seems to be organised almost in the fashion of the worldwide Web in that it has no centre and there is no central, overarching organisation. This is somewhat different to the semi-autonomous cell structure developed by the Irish Republican Army (IRA) to avert infiltration and monitoring by the intelligence agencies

The effectiveness of a terrorist group to withstand counter-terrorist actions and safeguards is stronger if the organisational structure is decentralised into quasi-autonomous cells but in this form the overall effectiveness, in terms of weapons capability and the impact of its attacks, may be weaker than if the terrorists organised into a military hierarchy which might then develop the ability and resources to implement attacks of significant scale. The al-Qaeda network compensates for this in that individual cells that seem to be entirely independent have the ability to be pulled together to swarm onto a single target or event as shown by the simultaneous aerial attacks of 9/11.[4,5]

However, as the State steps up its surveillance and security measures this may drive the terrorist organisation to downsize even further to smaller cells but this, in turn, somewhat denies opportunity for any individual cell to succeed in achieving a spectacular strike, either on a single site or as synchronised strikes at different locations. State security measures effectively narrow the range of available targets, further restrict availability of weaponry and armaments and, in doing so, direct the terrorist cell into ingenuity, resourcefulness and *‘thinking out of the box’* in selecting the targets, determining the means of attack and the weapons to be deployed.

In other words, it might be reasoned that the State itself has a hand in determining the terrorist target and how it is to be attacked.

Targets

Nuclear plants are highly hazardous plants.

When in operation, nuclear plants are staffed and, so far as is known, well defended. This is because nuclear plants are of the highest utility to the State and, particularly, being nuclear there is a public perception of dread and fear (ie a fate worse than

4 Gunaratna R. *Inside Al-Qaeda*, C. Hurst & Co., London, 2002.

5 Referring to the September 11 hijackings, Osama bin laden noted that *‘those who were trained to fly didn’t know the others. One group of people didn’t know the other group’* – G, *Quantitative Terrorism Risk Assessment*, Risk Management Solutions, 2003 and Krebs V, *Uncloaking Terrorist Networks*. First Monday, 74, 2002

death) associated with radioactive release which might, it could be argued, render plants such as the Sellafield complex or a nuclear power station highly prized targets to terrorists.

However, to mount an attack on a nuclear plant the terrorist cell would have to plan ahead, locate the particularly hazardous plants and stores, determine the amount and nature of the radioactive contents and how readily this might be dispersed into the atmosphere by breaching each level of containment, that is identifying the most vulnerable aspects of the buildings and the processes within.

As much as the terrorist experts employed by State will have been engaged to identify and rank potential targets,[6] such as transport systems, military installations, nuclear and other hazardous industries, etc., equally, and on its part, a terrorist organisation such as al-Qaeda would be expected to similarly optimise its preferential targets. The point here is that the State upon determining what it believes to be a terrorist-valued target will put in place measures that, so far as is practicable within the extant structures and design, reduce or remove the vulnerability. However, on its part, al-Qaeda with its small, autonomous cell structure might decide that to overcome the additional defence-in-depth measures would require too many individual terrorists and/or that the weaponry necessary would be too complex or demanding in technology to be, itself, risk free to achieve a striking success.

So if this rationale applies then although high utility hazardous plants, such as nuclear power stations with potential for maximum consequences, might be highly prized terrorist targets such would not necessarily be ranked as *preferential* targets because of the practicable difficulties in securing a successful strike.[7]

Decommissioning Nuclear Power Stations

Whilst operating, a nuclear power station undertakes a variety of processes, some of which involve intensely radioactive materials and highly reactive chemicals, much of the reactor structure and its enclosing containment is rendered radioactive, by irradiation and/or contamination, and radioactive wastes and materials accumulate on site over the working lifetime of the power station. Unlike other hazardous industrial plants, what is virtually unique about nuclear plants is that the dominant hazard, radioactivity, remains on site whilst much of the protective measures and containments around it are being dismantled.

---

6 The state's ranking might be tiered into economic and societal disruption, and attractiveness to the terrorist support organisations or 'home' base. For example, tall buildings such as the World Trade Centre towers have maximum economic and societal impact, nuclear plants would mirror the public perception and dread of all things nuclear, which brings in human and economic loss to the forefront of the ranking, but this might then be weighted by the symbolic value and its ready recognition in the terrorist's home base, which for al-Qaeda centres around the Middle East.

7 Of course, a terrorist attack on an operational nuclear plant should not be entirely discounted for the reasoning forwarded here. This is because the fundamental structural design of many of the nuclear plants in the UK and worldwide predate 9/11 and it may not be at all practicable to strengthen the resilience of these plants to terrorist attack. Nor should the terrorist modus operandi be assumed to be confined to an aerial attack with aircraft, as that of the airliners hijacked by the al-Qaeda on 11th September in the United States. A malicious attack on a nuclear plant could arise from armed insurgents, from an external explosive device such as a truck or four-wheel drive vehicle bomb driven into proximity of the plant, or via a passive or more directly by an active insider employed within the plant itself.

In effect, a decommissioning nuclear power plant becomes, as it is destaffed, mothballed and, eventually, dismantled, more vulnerable to attack and it assumes a low or negative utility value to the State therefore deserving of less security attention and effort. For these reasons, a decommissioning nuclear plant may move up the terrorist's preferential target ranking.

In terms of its success in maximising the radiological and economic consequences, because such power stations are usually sited at a remote rural locality, the impact of the local population would be expected to be limited. However, the remoteness turns to the terrorist's advantage because, during the decommissioning process, irradiated fuel[8] and radioactive wastes have to be prepared and packaged and then moved to another locality for processing, interim storage and/or ultimate disposal.

The movement of radioactive materials from the remote power station, usually located in a sparsely populated rural area, introduces a new dimension of vulnerability whilst the consignment is under road or rail transit along many miles of route which cannot be readily defended. Also, the outcome might be maximised if a successful attack is carried through in a densely populated urban area. Indeed, the increased vulnerability and movement of radioactive consignments into and through densely populated areas would most probably render, in the mind of the terrorist, the transportation stages of decommissioning a highly valued target.

Application to London

Obviously, a strike in the capital city London would also be high on the terrorist's preference ranking because the disruption and economic damage potentials are high.

It is possible to gauge the risk to London and Londoners on the run down of the nuclear power stations that are likely route irradiated fuel and wastes through and around London.[9]

In setting out the future role of nuclear power in the United Kingdom, the government's 2006 Energy Review[10] also deals with the radioactive waste legacy from the past and present generations of NPPs and from other nuclear activities, including nuclear fuel reprocessing at Sellafield, the industrial-military activities of Britain's nuclear weapon programme from the late 1940s, and the manufacture and post-use management of radioisotopes, and radioactive sources used in medicine, engineering, research and development applications. For this the government appointed *Committee on Radioactive*

8 In the UK, the seven, twin reactor advanced gas-cooled (AGR) nuclear power stations and the remaining Magnox plants in operation, routinely transfer irradiated fuel to Sellafield for reprocessing during operation and upon final shutdown it takes between two to four years to clear the residual fuel in the storage ponds and from the reactor cores. The sole pressurised water reactor (PWR) at Sizewell B nuclear power station is presently storing its irradiated fuel on site so at the end of its anticipated forty year service life there will upwards of 2,000tonnesU of irradiated fuel in the storage pond awaiting transfer to Sellafield or some other longer term storage/disposal site.

9 For the detailed analysis see Large J H, *HM Government Energy Review and its Influence on London,* Greater London Authority, Mayor of London, R3155-2, August 2006

10 *Energy Review*, HM Department of Trade and Industry, July 2006.

Waste Management (CoRWM) recommended[11] adoption of a *'phased disposal'* strategy involving a period of i) *interim storage* followed by ii) permanent disposal to a *deep geological repository*.

The earliest possible date for the completion of a deep repository (although a site for this has yet to be determined) is unlikely to be ahead of 2030 thus requiring radioactive waste and spent fuel not destined for reprocessing to be held either at the nuclear power stations and other source localities, or moved and held in a specially constructed interim store. Until the interim storage facility is built then stockpiles of past, present and future radioactive waste arisings, except limited volumes of low-level waste, have to remain at the source sites. Once the interim store/disposal repository are operational, and assuming these to be at a single site to the north or west of London,[12] then the existing nuclear power stations in the South-East of England, all being shut down by that time, would transit waste through or around London. These power stations are the twin Magnox reactors at Bradwell in Essex, the twin Magnox and twin AGR reactors at Dungeness and, possibly, the twin Magnox and single PWR reactors at Sizewell in Suffolk.

The volumes and number of freight packages from decommissioning expected to arise over the entire decommissioning and dismantling of these stations is given in Table A of APPENDIX 1.[13] Table B gives the projected transit package movement per decade over the projected decommissioning period of 25 years from shutdown of each nuclear power station and includes for a new-build nuclear plant becoming operational at both Bradwell and Dungeness sites some time during the 2011-20 decade.

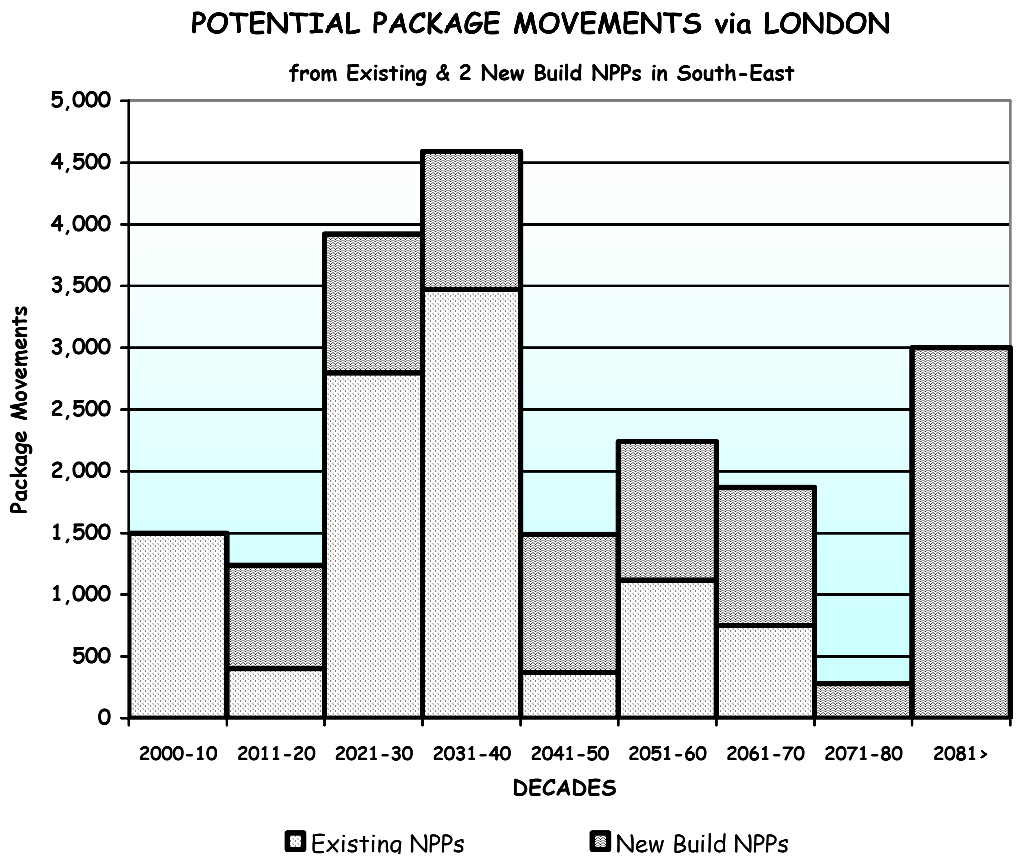
The waste and fuel movements through or around London can be projected and summarised on the assumption that an interim store/repository becomes available during the 2021-30 decade but, if not, then the bulk of the decommissioning waste transits cannot commence until a reception facility is available thereby moving the waste transits further into the future. The following graph illustrates the present level of transits (mainly irradiated fuel) being carried through London at about 1,500 flasks per decade, followed by a sharp reduction as all of the Magnox stations close down and empty of irradiated fuel, and then a rapid increase to 4,000 to 4,500 packages per decade as decommissioning commences in earnest during the period 2021-40, which includes the AGR station also at Dungeness and, finally, the PWR at Sizewell.

---

11 As some would opine in a somewhat confused and unscientific manner, see Large J H, *Carry On at CoRWM - Critical Review of the Deliberations of the Committee on Radioactive Waste Management*, Nuclear Engineering International, April 2005

12 Logistically an interim storage facility will have to be located at or nearby the site of the national deep repository so, only when the repository siting decision is made can construction of an interim store be expected to commence - to reach this go-ahead stage might take three to five years. Until the interim store is commissioned (about 5 to 7 years from its go-ahead date) stockpiles of past and present NPP operating radioactive wastes will have to be retained at the NPP and other source localities. If the final location of the interim store and deep repository (assuming both share a common site) is to the North or North-West of London then only radioactive waste movements from NPP sites to the South and to the East (Dungeness, Bradwell and, possibly, Sizewell) will dispatch radioactive waste through or around London. If the final repository location is to the South of London, which is considered most unlikely, then much large volumes of radioactive waste from the NPPs and other nuclear facilities to the North may travel through or around London.

13 *2004 United Kingdom Radioactive Waste Inventory*, DEFRA-NIREX, Electrowatt-Ekono, 2005.



Transportation of nuclear materials, the spent fuel and radioactive wastes from decommissioning operations, presents an increasing opportunity for terrorists over the next few decades, fitting into the time scale bemoaned by the head of Britain's security service:

> *" . . threat is serious, is growing and will, I believe, be with us for a generation. It is a sustained campaign, not a series of isolated incidents. It aims to wear down our will to resist "*

Safeguarding Spent Fuel and Decommissioning Transits – Security

There are separate IAEA recommendations[14] relating to the physical protection and security of nuclear materials which apply for both fixed nuclear installations and when the material is under transportation. The transport of nuclear material is recognized by the IAEA to be the operation most vulnerable to an attempted act of unauthorized

14 The transport of nuclear material is recognized by the IAEA to be the operation most vulnerable to an attempted act of unauthorized removal of nuclear material, terrorist attack or sabotage – see International Atomic Energy Agency, *The Physical Protection of Nuclear Material and Nuclear Facilities*, IAEA INFCIRC/225 Rev b which states *". . .the transport of nuclear material is probably the operation most vulnerable to an attempted act of unauthorized removal of nuclear material or sabotage. Therefore, taking into account the State's design basis threat, the physical protection provided should be "in depth" and particular attention should be given to the recovery of missing nuclear material. Emergency procedures should be prepared to counter effectively the State's design basis threat. . . . "*.

removal of nuclear material, terrorist attack or sabotage.[15] The IAEA recommends[16] that full account be given to the *'design basis threats'* (DBTs), that the physical protection provided should be *'in depth'*, and that emergency procedures should be prepared to counter effectively the identified DBTs.

That said, the IAEA recommendations,[17] on security, physical protection systems and sabotage prevention are specified in general terms, the salient features of which are as follows[18]

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

In the UK the *Competent Authority* that approves radioactive material in transit is the *Radioactive Materials Transport Division* (RMTD) of the Department for Transport. More specifically, the RMTD generally Reviews the nuclear safety arrangements, although matters relating to security are undertaken by arrangement with the Department of Trade and Industry's *Office of Civil Nuclear Security* (OCNS).[19,20]

OCNS regulates the security aspects of movement of all civil nuclear material by road and rail, classifying carriers so that IAEA *Category II* radioactive materials (such as spent fuel) may only be moved by a *Class A Approved Carrier*. The OCNS publishes little detail of its security requirements and assessments, although OCNS should reflect in greater detail the IAEA recommendations relating to the physical security of nuclear materials, these being:

- Minimizing the total time during which the nuclear material remains in transport;
- Minimizing the number and duration of nuclear material transfers, ie transfer from one conveyance to another, transfer to and from temporary storage and temporary storage while awaiting the arrival of a vehicle, etc.;

---

15 IAEA INFCIRC/225 states *". . .the transport of nuclear material is probably the operation most vulnerable to an attempted act of unauthorized removal of nuclear material or sabotage. Therefore, taking into account the State's design basis threat, the physical protection provided should be "in depth" and particular attention should be given to the recovery of missing nuclear material. Emergency procedures should be prepared to counter effectively the State's design basis threat. . . . "*

16 There is a plethora of regulations and statutes relating to the transportation of Category II materials in addition to the IAEA regulations (ST 1, TS-R-1 and INFCIRC/225) for the safe transport and physical protection of radioactive materials. Referring to the IAEA 1996 Regulations approvals and compliance is required for Multilateral Shipment Approval (IAEA 820) and fissile packages (IAEA 566), special use vessels (IAEA 566), details of the proposed route, controls and shipment period (IAEA 822), flooding (IAEA 671), etc.

17 The IAEA recommendations are legally binding insofar that these are adopted into UK statute law by a series of regulations.

18 The UK commitment to IAEA INFCIRC/225 is given in Note Verbale, dated 1 December 1997, communicating this to the Director General of the International Atomic Energy Agency (IAEA) – but see 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.

19 These departmental responsibilities and jurisdictions extend throughout the British Isles and its territorial waters (and British registered vessels) so, in effect, the UK approves the nuclear and security safety aspects of imports of spent fuel carried from overseas destinations on British registered ships.

20 OCNS dedicates 5% of its staff resource to security aspects of all classes of nuclear materials transport.

- Protecting nuclear material during transport and in temporary storage in a manner consistent with the category of that material;
- Avoiding the use of regular movement schedules;
- Requiring predetermination of the trustworthiness of all individuals involved during transport of nuclear material; and
- Limiting advance knowledge of transport information to the minimum number of persons necessary

The OCNS recently expressed[21] some concern about security issues at Willesden sidings in London where spent fuel trains are marshalled, requiring improvements to the security regime and streamlining of procedures to reduce the times a DRS train was kept standing at the sidings. Even so, a national newspaper reporter was able to gain direct access to a spent fuel train whilst it was being held over at the Brent (North West London) sidings in July 2006, having sufficient time so it is claimed to plant a dummy bomb.[22]

Design Basis Threats for Decommissioning Nuclear Plants

It is not at all clear how the OCNS defines its Design Basis Threat (DBT) scenarios, although a Government Minister then (2002) considered the DBT to be based on *'intelligence about the motives, intentions and capabilities of potential adversaries',*[23,24] which seems to imply that there is sufficient confidence to detect the intent of terrorist act before such are carried through.[25]

This somewhat academic approach does not seem to have changed following the London underground and bus bombing of July 2005. Indeed, the Nuclear Installations Inspectorate (NII - H&SE) assumes for its assessment of risk arising at nuclear power stations (both operational and shut down) that terrorist and other malevolent acts are not required to be taken into account for the operator and carrier's risk assessment reports required under the *Radiation (Emergency Preparedness & Public Information) Regulations*[26] (REPPIR). The

21 Office for Civil Nuclear Security, *The State of Security in the Civil Nuclear Industry and The Effectiveness of Security Regulation April 2004 to March 2005 A Report to the Minister of State for Energy*, Department of Trade and Industry by The Director of Civil Nuclear Security - http://www.dti.gov.uk/energy/nuclear/safety/dcns_report3.pdf

22 Daily Mirror, 22 July 2006 - http://www.mirror.co.uk/news/tm_objectid=17428696&method=full&siteid=94762&headline=n-train-firm-rapped-before-over-security--name_page.html and Daily Mirror 2 October 2006 - http://www.mirror.co.uk/news/tm_objectid=17854021&method=full&siteid=94762&headline=exclusive--24-hour-guard-on-nuke-waste-trains-name_page.html

23 Letter, Sunil Parekh, APS to John Denham, Home Office Minister to Large & Associates, 10 May 2002

24 Letter, Mike Smith, Manager Nuclear Security, Department of Trade and Industry to Large & Associates, 28 February 2003 – see also the Office of Civil Nuclear Security 1st Annual Report, October to March 2002

25 Further definition of DBTs is given in the *'UK Secret'* appendix of reissued (march 2003) Security Regulations - *Nuclear Industry Security Regulations 2003* - which are supported by the *Anti-Terrorism, Crime and Security Act (2001).* These regulations require a Security Plan to be approved by OCNS and this includes prior notification of any decommissioning plans. The *UK Secret* definitions of DBTs is believed to be based on intelligence about the motives, intentions and capabilities of potential adversaries; It includes a definitive statement of the possible scale and methods of attack that could be faced - there are 38 different malicious capabilities defined - such things as mortar attacks, vehicle borne bombs, suicide bombers and the insider threat; and It excludes threats and methods of attack that are judged not to be relevant to the civil nuclear industry in the UK.

26 *The Radiation (Emergency Preparedness and Public Information) Regulations* (REPPIR) are intended to implement articles 48 to 52 on intervention in cases of radiation emergency in a European Council Directive on the basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (Euratom BSS96 Directive).

NII consider that 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."*.[27,28,29,30]

Testing the Threats

This somewhat relaxed exemption, indeed some might consider lackadaisical attitude, is not shared by the Nuclear Regulatory Commission (NRC) of the United States where nuclear plant operators are required under the nuclear safety licensing regime to define and practice DBT against the plant.

The NRC has had regulations in place since the 1970s for protecting nuclear plants against terrorist attacks, although the regulations were not designed with the current nature and level of terrorist threat.[31] In 1991 NRC introduced a means to test nuclear plant security by carrying out exercises involving mock attacks, known as *Operationa*l *Safeguards Response Evaluation* (OSRE). The OSRE programme is intended to test both the effectiveness of the protective strategy and the skills of the armed response force.[32]

From 1991 through to 2001, 81 OSREs were run. At least one *target set* was destroyed in 46% of the exercises, meaning that the security or defending force was unable to prevent the attacking force from gaining access to vital areas and destroying enough equipment to cause a radioactive release. In most of these cases, the plant

27 E-mail Graham Holder, HSE to Large & Associates, 26 February 2003

28 A past Greenpeace UK incursion into the nuclear power plant at Sizewell showed that the UK nuclear security systems may not be able to circumvent a terrorist attack Brown P, *The Threat that's Bigger than Ricin*, Guardian, 17 January 2003.

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

30 *List of 'Terror Targets' Revealed*, BBC News, 22 March 2006, http://news.bbc.co.uk/1/hi/uk/4832740.stm

31 In the United States nuclear plants licensees are required to protect against the design-basis threat an attacking force consisting of "several" well-trained individuals, operating as a single team, armed with automatic weapons and explosives and assisted by an insider (who either actively participates in the attack or only supplies information). Following the 1993 car bomb attack on the World Trade Center, the DBT was enhanced to include a "four-wheel drive vehicle bomb." Airborne attack of any sort, including the use of a helicopter to gain entry, is not considered. More detailed information about the DBT, including the number of attackers, the types of weapons carried, and the size of the vehicle bomb is considered "safeguards information" and is not publicly available, although the DBT subset includes passive and active insiders and a single individual referred to as *Farmer Brown*. Who is reckoned to represent any aggrieved individual such as the Oklahoma Bomber Timothy McVeigh of 1995.

32 Before the OSRE, a series of 'tabletop' exercises are played through in which elements of the licensee's protective strategy are probed by the NRC. This is meant to simulate the role of a *'passive insider*' who provides detailed security information to the attackers. Finally, four different *force-on-force* exercises are conducted over a two day period. The goal of the attacking force in OSRE is the destruction of a *'target set'* A *target set* is defined as the smallest combination of pieces of equipment that, if simultaneously disabled or destroyed, would result in damage to the reactor core. Therefore, the attackers are judged to have *won* the exercise only if all elements of a target set are reached. Conversely, the defending force is considered to have *won* if it is able to protect a single element of a target set. However, a nuclear plant presents many different possible target sets, so the design of a protective strategy that can defend the plant against any possible attack scenario is a complex task. At some nuclear plants, a target set may consist of only one element, that is, a single location with enough safety equipment in close proximity that a single well-placed explosive could result in a radioactive release.

was fully in compliance with the security regulations and operational, so the OSREs have not been applied against a plant undergoing decommissioning where staffing is likely to have been drastically reduced and some of the physical safeguards and barriers may have been partially or wholly dismantled.[33]

Overall OSRE performance did not improve over time. Over the last two years (2000-2001) before the 9/11 crisis led to a suspension of the programme, the failure rate remained at 46%. The OSRE exercises were partially reinstated in February 2003 and, it is understood, fully engaged in October 2004, although little further information on the outcome of post-9/11 exercises is available in the public domain,[34] even so the effectiveness of the NRC's approach to operational safeguards has attracted considerable criticism.[35]

Setting the Standards – UK Decommissioning

It seems that the NII considers that an act of terrorism, on the basis of the established assessment routines, to be a very remote event it is likely to be considered beyond the design basis. However, *Principle 28* of the NII SAPs[36] requires fault sequences beyond the design basis that have the potential to lead to a severe accident to be considered and analysed (by bounding cases[37] if appropriate) and there may be specific requirements for protection of the plant against sabotage which are not published. This means that if it is acknowledged that a terrorist attack on a decommissioning nuclear plant could lead to a very severe radioactive release then, however remote the probability of this event, there is a requirement that the consequences be identified and assessed.

Put another way, this is a *consequence analysis* approach that disregards any offset from the probabilistic value of a foreseeable event ever happening but, this way or that, nothing is available in the public domain other than the NII passing off the responsibility for assessment to the OCNS in specific decommissioning applications under the *Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations*.[38]

---

33 Lyman E S, *Terrorism Threat and Nuclear Power: Recent Developments and Lessons to be Learned*, Rethinking Nuclear Energy and Democracy after 09/11, Int Symp, PSR/IPPNW/Switzerland, April 26/27 2002

34 Fact Sheet, United States Nuclear Regulatory Commission, *Force-on-Force Exercises at Nuclear Power Plants,* July 2003

35 *Comments in Support of Committee to Bridge the Gap's Proposed Rulemaking to Enhance the Design Basis Threat for Nuclear Power Station (PRM-73-12)*, Nuclear Information and Resource Service, Washington, January 2005

36 *Safety Assessment Principles for Nuclear Plants*, NII, Health & Safety Executive, May 2000 first introduced for nuclear reactors in 1979 and for nuclear chemical plants in 1983 and *The Tolerability of Risk*, Health & Safety Executive 1988, revised 1992

37 A *'bounding case'* is where the different faults and fault sequences may be grouped together in that the consequences for any fault sequence is as least as severe as every member of the groups of fault sequences to which it is bound.

38 For example see *The Decision on the Application to Carry Out a Decommissioning Project at Calder Hall Power Station under the Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations, 1999*, NII. June 2005 which states *"47. A number of consultees expressed concern over arrangements for security during the decommissioning project and the possibility of terrorist acts targeted at the site. Terrorism is the responsibility of the Office of Civil Nuclear Security in DTI and the 2-mile air exclusion zone around the site is the responsibility of the Civil Aviation Authority (CAA). NIA65 covers other possible incidents and accidents and associated emergency arrangements, including evacuation"* so much so that this particular topic was not pursed for evidence or further information by the NII in response to the consultees who had raised it.

Conclusions

This paper set itself a number of objectives. These were

1) Is there a terrorist threat and is it likely to persist into the future;
2) can it be predicted in terms of quantitative risk;
3) how does the risk pertain to the UK's nuclear decommission plants; and
4) is terrorist attack inevitable and, if so, how best to manage the consequences?

Terrorist Threat: The head of the UK's Security Service has publicly acknowledged that the terrorist threat is very significant and ongoing, and that it takes in hazardous installations, including radioactive plants. So, it follows can would-be terrorists access sufficiently detailed information about plants awaiting and/or undergoing decommissioning?

Using the United Kingdom plants as yardsticks, it is relatively straightforward to obtain all of the information required to establish the vulnerability of the target by simply accessing publicly available documents. Ministries and agencies of central government publish most of these sources of quite detailed information, and local authorities maintain records of planning applications that include details of extant as well as proposed plants and buildings.[39] These records and documents are readily accessible, it being possible to obtain copies directly from the originating department of documents that date back to 1996 and earlier.

Determining the Quantitative Risk: Within reason it should be possible to quantify the risk of terrorist attack, although this should not be confused with predicting the next terrorist attack.

The difficulty here is in identifying the values that the would-be terrorist will ascribe to the hazard, its vulnerability and its overall impact. This has to be set against and may be at odds with how State experts carry out their assessment and what security and/or resilience measures are implemented as a result of this. Unwittingly, State assessment may strengthen the resilience of obvious targets at the risk leaving the not so obvious more vulnerable.

Moreover, any determination of the risk must include an understanding of how the terrorist organisation might organise itself, not necessary today when the resilience is being planned, but at later times when the attack might take place. This is particularly relevant when considering the vulnerability aspects of nuclear plant decommissioning, because those features that might be included to facilitate the task at the design and reactor shut down stages might not be tested for a further 50 or more years. Similarly, over the decades the modus operandi, nature and severity of terrorist threats against

39 See article Daily Mirror 16 October 2005, report of nuclear details and potential found in abandoned car of member of the group involved with the unsuccessful London bombing of 21 July 2005 - Nuke Bomb Plot, Sunday Mirror, 16th October 2005 http://www.sundaymirror.co.uk/news/tm_objectid=16254342%26method=full%26siteid=62484%26headline=nuke%2dbomb%2d%2dplot%2d-name_page.html

the plant may have changed beyond all recognition from the original DBTs set down many years earlier.

Application in Britain: The nuclear safety and security regulators maintain an uncomfortable taciturnity about the terrorist threat to the UK's nuclear facilities.

Public concern, expressed in consultation exercises, has been put to one side or passed off as too sensitive to discuss further. There is no sense of how and in what detail the threat to decommissioning plants has been addressed and, along with this, there is a sense of lack of accountability across the regulatory regimes much reminiscent of earlier decades when an all enshrouding secrecy also served to cover up so much incompetence in the nuclear industry.

Consequence Management: It would not seem practicable for each and every building, process and transport arrangement at and associated with a decommissioning nuclear plant to be modified to provide adequate protection against terrorist attack. It would be foolhardy to believe otherwise particularly when almost all of the pre-9/11 plants were designed from a probabilistic accident approach, whereas a terrorist attack is an intentional and intelligently driven action.

So if a decommissioning nuclear plant is targeted by terrorists, the quantitative chance of success must be considered high, so high that the impact of the event needs to be assessed in terms of its consequence management alone since this is the only form of mitigation available. In other words, there are no practicable measures that might be implemented on site to provide to absolutely guarantee effective resilience against a terrorist attack should it be implemented.

APPENDIX I - DECOMMISSIONING AND SPENT FUEL ARISINGS

LOCATION OF MAJOR SITES OF NUCLEAR MATERIALS AND RADWASTE IN THE UNITED KINGDOM

TABLE A EXISTING SITES & NUCLEAR FACILITIES LIKELY TO INVOLVE RAIL TRANSPORTATION THROUGH OR AROUND LONDON

ASSUMES WASTE STORE/REPOSITORY AVAILABLE TO RECEIVE RADWASTE NORTH OF LONDON

			CONDITIONED[a] RADWASTE VOLUME AT 2020[b] m^3 (N° of Packages)		
LOCATION	**OPERATION**	**COMMENTS**	**LLW**	**ILW**	**HLW SPENT FUEL**
SIZEWELL	**OPERATIONAL MAGNOX**	Current Spent Fuel Transportation including defuel to, say, 2012 Decommissioning and Operational Wastes Transportation from, say, 2020	29,900 (1,690)	4,400 (477)	~1,000 fuel flasks over 40 years
	OPERATIONAL PWR	Spent Fuel Transportation, say, commencing 2030 or earlier Decommissioning and Operational Wastes from, say, 2050	10,300 (601)	892 (897)	~700 fuel flasks at some future time (say 2030+)
BRADWELL	**SHUT DOWN MAGNOX**	Presently Spent Fuel Defuelling to 2006-7 Decommissioning and Operational Wastes Transportation from, say, 2020	31,200 (1,770)	4,270 (698)	~800 fuel flasks over 40 years
DUNGENESS	**OPERATIONAL MAGNOX**	Current Spent Fuel Transportation including defuel to, say, 2012 Decommissioning and Operational Wastes Transportation from, say, 2020	34,700 (1,970)	4,110 (583)	~1,000 fuel flasks over 40 years
	OPERATIONAL AGR	Current Spent Fuel Transportation including defuel to, say, 2024 Decommissioning and Operational Wastes Transportation from, say, 2040	12,900 (734)	3,900 (371)	~1,400 fuel flasks over 35years
FORT HALSTEAD	**WEAPONS LABORATORY**	Operational, Experimental and Decommissioning RadWastes when Store/Repository available	22 (47)	0.5 (8)	-
CHATHAM	**PREVIOUS REFUEL/REFIT DOCKYARD**	Although closed down in 1983, Chatham Dockyard is believed to retain some RadWaste in storage from the nuclear powered submarine programme.	–	–	–
PORTSMOUTH	**RADIOISOTOPES FROM WARSHIPS**	Possibly excludes decommissioning wastes.	23 (2)	0.2 (1)	-
ALDERMASTON BURGHFIELD	**WEAPONS LABORATORY**	Operational, Experimental and Decommissioning RadWastes when Store/Repository available which may be routed through or around London – decommissioning wastes continue to be generated until 2060 – ILW package numbers high because of plutonium contaminated content of waste	382,000 (24,500)	7,380 (14,400)	(could be fuel from weapons development reactor Viper)
AMERSHAM INTERNATIONAL (GE HEALTHCARE LTD)	**COMMERCIAL RADIOISOTOPE PRODUCTION**	Possibly excludes decommissioning wastes.	11,500 (736)	570 (924)	(could be HLW target material)
		TOTALS[c]	**522,500m^3 32,000 packages**	**25,500 m^3 18,400 packages**	**~4,900 flasks**

a *'As Stored'* waste volumes are prior to processing, compaction, packaging and shielding – Packaging assumed to be undertaken at operation/dismantling site that that the single package is the transport unit – data taken from the *2004 United Kingdom Radioactive Waste Inventory*, DEFRA-NIREX, Electrowatt-Ekono, 2005.

b Final date of transfer from site to waste repository not fixed and could be much later than 2020.

c The totals of radwaste volume and packages should be treated with great caution because final quantities have yet to be determined, some source locations may not transport through or around London by either road or rail, wastes may be disposed of on site, decommissioning may be delayed for 100 or more years following shutdown – the number of **packages** generated provides an indication although not an absolute number of freight movements (rail wagons or lorry loads).

TABLE B PROJECTED FLASK AND PACKAGE MOVEMENTS THROUGH OR AROUND LONDON – EXISTING AND BRADWELL AND DUNGENESS NEW-BUILD NPPS

TASK/YEAR		2000-10	2011-20	2021-30[a]	2031-40	2041-50	2051-60	2061-70	2071-80	2081>	
				N° OF FLASKS/PACKAGES[f]							
BRADWELL	Spent Fuel	300 (to 2006-7)									
MAGNOX	Decommissioning[b]			2,500							
BRADWELL	*Spent Fuel*		*140*	*280*	*280*	*280*	*280*	*280*	*140*		Spent fuel reprocessed[d]
NEW-BUILD	*New MOX Fuel*		*280*	*280*	*280*	*280*	*280*	*280*			Assumes a 60 year operating life
	Decommissioning									*1,500*	
DUNGENESS	Spent Fuel	400									
MAGNOX	Decommissioning			1,300	1,300						
DUNGENESS	Spent Fuel	400	400	400							
AGR	Decommissioning				370	370	370				
DUNGENESS	*Spent Fuel*		*140*	*280*	*280*	*280*	*280*	*280*	*140*		Spent fuel reprocessed[d]
NEW-BUILD	*New MOX Fuel*		*280*	*280*	*280*	*280*	*280*	*280*			
	Decommissioning									*1,500*	
SIZEWELL	Spent Fuel	400									
MAGNOX	Decommissioning			1,100	1,100						
SIZEWELL	Spent Fuel				700						Spent fuel stored at NPP[c]
PWR	Decommissioning						750	750			
NPP TOTALS PER DECADE		**1,500**	**400 - *840***	**2,800 – *1,120***	**3,470 – *1,120***	**370 – *1,120***	**1,120 – *1,120***	**750 – *1,120***	***280***	***3,000***	
FORT HALSTEAD				55							
PORTSMOUTH				3							
ALDERMASTON/BURGHFIELD[g]				10,000	10,000	10,000	10,000				
AMERSHAM				750	750						
OTHER TOTALS PER DECADE		**0**	**-**	**10,820**	**10,750**	**10,000**	**10,000**				
OVERALL TOTALS PER DECADE		**1,500**	**400 - *840***	**13,620 – *1,120***	**24,220 – *1,120***	**10,370 – *1,120***	**11,120 – *1,120***	**750 – *1,120***	***280***	***3,000***	

a Assumes regional or national interim store/repository will not be available until about 2030.

b Decommissioning of NPPs assumed over 25 years, waste transportation shown here to be equally dispersed over two decades but likely to be larger number of movements in second decade when reactor internals dismantling underway.

c Presently Sizewell B spent fuel is not contracted for reprocessing and so remains in store at the station site – the fuel is assumed to be transported from Sizewell early on in the decommissioning period (about 2035-40).

d Both new-build NPPs are assumed to have contracted the spent fuel for reprocessing at an early stage.

f See note c of TABLE A for caution over interpretation of the tabulated data.

g The routing of Aldermaston/Burghfield decommissioning wastes, like all other nuclear sites, has not been determined – there is a possibility that these wastes could be routed through or around London at some time in the future.

h Assumes single Generation III new builds at Bradwell and Dungeness – contribution to transits *italicised.*