The threat of nuclear terrorism: from analysis to precautionary measures

Contribution by Mr Mycle Schneider, Director, WISE-Paris
to

Democracies Faced with Mass Terrorism Meeting

An international meeting organised by Mr Pierre Lellouche, Member of Parliament, Paris, held at the French National Assembly, 10 December 2001.

"Today, it can be said that the risks of nuclear terrorism are increasing. The large-scale production and use of plutonium in the form of MOX will lead to plutonium being spread over a large number of facilities. This requires numerous shipments to link the different stages of the process. In parallel, we are facing an appalling radicalisation and an astounding sophistication of certain terrorist groups. The facilities and transportation of plutonium materials will constitute obvious potential targets. The mere fact of not speaking about the dangers will not eradicate them."

Dr Frank Barnaby[1] **(**nuclear physicist) at a press conference organised by WISE-Paris on 21 November 1997 (See Annex 1), on the occasion of the publication of an analysis report on the plutonium and MOX industry[2]

What has changed since 11 September 2001

For many years, there have been voices attempting to warn of the extraordinary risk that nuclear terrorism represents for humanity. The nuclear sector, like other risk sectors, has always argued that the risk would be acceptable, by means of a simple formula: a potentially very great danger multiplied by a very low probability of occurrence equals an acceptable risk. On 11 September 2001, the world lost the re-assuring factor of low probability. The probability of acts of sabotage and terrorist attack is not calculated with mathematical formulae. Henceforth, we are condemned to manage the potential danger of sites and activities, and to act to minimise their vulnerability to potential attack.

[1] Researcher at Aldermaston Atomic Weapons Research Establishment in the 1950s, Director of Stockholm International Peace Research Institute (SIPRI) from 1971 to 1981, co-author of IMA report (see note below).
[2] J.J. Takagi, M. Schneider, F. Barnaby, J. Hokimoto, K. Hosokawa, C. Kamisawa, B. Nishio, A. Rossnagel, M. Sailer: "Assessment of social impacts of use of plutonium fuel (MOX) in light-water reactors", abridged French version in Final IMA Report (International MOX Assessment)

In addition, the scale of the threat and the capacities of terrorist organisations have been severely under-estimated. According to the American experts at the meeting organised recently by the International Atomic Energy Agency (IAEA) on nuclear terrorism:

> *"on 11 September 2001 the threat revealed itself to be bigger, smarter, better organized, and more deadly than the threats most of the world's security systems were designed to defend against.[3]"*

And yet, there has been no lack of precursor events in the world. There have been numerous cases of theft, blackmail, sabotage and attacks in most countries in the world that operate nuclear installations (some examples from France are given in Appendix 2).

There are two distinct types of risk:

First, **the concentration of a large inventory** of hazardous substances on a single site. It is obvious that, in the short term, there are few means other than those of a police or military nature to protect such sites. The decision by the French government to install batteries of anti-aircraft missiles to protect the nuclear reprocessing plant at La Hague illustrates this.

Second, **the acute vulnerability** of (i) the smaller inventory of hazardous substances, for example, of sites subject to little protection – as is the case for a large number of research centres in the world among the hundreds handling nuclear and radioactive materials – or (ii) of frequent transport, it being very difficult to make the latter safe. While some activities can, at least, be suspended without having a major impact on the national economy of a country, others are an integral part of the energy supply system or other fundamental activities, and thus are more difficult to interrupt in the short term.

The nature of the threat

Today the threat of nuclear or radiological attack by terrorist organisations is clearly taken very seriously by governments. The US Ministry of Defence has even been pushing to speed up the introduction of certain medicines reputed – rightly or wrongly – to be a palliative for certain effects of radioactivity[4].

Basically, the threat of nuclear terrorism can take three forms:

- credible threat with a stolen nuclear weapon;
- theft of nuclear and/or radioactive materials;
  - threat with one or several radiological weapons,
  - threat with a 'home-made' explosive nuclear device,
- attack on, or sabotage of, nuclear installations or transport.

While we do not know of a case of threat with a stolen or 'home-made' nuclear weapon, there are numerous cases of theft of nuclear and/or radioactive materials. IAEA Member States have confirmed the discovery, since 1993, of 175 cases of illicit trafficking of nuclear materials, a "few of which" involved significant quantities[5] and 18 cases involving plutonium or highly enriched uranium. There have been various indications reporting that terrorist networks have attempted several times to obtain nuclear materials.

[3] Bunn, Matthew, and George Bunn. *"Reducing the Threat of Nuclear Theft and Sabotage."* Presented at the International Atomic Energy Agency Safeguards Symposium, Vienna, Austria. October 30, 2001, http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/pubs/nucleartheft.
[4] New York Times, 7 December 2001
[5] Protection Against Nuclear Terrorism – Report by the Director General, IAEA, Board of Governors, 14 November 2001.

Important cases of illicit trafficking or attempted thefts that have been reported include the following example where the quality and quantity of the material involved comes dangerously close to the quantities required to make an explosive device: in 1998, the attempted theft by Russian officials of 18.5 kg of highly enriched uranium by the employees of a major Russian nuclear weapons site was only just thwarted[6].

The risk of attack on nuclear installations

"So the unforeseeable event of one decade becomes the nightmare of the next, one almost-rational step at a time. An enemy sufficiently resourceful and determined could convert today's nuclear power plants to weapons. Perhaps that vulnerability can be corrected. If not, the plants -- which are replaceable, though at some cost -- should close."

Peter Bradford, former Commissioner to the US Nuclear Regulatory Commission, Professor of energy policy at the Yale School of Forestry and Environmental Studies, **On Earth Magazine, Winter 2001**[7]

In the past, there have been numerous cases of attempted intrusion and of terrorist or military attacks on nuclear power stations, for example in South Africa, Spain, France (where, in 1982, two - out of five - rockets reached the site of the Superphénix breeder reactor at Creys-Malville), Iraq and Iran. Fortunately, most of the attacks took place before the installations began operating.

In 1993, the authors of the car-bomb attack on the World Trade Center, belonging to terrorist networks claiming to be part of the islamic *jihad*, had – in a letter received four days later by the *New York Times* and authenticated by the authorities – threatened to target nuclear installations. The inquiry also revealed that this terrorist group had trained, in 1992, in a camp very close to Harrisburg, Pennsylvania, only a few kilometres from the Three Mile Island power plant[8].

After the dreadful experience and unforgettable images of the kamikaze aircraft in New York, the possibility of the deliberate crashing of an airliner with a full load of kerosene onto nuclear installations rightly focuses the attention of populations and decision-makers. Nevertheless, it is only one possibility among a whole series of scenarios that have now become "actually imaginable".

The threat of attacks on installations by trucks filled with explosives is part of the scenarios most feared by specialists[9]. In 1981, the American safety authority (Nuclear Regulatory Commission - NRC) estimated that the attack on the San Onofre power plant by such a mobile bomb would, in the long term, lead to 130,000 deaths (mostly from cancer)[10]

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[6] Mathew Bunn, "the Next Wave: Urgently Needed New Steps To Control Warheads and Fissile Material", Carnegie Endowment for International Peace and Harvard Project on Managing the Atom, April 2000. (http://www.ceip.org/files/projects/npp/pdf/NextWave.pdf)

[7] http://www.nrdc.org/onearth/02win/nuclear1.asp

[8].For more information, see Three Mile Island Alert website: http://www.tmia.com/threat.html

[9]Nuclear Regulatory Commission, "Supplement to Draft Environmental Statement Related to the Operation of San Onofre Nuclear Generating Station, Units 2 & 3," NUREG-0490, January 1981. See also Sandia Narion Laboratories, "An Analysis of Truck Bomb Threats to Nuclear Facilities," 1984; Sandia National Laboratories, "Summary report of Workshop on Sabotage Protection in Nuclear Power Plant Design," February 1977; quoted from George Bunn and Fritz Steinhausler, "Guarding Nuclear Reactors and Material from Terrorists and Thieves", Arms Control Today, October 2001.

[10] US-NRC, « Supplement to Draft Environmental Statement, San Onofre Units 2 and 3, NUREG-0490, January 1981, quoted from M. Bunn, G. Bunn, "Reducing the Threat of Nuclear Theft and Sabotage", IAEA-SM-367/4/08, November 2001

Among the other attack or sabotage scenarios that should now be analysed seriously, the following can be mentioned:

• Crashing of a large gas tanker loaded, for example, with liquefied petroleum gas (LPG)[11] onto a nuclear power plant located on the coast, such as Japanese plants and numerous reactors in other countries, including France.

• Sabotage of internal installations either by employees or by intruders.[12] The control room, electricity supply and main reactor steam lines of some installations are especially vulnerable and damage or destruction could have adverse consequences for complete confinement of radioactive substances.

• Sabotage or attack on external installations and, in particular, energy supply, plutonium stores, irradiated fuel, high-level wastes, flammable substances and transport. This type of attack could be made using "kamikaze" vehicles, such as trucks loaded with explosives (many power plants throughout the world do not have anti-truck barriers), private airplanes or helicopters[13] or with projectiles (rocket launchers, anti-tank or air defence missiles).

Limited protection of nuclear installations against aircraft crashes

To our knowledge, no nuclear installation in the world has been designed to withstand the impact of an airliner (with the exception, no doubt, of certain nuclear weapons silos). Before the attacks of 11 September 2001 in New York and Washington, almost no one seriously envisaged that an airliner could be used as a projectile against a nuclear installation. The only precursory event known to us dates back to 12 November 1972, when three hijackers re-routed a Southern Airlines DC 9 and threatened to crash it onto the research reactor at the military nuclear research centre at Oak Ridge, in Tennessee. The hijackers fled to Cuba after receiving US$2 million.

Sizing design of French nuclear installations in the face of the risk of an aeroplane crash is based on two fundamental safety rules (RFS – *règles fondamentales de sûreté*), issued by the safety authority, applicable to "*taking account of risks related to aircraft crashes*":

- Rule N° I.2.a of 5 August 1980, applicable to "*nuclear units with a pressurised water reactor"*;
- Rule N° I.1.a of 7 October 1992, applicable to "*basic nuclear installations other than reactors, with the exception of installations intended for long-term storage of radioactive waste."*

Prior to the dates of publication of these RFS, no regulatory specification existed for taking account of this particular risk in the design of the corresponding installations, which excludes *de facto* most existing installations except reactors (including the installations of La Hague), designed before the RFS came into force in 1992.

The risk of a crash of a civil or military aircraft is deemed to be below the probable risk threshold for consideration as a "plausible aircraft crash" (the only subject of these rules), in the terms of RFS N° I.1.a.

[11] The largest gas tankers carry up to 80,000 m^3 of LPG.
[12] Most cases of theft of radioactive material are in-house or at least have the benefit of assistance from employees.
[13] On 23 September 2001, a civil aircraft flew directly over the site of the La Hague reprocessing plant at low altitude with a German television crew without being inconvenienced. On 19 Octobers 2001, I was onboard a helicopter with a crew from France-2 which flew, at low altitude, several times around the irradiated fuel rail-road transfer site at Valognes, the Flamanville nuclear power plant, and the La Hague site.

For the sizing of installations in relation to the only risk taken into account, i.e. the crashing of a general aviation type aircraft (weighing less than 5.7 tonnes), the RFS define two types of aircraft "*deemed representative*": the CESSNA 210, single-engined craft of 1.5 tonnes (propeller) and the twin-engined LEAR JET 23, 5.7 tonnes (two jet engines), both assumed to impact the installations at a speed of 100 m/s. This is far from the 400 tonnes of a Boeing-747 and its speed of 250 m/s, not forgetting the 100 tonnes of kerosene or more.

For certain countries, for example Germany, the containment structures of the most recent reactors have been sized to withstand the impact of a military fighter aircraft, but not of an airliner.

Furthermore, it should be stipulated that in all cases, it is the strength of reactor containment structures that is calculated. The protection specific to other sensitive parts such as control rooms, energy supply stations, main steam lines or irradiated fuel stores is no doubt inferior to the sizing of the reactor building. Damage to, or destruction of, these parts could also lead to accident situations involving the release of large quantities of radioactive substances.

The case of nuclear reprocessing plants

On the day after the events of 11 September 2001, WISE-Paris alerted the public authorities and national and international public opinion to the altogether exceptional potential danger of nuclear reprocessing plants.[14] In fact, a just few days before, we had submitted a study on the subject of the potential toxic impact of the reprocessing plants at Sellafield in the UK and La Hague in France, carried out for the European Parliament's Directorate General for Research[15] This report does not, as has often been written, focus on the potential impact of an aeroplane crash on the reprocessing plants but above all on the impact of these plants on the environment and health in normal operating conditions. However, the study provided the opportunity to assess the radioactivity inventory, especially of the cooling pools for irradiated fuels, and the potential release of radioactivity in the event of a serious accident.

The hypothetical accident calculation was made for the case of a fire in the irradiated fuel storage pool D, assuming this to be filled to 50 per cent of its present storage capacity of 3,490 t (thus reflecting the current average situation for storage pools at La Hague), and assuming a release of 100 per cent of the cesium contained therein. The exercise simply shows that the presumed inventory of cesium in pool D corresponds to 67 times the amount of cesium released by the Chernobyl accident.

The impact assessment is based on release hypotheses taken from a study published in October 2000 by the NRC (American nuclear safety authority). In this study[16], the NRC assesses the risk of a "zirconium fire" after loss of water from an irradiated fuel storage pool. The study reveals, with hypotheses qualified by the authors themselves as conservative, that if the temperature of the irradiated assemblies for light-water reactors reached around 900 °C, the "zirconium fire", then self-sustaining by various chemical reactions, would cause the release of 50–100 per cent of the inventory of volatile materials present. They also underline that criticality calculations should be made specifically in case of particular fuels such as MOX.

COGEMA estimates, on its website, that "the hypothesis adopted by WISE, i.e. discharge of all of the cesium contained in the fuels, is "unrealistic". The Secretary of State for Industry, Mr Christian Pierret, in a televised debate, estimated that "it is a very particular case, wholly exceptional, subject to hypotheses and parameters, the probability of which is very low."[17] The Deputy Director of the *Direction de la sûreté des installations nucléaires* (Directorate for Safety of Nuclear Installations), Mr Daniel Quéniart, has confirmed the calculation for the cesium inventory. He then declared that "for the rest, it would require years to be able to provide a truly scientific response to this hypothesis […]".

[14] See http://www.wise-paris.org/francais/links_fr.html
[15] Full version available at http://www.europarl.eu.int/stoa/publi/pdf/00-17-01_en.pdf
[16]. US NRC, « Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants », October 2000.
[17] "Mots croisés", France-2, 22 October 2001

Mr Quéniart also suggested not "taking, as WISE-Paris does, the NRC (American nuclear safety authority) documents as 'gospel'."[18] So be it.

Transposing the area destroyed or damaged by the crash of a Boeing 767 onto the fuel storage pool sector at La Hague shows that the impact could extend far beyond the destruction of a single pool. The tanks are not sunken, but are mounted on neoprene blocks allowing for their thermal expansion and ability to withstand an earthquake (see Figure 1). It cannot be ruled out that the impact of the crashing of an airliner could lead not only to total destruction of one but of several pools at the same time.[19] (See Figure 2)

What is beyond doubt is that the La Hague site contains quantities of radioactive substances that are several orders of magnitude greater than the radioactivity and toxicity inventory of other sites:

• The quantity of irradiated fuel stored at La Hague, around 7,500 tonnes (on 30 June 2001), goes far beyond the quantity of fuel of the 58 reactors in France. The inventory of cesium-137 contained in the fuels at La Hague is around 7.5 tonnes, i.e. 280 times the quantity released during the Chernobyl accident (26 to 27 kg). Current capacity of the pools is 14,000 tonnes of irradiated fuel. COGEMA has requested authorisation to increase this capacity to some 17,000 tonnes. This would enable the cesium inventory to be extended to over 500 times the quantity released at Chernobyl.

• Moreover, COGEMA stores in these pools around 100 tonnes of MOX manufacture rejects (in the form of un-irradiated assemblies), containing some 5 tonnes of plutonium. We did not find any source of information in scientific literature as to the potential impact of an aircraft crash on such a quantity of MOX fuel. Criticality phenomena are not to be ruled out.

• COGEMA stores very large quantities of waste in various forms on the La Hague site, more than half of which is in unpackaged form: more than 1,400 m^3 of highly radioactive glass; more than 10,000 m^3 of hulls and plugs (75 per cent of which are packed in drums); and more than 11,650 m^3 of radioactive sludge (only 20 per cent of which are packaged in drums) [20], as well as several thousand cubic metres of other wastes with lower levels of activity and large quantities of chemicals, some of which – e.g. solvents – are highly flammable.

• Finally, the plutonium storage building contains around 55 tonnes of plutonium in the form of oxide powder. These quantities should be considered against the few tens of millionths of a gram inhaled that are sufficient to cause lung cancer and the few kilograms required to make an explosive device.

The storage of highly radioactive vitrified waste, of which a large part – as for the other substances stored at La Hague – comes from reprocessing of foreign fuels, contains up to an additional 14 tonnes of cesium-137, i.e. in total, more than 20 tonnes of cesium-137 contained in irradiated fuels and vitrified wastes.

The 1979 environmental impact assessment for the UP2-800 plant at La Hague gave an annual probability for impact by any type of aircraft of "less than 10^{-8} for the two most sensitive points (control room and pool C for storage of fuels before processing)." Conclusion: "It therefore does not seem necessary to plan specific protection against aircraft crashes". In other words, the pools have *no* protection against crashing aircraft, regardless of their size."[21]

There is no site in France – and probably only one other site in the world, Sellafield in England – that contains as high a potential for toxicity as that of La Hague and which is so little protected from the sizing point of view. (See Figure 3)

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[18] La Manche Libre, 11 November 2001
[19] For more details, see http://www.wise-paris.org/francais/nosbriefings_pdf/010926BriefNRA-fr.pdf
[20]. WISE-Paris calculations based on national inventory of wastes established by ANDRA, 2000 edition.
[21] According to a reliable source, the pools were in the open air for the first years of operation of the La Hague plant. They were covered because dead leaves and …. frogs were causing problems.

The Sellafield plant poses an additional problem: the storage of a very much larger quantity of high level wastes in unpackaged liquid form. These wastes, stored in 21 containers grouped in a single building, contain around 2.5 tonnes of cesium-137. The crashing of an airliner onto this building would have consequences that are difficult to imagine as the volatile radionuclides would be present in the most directly dispersible form (See Figure 4).

The case of nuclear transport

The most vulnerable point of the nuclear system is the transport of strategic material, in particular, of plutonium. It is astonishing to observe that, under the Vigipirate plan, litter bins in Paris are sealed, schools are forbidden to open mail-voting envelopes from parents' representatives, but, on average, twice a week large quantities of plutonium and un-irradiated MOX fuel are transported over hundreds of kilometres right across France and beyond.

The plutonium system, in France, gives rise to the following plutonium shipments:

- more than 400 shipments per year of irradiated fuel by rail/road for reprocessing (See Figure 5);
- more than 100 shipments by road of quantities of around 120 kg of plutonium in oxide powder form between La Hague and plants manufacturing plutonium fuels at Cadarache, Marcoule and Dessel (Belgium);
- an unknown number of shipments by road of MOX elements to the Dessel assembly plant;
- some 20 road shipments of MOX fuel to French nuclear power plants;
- an unknown number of shipments by road of rejected MOX assemblies.

For example, Figure 6 illustrates the transport routes of German plutonium in France.

Each shipment constitutes an obvious potential target for a terrorist attack, either to steal the strategic material that the plutonium constitutes – the 120 kg or so transported would provide the raw material for several explosive nuclear devices – or with the aim of dispersing radioactivity into the environment, seeking a maximum impact.

By way of conclusion: what measures should be taken without endangering the foundations of democracy?

"A civil norm in favour of liberties cannot withstand strong pressure to put in place draconian security measures if thousands of lives are at stake. In such situations, the context of the Constitution will not change, but its intrinsic value will be altered. No one will notice the change, as the norms for evaluation will develop at the same time as the meaning of the terms of the Constitution."

Prof. Alexandre Rossnagel,
professor of civil law at the University of Kassel, in charge of technical and environmental law, and scientific director of the research group into the design of technologies compatible with the Constitution[22]

The few points below are to be considered as subjects for further reflection. They are not in any way exhaustive.

In the short term, possibilities for action beyond the area of security are limited:

• Reinforcing monitoring measures and physical protection of installations and materials. The decision to deploy air defence missiles at La Hague is a step in that direction. This decision is to be considered irreversible in terms of duration. Given the grave inadequacies as to the level of information from the specialist services, illustrated by the total surprise with which the terrorists were able to act in the United States, it is difficult to see a government deciding to withdraw this protection.

• The transport of plutonium and fresh MOX should be interrupted. Such a measure would not cause problems for the electricity supply system in France. The manufacturing capacities for uranium fuel are adequate to compensate for the MOX share. The practice of not marking the convoys, the discrete close protection, satellite tracking and secrecy that surrounds the shipments are hardly a total guarantee in the face of ultra-sophisticated terrorist organisations. The convoys leave one particular place to go to another particular place (there are only three possible fuel manufacturing plants).

• Inter-disciplinary "think tanks" should be set up giving free rein to the imagination to develop scenarios for intrusion, sabotage and attacks on nuclear installations and transport. The basis of reflection is known: what plan can be implemented with 20 educated people, trained and prepared to die. The results should be analysed by the relevant departments for national defence, civil defence and other specialised technical services (IPSN). Changes in organisation and/or equipment could be offered to operators in a relatively short time.

"Security is only as good as its weakest link."

Mohamed ElBaradai
IAEA's Director General
14 November 2001

In the mid-term, the following actions would be desirable:

• improving the conditions of physical protection and systems for monitoring guarantees. It appears unbearable that the IAEA has, for years, remained well below its budgetary requirement – IAEA's Director General quantifies the gap in the annual budget at around US$40 million – whereas certain countries do not hesitate to commit tens of billions of dollars to a "war against terrorism".

[22] J. Takagi, et al. Op. cit.

• reducing the inventories of nuclear and radioactive materials and therefore the potential danger per site and unit of transport. At the La Hague site, COGEMA has established a concentration of nuclear and radioactive substances that cannot be justified in industrial terms. De-storage strategies should be developed rapidly, especially packaging and return of waste from reprocessing of foreign fuel. The policy of substitution practised by COGEMA – a little more high-level waste against greater average volume and lower level – is not acceptable, and is contrary to the 1991 Act which prohibits the storage of foreign waste in France. Other sites, such as Cadarache and Marcoule, also pose problems regarding the high density of nuclear and radioactive substances.

• stopping the separation and handling of plutonium. In the future, it would be necessary to justify the acceptance of a large industrial and terrorist risk by significant social benefit. The plutonium industry has lost its *raison d'être* with the limitation of military programmes and the end of fast breeders. EDF, like the British government, has assigned a zero value in its accounts to its plutonium stocks. The process leads to very large releases of radioactivity, and the use of plutonium fuel requires numerous shipments of highly radioactive and strategic materials. Effective control and protection of this industry requires military and police means which endanger the fundamental freedom of our democratic society.

"At the United Nations: it's OK, it's only an accident"

Headline in ***Le Monde***
14 November 2001 after the crash of an airliner in the Queens district of New York which killed at least 257 people.

In the longer term, it will be necessary to revise our concepts of acceptance of industrial risk. The astonishing reactions after the AZF accident in Toulouse and the aeroplane crash in the Queens district of New York two months later – not serious, it's only an accident – indicate that we have not yet realised the extent of changes to come. The facility with which some people say that within 10 years we will have two *accidental* airline crashes *per week* in the world is appalling. Inevitable? How many Erikas and Chernobyls are we still able to accept? What these events have in common is the disproportionate scale of the disaster in relation to social benefit. Who is asking what was manufactured in Toulouse? What were the products used for? No one wants plutonium. Both its social *and* commercial value are negative.

Industrial society is fragile. The phenomenon of ultra-sophisticated terrorism forces us to re-examine our approaches. Tomorrow we will be condemned to succeed. Security measures will only serve in the short term. The true structural solutions will prove beneficial for the fight against terrorism, for the safeguard of our freedom, for the environment, and for the heath of future generations.

Appendix 1

IMA Report, November 1997
WISE-Paris Press Conference, 21 November 1997

Declaration made by Franck BARNABY

Parmi les arguments contre l'utilisation du MOX, on accorde le moins d'attention au fait que cela augmente les risques de prolifération nucléaire et de terrorisme nucléaire.

On dit parfois que le plutonium produit dans les réacteurs nucléaires ne peut pas être utilisé pour la fabrication de bombes ou d'explosifs nucléaires. C'est tout simplement faux, comme tout physicien nucléaire le sait ou devrait le savoir. Selon Robert Selden, du Lawrence Livermore Laboratory : "tout plutonium peut être directement utilisé dans des explosifs nucléaires. Le concept (…) d'un plutonium impropre à la fabrication d'explosifs nucléaires est fallacieux. Une forte teneur en plutonium-240 (plutonium de qualité réacteur) représente une complication, mais pas un obstacle".

Il a été prouvé en 1956 que le plutonium de qualité réacteur pouvait être utilisé pour la fabrication d'armes nucléaires, lorsque les Britanniques ont fait exploser une bombe de ce type au cours d'une série d'essais nucléaires en Australie, puis en 1962, lorsque les Américains firent de même. Le fait est que tout pays qui dispose d'un stock de plutonium et de quelques scientifiques nucléaires pourrait concevoir et fabriquer des armes nucléaires efficaces.

Matthew Bunn, qui a dirigé le projet de l'Académie des Sciences Américaines sur l'évaluation des options de gestion de plutonium militaire, dans une déclaration fracassante devant l'AIEA (Agence internationale de l'énergie atomique) en juin 1997, a mis les choses au point :

"Pour un simple proliférateur, fabriquer une bombe grossière avec une puissance assurée d'une kilotonne ou plus - et donc un rayon destructif d'environ un tiers ou la moitié de celui de la bombe d'Hiroshima - avec du plutonium de qualité réacteur ne nécessiterait pas plus de perfectionnement que pour faire une bombe avec du plutonium de qualité militaire (...) Et des grands pays détenteurs d'armes nucléaires comme les USA ou la Russie pourraient, s'ils le décidaient, fabriquer des bombes avec du plutonium de qualité réacteur, avec des caractéristiques de puissance, de poids et de fiabilité similaires à celles fabriquées avec du plutonium de qualité militaire. Le fait qu'ils ne l'aient pas fait par le passé tient à des raisons de convenance et au désir d'éviter des doses de radiation aux travailleurs et au personnel militaire, pas à la difficulté d'accomplir ce travail. (…) En fait, un constructeur d'armes russe qui s'est penché en détail sur cette question a critiqué les informations déclassifiées par le DOE [Department of Energy américain] parce qu'elles n'indiquaient pas que, pour certains aspects, il serait en fait *plus facile* pour un simple proliférateur de fabriquer une bombe avec du plutonium de qualité réacteur (car il n'y aurait alors pas besoin de générateur de neutrons)".

La séparation du plutonium contenu dans des combustibles irradiés provenant de réacteurs électronucléaires, son introduction dans du combustible MOX et le transport du MOX vers l'étranger constituent clairement un réel problème de prolifération des armes nucléaires.

La prolifération nucléaire représentera un facteur de déstabilisation dans la région concernée. La seule acquisition de capacités pour se doter d'armes nucléaires affectera la sécurité de la région. Cela encouragera d'autres pays de la région à se doter de leurs propres armes nucléaires. Ainsi, la capacité du Japon de fabriquer des armes nucléaires, par exemple, encouragera-t-elle la Corée du Nord et du Sud à se doter d'une telle capacité, et la Chine à renforcer sa propre force nucléaire. Fournir du MOX au Japon aura donc de graves conséquences sur la sécurité globale et régionale.

En outre, les transports de MOX peuvent encourager des groupes terroristes à se doter d'explosifs nucléaires artisanaux. Ce type d'engins n'est pas difficile à concevoir et à fabriquer. On peut par exemple, avec des procédés chimiques relativement simples, séparer l'oxyde de plutonium de l'oxyde d'uranium contenu dans les combustibles MOX.

Il y a dans certains groupes terroristes des personnes ayant de remarquables compétences scientifiques et techniques. La fabrication de la bombe qui détruisit le boeing 747 de la PanAm, le 21 décembre 1988, au-dessus de Lockerbie, avait nécessité des compétences considérables. Il en est de même pour l'utilisation des gaz de combat par la secte Aum dans le métro de Tokyo le 20 mars 1995. C'est un fait déconcertant : la fabrication d'explosifs nucléaires rudimentaire, par opposition à une arme nucléaire militaire, ne nécessiterait pas plus de compétence que pour la bombe de Lockerbie ou les gaz de combat de Tokyo. Des groupes terroristes ont désormais accès à des scientifiques professionnels, à des compétences techniques, et à d'énormes sommes d'argent.

C'est sous forme d'oxyde, que le plutonium est normalement stocké dans les usines de retraitement et transporté vers les usines de fabrication de MOX. C'est sous cette forme que les terroristes risquent le plus de s'en procurer. La **masse critique** d'une sphère de plutonium de qualité réacteur sous forme oxyde est d'environ **35 kg**, ce qui représente une **sphère de 9 centimètres** environ de rayon.

Dans une bombe artisanale, l'oxyde de plutonium pourrait être contenu dans un récipient sphérique placé au centre d'une grande quantité d'explosifs classiques puissants. Plusieurs détonateurs seraient utilisés pour mettre feu aux explosifs, probablement à distance. L'onde de choc provoquée par l'explosion pourrait suffisamment comprimer l'oxyde de plutonium pour amorcer la réaction en chaîne.

La puissance de l'explosion nucléaire d'une telle bombe est impossible à prévoir. Mais même si elle ne correspondait qu'à quelques dizaines de tonnes de TNT elle pourrait dévaster entièrement le centre d'une grande ville. Une telle bombe aurait de fortes chances d'atteindre une puissance explosive d'une centaine de tonnes de TNT au moins et il ne serait pas impossible qu'elles atteignent mille tonnes ou plus.

Une bombe atomique artisanale fabriquée par un groupe terroriste pourrait être placée dans un véhicule de type camionnette. Cette camionnette pourrait être disposée de façon à ce que, même si la bombe ne provoquait pas d'explosion nucléaire significative, l'explosion due aux puissants explosifs chimiques disperse largement le plutonium. Si des matières incendiaires étaient ajoutées, l'explosion serait accompagnée d'un incendie violent.

Le plutonium brûlerait au cours de l'incendie, entraînant la formation de petites particules. Celles-ci seraient emportées dans l'atmosphère dans la boule de feu, puis largement dispersées dans l'air. Une part importante des particules seraient suffisamment petites pour être inhalées et atteindre les poumons, où elles pourraient se fixer, et irradier les tissus avoisinants. L'irradiation par des particules alpha présente un risque très élevé de cancer. C'est pourquoi le plutonium, lorsqu'il est inhalé, a une grande toxicité.

La menace de dispersion rend ces explosifs nucléaires rudimentaires des armes particulièrement attrayantes pour les terroristes nucléaires. La dispersion de plusieurs kilos sur un quartier d'une ville rendrait la zone inhabitable sans opération de décontamination, ce qui pourrait prendre des mois. La grande peur que représente la radioactivité parmi la population renforcerait considérablement la menace.

Pour bien comprendre l'ampleur de la menace de l'explosion d'une telle bombe, il faut rappeler que la plus forte explosion terroriste à ce jour était d'environ 2 tonnes de TNT. Une explosion nucléaire équivalent à 100 tonnes de TNT dans une zone urbaine serait une catastrophe, à laquelle les services d'urgence ne pourraient pas réellement faire face.

Avec une explosion nucléaire au niveau ou juste au-dessus du sol, les retombée radioactives immédiates seraient relativement importantes. Les particules radioactives s'élèveraient sous l'effet de la chaleur dégagée par les incendies, puis seraient emportées par les vents et retomberaient au sol en quantité et à des distances en fonction de la vitesse du vent et des conditions météorologiques. Les zones contaminées de façon significative seraient inhabitables sans décontamination.

Les zones concernées pourraient couvrir plusieurs kilomètres carrés. Pour fixer les idées, il faut imaginer que si un kilo de plutonium était réparti de façon uniforme, on obtiendrait un niveau de contamination de 1 micro-curie par mètre carré - soit le niveau maximum admissible pour le plutonium dans les réglementations internationales - sur 600 kilomètres carrés environ.

C'est peut-être la menace de dispersion qui représente le plus grave danger de l'acquisition de plutonium par un groupe terroriste. En fait, ce danger est si important que la simple possession de quantités significatives de plutonium par un groupe de terroristes est une menace en soi. Prouver à un gouvernement qu'il possède du plutonium, permettrait à un groupe terroriste de se livrer au chantage.

En conclusion, on peut dire qu'aujourd'hui les risques de terrorisme nucléaire grandissent. La production et l'utilisation à grande échelle de plutonium sous forme de MOX conduira à une dispersion de plutonium à un grand nombre d'installation, nécessitant de multiples transports pour relier chaque étape. Parallèlement, nous sommes face à une radicalisation effroyable et une sophistication stupéfiante de certains groupes terroristes. Installations et transports de matières au plutonium constitueront des cibles potentielles évidentes. Le simple fait de ne pas parler des dangers ne saura les éliminer.

Appendix 2

EXAMPLES OF ATTACKS ON NUCLEAR INTERESTS OR INVOLVING NUCLEAR MATERIALS

1977–1990

Compiled by WISE-Paris, December 2001

1977 - "Nuclear's night of terrorism"[23]

In September 1977, more than 10 acts of violence targeted EDF installations or companies working for the nuclear sector in a single night. EDF was the victim of an explosion outside the building occupied by its senior management (Paris), at a garage (Lyon), in buildings (Toulouse and Talence), and on pylons (at Saint-Vulbas on the line supplied by Bugey, and Saint-Maurice de Gourdans).

The attacks were claimed by C.A.R.L.O.S (French acronym for "the autonomous coordination of revolutionaries in open conflict with society") which states, "*it is essential to intensify acts of sabotage which […] make it possible to delay or even stop the building of power plants, mines or plants linked to the nuclear sector."*

1979 - Iraqi reactor components destroyed - La Seyne sur Mer

During the night of 5 April 1979, three members of a commando penetrated into the Méditerranée nuclear hangar for naval and industrial construction containing components for two Iraqi nuclear reactors, which they blew up. The attack was attributed to unidentified secret services.[24]

1979 - Theft and damage at the Bugey power plant

After failure of a test on a reactor operating at full power, cables were found to have been cut and a valve failed to operate. Engineers attributed these faults to acts of vandalism committed by people with good technical knowledge. Thefts and other incidences of damage have been committed recently. EDF registered a complaint.[25]

Reaction from the power plant's CGT union chapter:

We suspect the public authorities of using these incidents as a pretext to reinforce security measures and above all to control site personnel. Measures have been continually reinforced over the last two years. Today, there is talk of magnetic badges and fingerprints."[26]

The CFDT union, for its part, denounces "*the development of a veritable sabotage psychosis which can but favour the introduction of binding measures and reinforcement of police systems […]*."[27]

1979 - A group scatters irradiated plates stolen in Lyon

The CRANE (acronym for "revolutionary anti-nuclear and ecology cell") strewed stolen "irradiated" plates (14 in all) around the university buildings in Lyon. Eleven of these were found. They were placed in the letter box of the '*Progrès*' newspaper, in a car, in the metro, in large stores, and in the electoral surgery of Mrs Simone Weil.

The CRANE *"intended to demonstrate what a terrorist organisation could do if it came into possession of radioactive sources."*[28]

[23] Libération, 22 November 1977
[24] Nouvel Observateur, 14 April 1979
[25] Le Monde, 8 June 1979
[26] Le Monde 10–11 June 1979
[27] Le Monde 10–11 June 1979
[28] Libération, 8 June 1979

1982 - Rocket attack on Superphénix

On 18 January 1982, five rockets were fired at Superphénix, two of which reached the buildings. The perpetrators were never apprehended.[29] Magdalena Kopp, the wife of international terrorist Carlos, is said to have recognised having provided logistical support for this attack.[30]

1987 - Action Directe said to have planned abduction of a senior CEA manager

In February 1987, four leaders of the Action Directe group were arrested. According to the *Le Point* weekly, the abduction of a senior CEA manager was planned two days later.[31]

1987 - Attack on high-voltage power lines[32]

In February 1987, a group known as "Vert Dur" (Hard Green) announced it would "*bring down*" three high-voltage power lines, and carried this out as part of a "*sustained intentional breakdown of the national supply grid.*" In particular, one of the attacks affected the line supplied by the Dampierre power plant.

1987 - DPSD agents reach the control room - Nogent

In March 1987, a commando of agents from the DPSD, a former military security body, succeeded in reaching the control room of the Nogent-sur-Seine power plant.[33]

1989 - Theft of a flask of iridium-192 and radiological threat - Grenoble

A security guard stole a flask of iridium-192 from the premises of the Neyrpic company where he was carrying out surveillance duties, and then attempted to blackmail his employer by claiming that he had connected the flask, hidden in the left luggage office at the railway station in Grenoble, to an explosive device. The flask was found there, but not connected to any firing device.[34]

1990 - Attacks on a dam claimed by an anti-nuclear movement - Malause

In April 1990, the EDF dam at Malause (10 kilometres from Golfech) was damaged by the explosion of 11 charges. An "*anti-nuclear movement."* claimed responsibility for the attack.[35]

1990 - Attack on Albertville - Rondisson line, in Piedmont

Two pylons 300 metres apart were destroyed and a kilometre of cable was brought down by explosives in an attack (in September 1990, at Baldisser Carnavese, Piedmont) against the line providing connection between France and Italy. The attack is attributed to Italian eco-terrorists. The weekly *Enerpresse* indicated that "*the attack […] seemed to be directed against Superphénix"*.[36]

1990 - Attack on a pylon at Golfech nuclear power plant

On 21 December 1990, at around 1 kilometre from Golfech, a pylon supporting the line carrying electricity generated by the power plant collapsed after explosion of two charges.[37]

1990 – Publication of a report on lack of protection of nuclear power plants

The '*Canard Enchaîné*'[38] newspaper published extracts from the 1988 report by Mr Jacques Doucet, Police Commissioner seconded from the Ministry of the Interior, intended for the Director General, Mr Jean Bergougnoux. According to the '*Canard*', this confidential 5-page report indicates important failings in security, summed up by the paper as "*your power plants are like sieves*."

[29] Le Monde, 15–16 January 1984
[30] Der Spiegel, 26 February 1996
[31] Le Point, 23 March 1987
[32] Doucet report, quoted in "Le Canard Enchaîné", 18 April 1990
[33] Le Parisien, 26 April 1990
[34] Libération, 30 January 1989, AFP, 28 January 1989
[35] Libération, 15 April 1990
[36] Enerpresse, 12 September 1990
[37] Quotidien de Paris, 24 December 1990
[38] Le Canard Enchaîné, 18 April

In particular, it reveals the results of intrusion exercises during which commandos were able to penetrate unhindered into the control room of a nuclear power plant; the presence among personnel of outside contractors of persons known from terrorist and serious-crime files (in particular members of the Red Brigade responsible for cleaning at Nogent); and terrorist actions, relatively localised, but at well chosen places at dispatching points, major stations or on the 400,000 volt power lines (of the type near Dampierre and in the Rhône valley).

According to the '*Canard*', regarding physical protection, the Doucet report notes that the installations comply with instructions from the Ministry of Industry, all the more so because "we do not have to defend ourselves against armed and determined commandos (at least, not yet)."