Security

An industry incapable of adapting to the post-9/11 world

> *"Security measures offer no real guarantee against the kind of kamikaze actors."*
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> **French Ministry of Defence internal memo, cited by *Libération*, 12 September 2001**

For the nuclear industry, security, or protection against malicious acts, is a preoccupation that runs parallel to safety, or protection against accidents. In both cases, the objective is to prevent nuclear installations from being exposed to the situations foreseen, and to limit by design the possible consequences to these installations if these situations occur in spite of everything. While the logic of prevention is necessarily different with respect to chance events and deliberate actions, the two areas overlap at the level of installation design.

Unlike accident scenarios, malicious acts are by definition intended to produce the desired level of damage. A key issue in the field of security is therefore to identify threats judged to be "credible", by evaluating (in particular through intelligence) the interest of groups or individuals in targeting a nuclear installation and the means that they could employ.

The impractical challenge of evolving threats

Here the nuclear industry runs up against a fundamental difficulty inherent in the fact that threats evolve over time, whereas the degree of protection that installations have is essentially fixed for their whole lifespan when they are designed. If threats develop which exceed the load level built into the design, protection must henceforth rely on prevention alone.

In France, the authorities have chosen not to make any information available on "design basis threats", in other words the types and levels of credible threat of a malicious act against which nuclear installations should be protected. These details are covered by the secrecy rules protecting national security – "defence secrecy". As a result, we do not know whether these threats have been re-evaluated, and if so in what way, since the attacks of 11 September 2001 in the USA.

Nonetheless, it is incontestable that this date marked a major turning point. Previously, it appears that the threats taken into account were limited by a principle extending nuclear deterrence to any action against nuclear installations carried out with clearly identified foreign support. In the context of the time, only small-scale attacks had to be allowed for in the design under these conditions.

Since then, the design basis of installations has been essentially, if not totally, determined by external attacks or internal situations of accidental origin, liable to cause mechanical or thermal stresses greater than those caused by limited malicious acts.

During the 1980s and 1990s, France witnessed several attacks on its electrical industry. Most aimed to destroy pylons of high-tension transmission lines. The most notable, however, hit the Superphénix reactor on 19 January 1982. Activists opposed to the breeder reactor project attempted to destroy the reactor, then under construction, by attacking it with heavy weaponry. They failed to hit their precise target, but out of five rockets fired, four hit the reactor – three hitting the containment building and one a lifting system. The damage was estimated at around 100,000 francs at 1982 prices (€15,000). The perpetrators, who had obtained the necessary equipment from actual terrorist groups, were never found until one of them confessed of his own accord 22 years later.[64]

Weapons of the type used, while rare and hard to obtain at that time, have become commoner and more accessible in the last twenty years, as is shown by their being used increasingly often in heavily armed attacks on armoured money convoys. Thirty years after the first French reactors entered service, the threats that need to be taken into account today bear no resemblance to those of that time.

After the World Trade Center attacks, any scenario involving twenty or so people prepared to sacrifice their lives has to be considered as plausible. Obviously this includes the use of hijacked airliners to hit installations – which, whether reactors or fuel manufacturing or processing plants, have not been designed to withstand such an impact.

This fact clearly shows the limitations of the essentially probability-based approach to the design basis of installations. Faced with the risk of malicious acts, a different approach is required. Security thus depends upon an evaluation of the potential dangers. This, as the IPSN (now IRSN) explained after 11 September 2001, involves an estimation of risk based on the identification of the system's sensitivity (ie the potential for a release of radioactivity) combined with its vulnerability (how difficult it is to cause such a release).[65]

Blackout on evaluation and mitigation

No public evaluation exists of the potential consequences of an airliner crashing into one of EDF's 58 reactors. Following an independent assesment published by WISE-Paris in the context of the debate aroused by 9/11 on the potential consequences of such a crash on the fuel ponds at La Hague, an official evaluation by IRSN concluded that if such a scenario occurred it could bring about the release of up to 10% of the radioactive inventory of the fuel in one pond. The release of around 1.5% of the caesium contained in one pond would correspond to the caesium released by the Chernobyl accident.[66]

However, this scenario is not the only one to be taken into account – intruders must also be considered. According to what little information is available on this subject, exercises carried out by the French special security forces have highlighted the poor extent to which nuclear installations are protected against an attack. At another level, Greenpeace anti-nuclear activists have on several occasions been able to carry out protests actually inside power stations, evading security for several hours and reaching sensitive areas of the installations.

At the same time, insider collusion may enhance the effectiveness of malicious acts. Several incidents have shown how vulnerable nuclear installations are in this respect. One incident at the Bugey power station in 2003, which went totally unnoticed by the public, illustrates this vulnerability. On 12 June 2003, during a strike at the site, the mere closing of a hatch triggered a sequence of security system activations, culminating in the automatic shutdown of unit 2 as a result of the activation of the turbo-alternator group protection systems. It is easy to see the potential danger of such an action if the perpetrator had intended to cause more serious harm.

Moreover, nuclear installations are not the only elements to be taken into consideration. The very numerous transports of radioactive material – and especially nuclear material (uranium and plutonium) – resulting from the industry's activities can be seen as so many hard-to-protect "mobile installations". There is a risk both of an attack aiming directly to disperse the material being carried by a transport,

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[64] The rocket launcher, an RPG-7, and the rockets were obtained from the German RAF (Red Army Faction) group via the Belgian CCC (Communist Combatant Cells) group, according to one of the perpetrators, Chaim Nissim, in a book published in 2004.

[65] IPSN, *La protection des installations nucléaires contre la malveillance* [The protection of nuclear installations against malicious acts], note of 30 October 2001.

[66] In other words around 26kg, which according to international estimates was responsible for three-quarters of the overall long-term collective dose caused by the accident.

and of an attempt to hijack these materials in order to use them subsequently for a “dirty bomb” or, if nuclear material is involved, to make a nuclear weapon. This risk of misappropriation also exists for all installations that have a significant stock of radioactive material.

Faced with these different risks, how well is the French nuclear industry protected? Planned with reference to threats which are now superseded, the industry appears badly adapted in terms of the design of its installations as much as in its general organisation. As we have seen, the reactors and plants have not been designed to resist the sorts of attack that can now be envisaged. Nor has their location: for example, the centralisation of all reprocessing activities at La Hague gives rise to long transport journeys from the reactors. Even more so, the distance between La Hague, which separates plutonium, and the MOX fuel manufacturing plant at Marcoule which uses it, bears witness to the priority given to economy (in terms of minimising the volumes transported)[67] over security.

Would it have been possible to predict better the way in which threats have evolved? This question is a very difficult one to answer. On the other hand, one might ask how capable the nuclear industry is of adapting. While some parameters are fixed – such as the design basis and the general design of the installations, other factors may be developed in such a way as to reduce the system’s vulnerability or sensitivity to the risks of attack.

External security measures have undoubtedly been strengthened – both in the short term, such as the temporary deployment of radar and anti-aircraft missiles to protect the installations at La Hague or in the Rhône valley, or more permanently. On the other hand, the authorities have given no indication of any possible adaptations at the level of the industry.

On the contrary, nothing seems to have changed, even in the most at-risk areas. So, in spite of the anxieties aroused by nuclear transports crossing the country, these transports continue, apparently under the same conditions. The industry’s chosen path of reprocessing, of separating plutonium and reusing it in twenty or so of EDF’s reactors, which increases the number of transports even while exacerbating their intrinsic danger, has not been revised at all in terms of the security factor. These choices, moreover, result in the long-term accumulation of very large amounts of radioactive material in temporary, low-security storage, by comparison for example with underground stores such as could be implemented in the space of a few years. One again, this issue does not appear to trouble the industry.

In reality, it is by choice that protection relies above all upon external arrangements, so as to dismiss any calling into question of the industrial system’s design and direction. Detecting preparation for actions by surveillance of the national territory, and preventing those actions from being carried out through the intervention of security forces, are therefore key.

Secrecy, a substitute for security?

One consequence of this doctrine is the enforcement of a maximum level of secrecy. Of course, as the ASN explained as early as the end of 2001, counter-terrorist protection measures “like the studies conducted into the resistance of nuclear installations to a terrorist act, cannot, by their very nature, be publicly communicated”.[68] Details of them must not be disseminated. But the doctrine implemented by the nuclear industry and the French authorities implies any security flaw in the design of the industrial system should be accepted, so long as that flaw can be kept secret!

Having become the first line of defence, secrecy must be protected at all costs – or at least the appearance of secrecy. By this logic, no explanation is possible; nor even any serious expression of doubt. No internal analysis is disseminated outside the circle of those privy to the secret, and any criticism from outside is immediately denounced as playing into the hands of potential terrorists.

Soon after 11 September 2001, several members of Global Chance involved in a working group on France’s energy security inside the Commissariat Général au Plan (French planning commission)

[67] Marcoule is near the enrichment plants that produce the depleted uranium which makes up over 90% of the MOX fuel, as against 10% of plutonium.
[68] DGSNR, Annual Report 2001.

proposed that it should include a consideration of the relative resistance of different energy systems to malicious acts (particularly in terms of their degree of centralisation and of the networks on which they depend). The representatives of Cogema (now Areva) and EDF in particular refused point blank to discuss the resistance of different installations to different kinds of attack, bringing the group's work to an end.

This logic can tip over into absurdity when it attempts to keep secret elements that are under the eyes of the public, such as the timetables and itineraries of nuclear material transports, which regularly take the biggest public roads in an easily identifiable form. Again, the lack of any guarantee as to the resistance of present-day reactors to a crashing airliner can hardly be considered a secret.

Deadlock on updating security standards

The same policy now extends to the new EPR reactor project. In 2005-06 the dedicated commission organising a national public debate (Commission Particulière du Débat Public, CPDP) on the Flamanville project censured a paragraph of the contribution by the Sortir du Nucléaire network which cited a note from EDF in support of its doubts as to the reactor's ability to withstand an airliner crash. The problem was the Network's proposal to circulate this note – seen as a "compromise" of defence secrecy, even though the note, classified as "confidential" by EDF, had already been leaked into the public domain.

The dossier submitted to the national public debate thus included contradictory statements, discussion of which was forbidden by defence secrecy. In the context of a democracy, however, it seems vital to assess the EPR in these terms and so to determine what progress it represents in comparison with present-day reactors. The crisis which this incident instigated notably led, in the context of the public debate, to the creation of a working group on freedom of information in the nuclear field.[69] This group acknowledged that, while defence secrecy is an indispensable element of nuclear security, its exact role in the protective arrangements, and thus its limits, remain subjects for debate.

The progress of the debate on the EPR reactor exemplifies the doctrine which gives more importance to secrecy about the EPR's degree of resistance to new terrorist threats not anticipated by its design basis, than to consideration of how to address these threats better at the design stage of a new reactor. Security still ranks low down the list of both short- and long-term priorities, as the industry's preferred vision of the reactors of the future shows.

This vision is in line with international work on the 'fourth generation', a catch-all term which encompasses all reactor concepts, whether new or resurrected, that make a break with the models which currently dominate the industry worldwide.[70] This work is carried on in particular in the context of the Generation IV International Forum, which brought together the "world's top nuclear experts" to define the objectives to be reached and select the most suitable concepts to achieve them.

The objectives, set in April 2001, prioritise safety and above all the management of uranium and waste. Moreover, five of the six design concepts chosen in 2002 rely on a 'closed cycle', not only of plutonium but also of the minor actinides. This choice of designs which require more complex management involving the separation of the most dangerous materials reflects the lack of concern about the terrorist threat.

France's participation in the Forum gives priority to the liquid sodium-cooled fast breeder reactor family. The nuclear industry's objective in this context is to have a prototype put into service in 2020 that would dispel the sense of failure produced by the 1998 closure of the Superphénix breeder reactor, which belonged to this family. This choice, synonymous with a potential worsening of the nuclear system's vulnerability and sensitivity to terrorist threats, shows the French nuclear industry's profound inability to carry out the increasingly urgent updating of its security doctrine.

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69 Commission Particulière du Débat Public on the project of a first EPR at Flamanville, *Rapport de restitution du groupe de travail dit "Accès à l'information"*, February 2006.

70 Known as 'second-generation' reactors, while the reactors developed from these designs, such as the EPR, are referred to as 'third-generation'.

Focus 11 Nuclear reactors as ‘pre-deployed weapons’

“There is no regulatory system in the world that can guarantee that a power station will not be damaged by a crash involving a large aircraft.”

Jérôme Goellner, Assistant Director, DSIN (now ASN), quoted in *Les Échos*, 13 September 2001

To some experts, nuclear reactors appear to be ‘pre-deployed nuclear weapons’. The idea suggests that a successful attack on a nuclear reactor would cause devastation comparable to that unleashed by an actual atomic bomb. In reality, the same instantaneous force as produced by a nuclear explosion would not be liberated, but the impact of the massive contamination that the destruction of a nuclear reactor could cause would be just as great.

Can this vision, chilling as it is, be regarded as realistic? The question was barely asked before 11 September 2001. But the attacks carried out in the United States that day clearly changed everything. The question of nuclear reactors’ degree of resistance to airliner crashes, which people were simply not considering only a few days before, became a major preoccupation over the following period. The debate which developed at that time in France, rapidly stifled by the convenient pretext of “defence secrecy”, brought no reassurance.

In fact, the traditional response to the question of a threat to French reactors – as far as that risk was actually taken into account – lay in the military doctrine of nuclear deterrence, since it was thought that an attack on this scale could only be organised at a military or paramilitary level, with the direct support of a foreign government. The country in question would be laying itself open to the same response – a nuclear strike – as if it had actually aimed an atomic weapon at France. But as soon as it was possible to imagine such an attack being carried out by a group not associated with a foreign government, as 9/11 showed, this doctrine fell apart.

An important consequence of this doctrine had been that any large-scale attack was ruled out of consideration when drawing up the design basis for nuclear installations. This was essentially based on the constraints that could result from accidental external impacts, assessed in terms of probability – since the only malicious acts judged plausible at the time would not have an effect greater than that of the earthquakes or chemical explosions that were taken into account. By this reasoning, only an accidental light aircraft crash seemed probable enough (over one change in a million per reactor per year) to insist that a reactor be designed to withstand it. The impact of such an aircraft bears no resemblance to an airliner crash, particularly when one takes account not only of the collision but of the burning of its fuel.[71]

The ‘plausibility’ of terrorist attacks on nuclear installations using airliners loaded with aviation fuel is unfortunately no longer in doubt, any more than the fact that such an attack could have catastrophic consequences if it succeeded in hitting one of the 58 reactors operating in France (or anywhere else in the world). What is more, reactors are not the only nuclear installations at risk (to say nothing of the fact that other industrial installations could also be targeted). For example, nuclear fuel cycle plants and the various storage and stockpile sites for radioactive material sometimes have a larger radiological inventory than reactors, without enjoying a level of protection equivalent to that provided by a reactor containment building. This is particularly true in the case of the irradiated fuel storage ponds at La Hague, as the debate of autumn 2001 revealed.

[71] The thermal energy that would potentially be released by the burning of between 20,000 and 200,000 litres of aviation fuel (two-thirds of the maximum fuel payload of the Airbus A320 and A380 respectively) is much greater than the 2,300 to 19,000 megajoules of kinetic energy that these aircraft would have (on the basis of their maximum weight and speed).

Today's official response – apart from preventing any public analysis of the situation from developing, by invoking official secrecy – consists of reassuring the public that such an attack would be stopped before it reached its target, thanks to intelligence systems and alert and reaction plans: fighter aircraft would be mobilised to intercept any threatening airliner and shoot it down if necessary, after confirming the threat and going up the chain of command according to an established protocol. All the same, in the case of La Hague, radar-guided surface-to-air missiles were deployed close to the site for a time.

The vulnerability of existing installations and the impossibility of adapting them to a threat that postdates their design create a very difficult situation for the authorities. Any discussion beyond platitudes is impossible. The questions that one might want to ask as to the effectiveness of these preventative measures against an attack like 9/11, or about the possible resistance of installations to other conceivable types of massive attack and about the prevention of these, receive no reply beyond the need for secrecy.

The question is – or should be – framed differently in the case of new installations. One might therefore have thought that new requirements for protection against malicious acts would have been set out, or at least discussed, before new projects were built. Nothing could be further from the truth. The EPR reactor whose construction has been authorised at Flamanville was designed in the 1990s to the standards current at the time. In terms of air crashes, it has merely benefited from Franco-German cooperation to incorporate into the design basis resistance to a military aircraft crash (which was considered more likely in Germany in light of the accident statistics for aircraft from American airbases).

The lessons of 9/11 have not led the authorities to review the design basis requirements. They have been content to ask the operator to carry out studies on resistance to an air crash outside the design basis process, without making this a regulatory obligation. The final results of these studies are not publicly available. EDF states about the EPR that "in consequence of several additional precautions decided after 2001, it is capable of resisting airliner crashes."[72] The constructor of the EPR, Areva, and the authorities do not contradict this. Nevertheless a leaked provisional document, published by numerous sources even though covered by defence confidentiality, seems to suggest that "crashes" does not mean "all crashes", or in other words that in some cases the EPR might not be able to withstand the kinetic shock. Moreover, no information exists regarding evaluation of the combined effect of impact and heat, and still less on the consideration of other design basis threats, even the list of which is secret. Conceived at the end of the 20th century, the EPR does not seem ready to face the dangers of a new century inaugurated by the collapse of the Twin Towers.

[72] EDF, *Débat public 2005/2006, Projet Flamanville 3 – Construction d'une centrale électronucléaire "tête de série EPR" sur le site de Flamanville – Le dossier*, document submitted to the public debate, July 2005.

Focus 12 Transports, a weak link in the nuclear chain

Hundreds, if not thousands of packages of radioactive material criss-cross French territory every day, mostly intended for medical or industrial purposes not involving nuclear power. These numerous journeys do of course pose some security problems, particularly in terms of the risk of misappropriation, since some of them contain sources that could be used in a 'dirty bomb' (combining a conventional explosive device with a radioactive source in order to spread contamination).

But the main security issue with transportation concerns the more significant transfers of radioactive material generated by the nuclear industry, and in particular the transportation of nuclear materials used in fuel (which are the same as those used in nuclear weapons, although usually of a different grade and form). On average, there are over four transports of such materials on France every day.

Each of these carries enough material to qualify, if it were stationary, as an *installation nucléaire de base* (INB – regulated nuclear installation, the French term for a nuclear facility significant enough to require a certain level of regulation). Any vehicle park, railway station or service station where one of these transports stops also effectively becomes an INB, albeit without having any of the protection required by this specific regulatory status. This is the root of the problem: beyond its walls, the nuclear industry needs to put in place protective measures suited to a mobility which by its very nature weakens the traditional mechanisms. For example, the containment barriers are necessarily less thick and the restrictions on public access less controllable than in the case of a fixed site.

Some of these transports are vital to the functioning of the nuclear industry. However, France has made industrial choices which hugely increase the risks, by developing reprocessing and plutonium reuse activity, not only for its domestic purposes but also for foreign clients.

This increase in risk is in the first instance quantitative. The very principle of separating and reusing plutonium implies additional transports between the places where the various stages in this cycle are carried out. The increase is all the greater in that, for other reasons, these locations are spread all around the country – in particular the spent fuel reprocessing and new plutonium-based fuel manufacturing plants, located respectively at La Hague in the North-West and Marcoule[73] in the South-East, and so necessitating a journey right across the country.

The increase can be measured by calculated the total number of kilometres covered by packages of nuclear material containing plutonium, or even the kilometres covered by the tonnages of plutonium involved in the different transport stages (expressed respectively as 'package kilometres' and 'tonne plutonium kilometres' – see Figure 14). By this method it can be estimated that, in a typical year of flows generated by the industry, over 250,000km are covered on French territory by transport packages containing plutonium. In addition to uranium transports further up the fuel cycle, the choices associated with plutonium reuse lead to a trebling in tonne kilometre terms of transports related to the lower part of the cycle, half of it attributable to domestic and half to overseas users.[74]

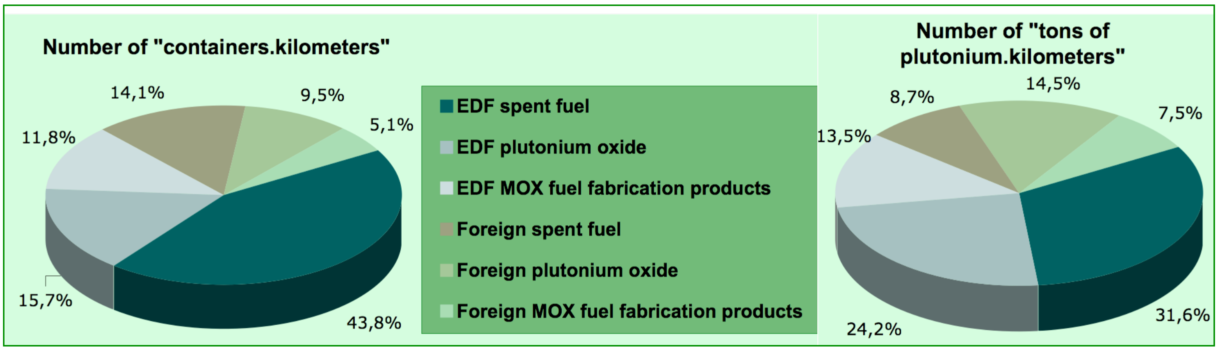
The increase is also – and perhaps above all – qualitative. In accordance with the stages in its reuse, plutonium is transported in forms very different from the one form encountered in the absence of reprocessing. In this instance, plutonium remains included within the matrix of spent fuel in which it was formed. Its reuse entails an initial transport of the separated plutonium to the MOX manufacturing plant, in the form of oxide powder, then a transport of non-irradiated MOX fuel to the power station that is going to use it. Finally, the spent MOX, hotter and more radioactive than conventional spent fuel, is transported to La Hague for storage. These different forms represent an additional sensitivity in terms both of the risk of misappropriation of material and of the potential impact if they were

[73] Two other plants, now closed, used to receive plutonium separated at La Hague: Cadarache, even further to the South-East than Marcoule, and Dessel in Belgium.

[74] These figures, representative of the beginning of the decade, are tending to fall as a result of the halting of massive imports of foreign fuel with the gradual ending of all the big foreign reprocessing contracts.

dispersed. This applies particularly to the first two forms which, in the classification of transported nuclear materials, belong to the best-protected category of non-irradiated nuclear materials.

Figure 14 Total transports[a] linked to the plutonium industry (2003[b])



a. The total level of nuclear material transports in France is here broken down into French and foreign material, and according to the main transport stages after discharging of the fuel (transfer of irradiated fuel to storage, transfer of separated plutonium from reprocessing to the MOX manufacturing plant, transfer of the products of the MOX manufacturing process (including waste from manufacturing). This total is calculated in terms of two scales:
• the estimate in 'package kilometres' corresponds to the total number of kilometres covered by packages of material of each of the categories included
• the estimate in 'tonne plutonium kilometres' relates the distances covered to the quantities of plutonium transported, according to the average content of each category.

b. The estimates presented have been produced by WISE-Paris in terms of a 'standard' year – in other words one representative of the average flows of material associated with EDF's reprocessing services and with foreign customers (before the decline in the latter activity).

Source: Estimates from WISE-Paris, 2003

Moreover, transports of this category of material go by road, unlike the other categories which are generally carried by rail. The idea, in view of the particular threats to which these sensitive transports can be exposed, is to enable greater flexibility in their organisation and to offer possible alternatives in the event of a known threat. Of course, this choice of policy is not a neutral one in terms of the risk of an accident and of the potential for the public to be exposed.

An intense controversy has developed in the last few years around the security of these transports and the associated risks. Greenpeace in particular observed that the transports between La Hague and Marcoule, amounting to one or two transfers of 150kg of plutonium over more than 1,000km every week, were taking place at fixed days and times and following a regular route – to the point that the organisation was able to observe the transports and reconstruct their timetables and itineraries. In 2003, in a spectacular action intended to call attention to this situation, Greenpeace blockaded a lorry carrying this plutonium in the middle of Chalons-sur-Saône, where it was preparing to spend the night in a barracks.

The logic of secrecy dictates that no failing can be acknowledged. The authorities accordingly turned the burden of responsibility on its head: the problem was not that these transports were regular and completely identifiable on the public highway, but that Greenpeace was making this information public. Those in charge of security thus maintained that the system of protection was based above all on intelligence, in the sense that it was precisely when observing the transports to obtain this information on timetables and routes that a malicious group would be spotted. So, they went on, Greenpeace's activity was indeed spotted; conversely, the publication of the information that the organisation had collected would enable a genuine malicious group to prepare an attack without attracting the attention of the intelligence services.

By the same logic, the authorities maintained that the straightforward immobilisation of the lorry did not show any weakness in the onboard protection systems, but on the contrary demonstrated the effectiveness of the decision-making chain, since rapid identification of the nature of the group had enabled certain methods of defence (whose nature is unknown) not to be brought into play. It is true that the Greenpeace activists were wearing visible signs that they belonged to the organisation. But what would happen if actual terrorists adopted a disguise of this sort?

The controversy also extends to the possible consequences of an attack on these transports. In several successive reports since 2003, the independent British and French experts of Large & Associates and WISE-Paris have analysed the risks of a plutonium release in the event of an accident or a malicious act. These studies note that while the IRSN considers “that a transport accident could not cause a rupture in the container” of the type used (FS47) – a point on which they cast doubt elsewhere – the same institute has published test results showing that this container would not withstand the impact of a rocket, a type of weapon plausibly accessible to organised sub-national groups.[75]

It seems relatively clear that actions intended expressly to cause damage, if they succeeded in their goal, could have a major impact on the integrity of the containment and result in significant releases of plutonium powder. Quite apart from the socio-economic impact of contamination, the health consequences could be serious, in view of the acute radiotoxicity of plutonium. Inhaling just a few dozen microgrammes (less than one ten-millionth of the contents of a transport) is enough to trigger lung cancer with certainty. For example, Large & Associates estimate that a zone of 250km^2 could be affected, which in an urban area would represent around 125,000 inhabitants, with some 500 resultant fatal cancers.

More broadly, analysis of the infrequent published explanations of the French approach to the security of nuclear material transports suggests a failure fully to apply the recommendations of the International Atomic Energy Agency (IAEA), even though these recommendations precede 11 September 2001 and there are currently calls for them to be revised. The particular attention aroused by an exceptional transport of 150kg of American military plutonium from La Hague to Cadarache[76] in October 2004 led to a double standard: the visible security measures for this transport, including a heavily reinforced escort and the guarding of all the bridges, tunnels etc on the route, seemed to have nothing in common with the light measures applied every week to the French transports.

However, one anecdote calls into question the seriousness of the highly conspicuous arrangements deployed in this media-friendly context. Parked in order to refuel at a service station previously ‘secured’ by the arrival of armed personnel, the lorry could be seen and approached, with nobody on board, in the midst of the petrol pumps… Besides, the measures deployed for the occasion have remained exceptional: transports of plutonium and other nuclear materials subsequently recommenced in the same form as before. Barricaded behind their defence secrecy, the authorities show no sign of developing their doctrine on the security of these high-risk transports.

[75] The seizures occasionally carried out by the police show that modern weapons, capable of striking a vehicle travelling at 80km/h at a range of several hundred metres, are in circulation in some quarters.

[76] This plutonium was transported for the manufacture in Europe of four MOX fuel assemblages intended to be tested in an American reactor, with the aim of adopting this procedure generally as a means of eliminating the 34 tonnes of military plutonium declared surplus by the USA.

France, a pyromaniac fireman of proliferation

"We've got it in France, why can't they have it in Morocco?"

Nicolas Sarkozy, President of the French Republic, Speech delivered at Marrakech, October 2007

The risk of proliferation, in other words the misappropriation for military purposes of the infrastructure, equipment, technologies and materials of civil nuclear programmes, has not traditionally loomed large in the debates on nuclear power in France. While public opinion and political decision-makers appear, as elsewhere, to be anxious about the risk of escalation in nuclear arms at the global level, for the most part their analyses seem to disconnect this issue from the questions raised by the development of the French nuclear industry.

French nuclear plans: detached from proliferation issues?

In the first place this risk is completely ignored as far as activities in France are concerned. In a country which had a military nuclear programme before embarking on a civil one, the interaction between the two raises few questions. The idea that the nuclear installations operating in France might help the development of nuclear programmes in other countries seems incongruous. For example, it is likely that very few French people know that since 1974 Iran has had, and still has, a 10% share in the Eurodif uranium enrichment plant at Tricastin.[77] What is more, when in the midst of the Iranian enrichment crisis a report on proliferation recalled this state of affairs in detail, it was largely ignored by politicians and the national media.[78]

Likewise, the consequences in terms of proliferation have very rarely been a subject of debate where French nuclear technology export projects are concerned. During the 1970s and 1980s, France showed itself generous in this area. Most of the official and unofficial nuclear-armed countries enjoyed its help. The development of the Israeli nuclear weapon relied on French technology, as did the Iraqi programme which was abandoned after Israel itself destroyed the Osirak reactor, of French origin. The South African programme, too, benefited greatly from French support.

Even the reprocessing of spent fuel, a proliferating technology *par excellence* whose origin is obviously the military need to obtain separated plutonium, raises but little concern. When the Carter administration decided to stop reprocessing in the USA in 1977, because of its proliferating nature, France embarked on a massive programme of commercial reprocessing at La Hague. At the same period, it was not opposition in France, but rather a US veto, which stopped France from delivering a reprocessing plant to Pakistan.

This indifference continues. When in 2007 the economic media announced as the "contract of the century" the draft agreement for Areva to supply two reactors to China, it mentioned the difficulties arising from China's insistence on extending the contract to encompass fuel management, including a reprocessing technology transfer. This news did not create much of a stir, and there was no public follow-up on the refusal announced by Areva – which was perhaps motivated more by commercial than geopolitical logic. Similarly, the nuclear cooperation accords signed by France with India, an officially nuclear-armed country but not a signatory of the Non-Proliferation Treaty (NPT) have attracted very little public attention. India's military programme has clearly been reliant on the diversion of civil cooperation, although it is blacklisted by the international community. The

[77] By way of the Atomic Energy Organisation of Iran's 40% holding in Franco-Iranian consortium Sofidif, which in turn holds 25% of the multinational group Eurodif, whose principal shareholder is Areva. The dividends that Iran has accumulated, estimated at several tens of millions of euros, are frozen in French bank accounts in consequence of the international restrictions linked to the Iranian enrichment programme.

[78] Schneider, M., *The Permanent Nth Country Experiment – Nuclear Weapons Proliferation in a Rapidly Changing World*, Report commissioned by the Greens/EFA group in the European Parliament, March 2007.

cooperation established between France and India in the nuclear field, formalised by a joint declaration in February 2006, has aroused no debate. It has a counterpart in the shape of a draft agreement between India and the USA whose ratification, in comparison, was debated in Congress and more widely for over a year.

Salesman of the French nuclear industry

The President of the French Republic, Nicolas Sarkozy, has willingly put on the mantle of salesman for the French nuclear industry since he came to power in mid-2007. In particular he is pursuing a policy of actively promoting nuclear power, accompanied by the offer of cooperation, in the countries of North Africa and the Middle East, where the aim is above all to maintain influence by offering an alternative to cooperation with the USA.

This posture aroused opinion for the first time when France offered to deliver an EPR reactor to the Libya of Colonel Gaddafi, who was received with great ceremony at the Elysée palace in autumn 2007; a nuclear cooperation agreement was signed between the two countries. But France has also in recent months signed similar agreements with a number of other countries in the region – Algeria, Jordan, Morocco, Tunisia, the United Arab Emirates (UAE) – without giving rise to the same reaction.

On every occasion, these agreements are negotiated without any form of prior debate, and announced as a *fait accompli*. The government, through the mouthpiece of it Foreign Minister Bernard Kouchner, has justified this policy once and for all: "the demands of countries who want to benefit from this clean, inexpensive energy are legitimate." He calls for a "new nuclear era […] synonymous with collective security and shared prosperity"![79]

The President and his government seems to see no connection between their policy of encouraging the development of nuclear power in some of the most unstable parts of the world, and the problem of proliferation. But the revelations about the clandestine network around one of the key individuals in charge of the Pakistani military nuclear programme, the successive crises in North Korea and Iran, and (to some) the breaking of the Indian embargo begun by the United States are seen on the international stage as worrying signals.

The arrangements put in place to prevent the development of military nuclear programmes are being tossed aside one by one. France is wrapping itself in virtue by advocating a strengthening of the guarantees against proliferation around three 'imperatives':

- not to export "any technology to countries which do not respect their obligations" (in the context of the NPT or UN Security Council resolutions)
- to apply to "the exporting of enrichment and reprocessing technologies […] much stricter criteria" than to the exporting of reactors and fuel, and to offer countries access to a "multilateral supply mechanism" (fuel bank) for which France would, of course, be one of the main suppliers
- "only to export non-proliferating, ie light water, reactors" – exactly the main technology that France is offering for export.[80]

Obvious weakness of guarantees

These proposals, not without commercial ulterior motives, display extreme naivety. Many countries have benefited from technology imports (including of French technology) while avoiding their international obligations. Some countries have acquired enrichment technology without officially importing it. Finally, while pressurised water reactor technology has not been diverted to military ends by countries which have chosen more direct means, it is still not intrinsically non-proliferating.

It is precisely the obvious weakness of guarantees of this sort that has led to the present crisis. The international non-proliferation regime appears "on the point of imploding", in the words of Joschka Fischer, the former German Foreign Minister. In this context, the mere fact of suggesting that nuclear

[79] Bernard Kouchner, *Les Echos*, 29 April 2008.
[80] B. Kouchner, *ibid*.

technology can be developed, with no danger and for the benefit of all, in any country that shows itself tractable enough, is tantamount to playing with fire.

The French attitude is all the more open to criticism in that the ‘need’ to resort to nuclear power in the countries concerned is questionable. None of them has the regulatory system, the capacity of expertise and inspection, the qualified personnel, the maintenance infrastructure or even the grid capacity. The ASN, which underlined the importance of this issue in January 2008, estimates that it would take around 15 years to develop the necessary structures to operate a nuclear reactor in a country that was starting from scratch. The French Government has set up an agency, Agence France Nucléaire International, within the Commissariat à l'Énergie Atomique (Atomic Energy Commission) to help the countries concerned to “prepare the institutional, human and technical environment” that they will need.

A reactor such as the EPR, with a power rating of 1,600 MWe, is too large for the needs and the grid capacity of countries whose total installed capacity is currently between 1,900MWe (Jordan) and 6,600MWe (UAE). Jean Syrota, the former president of Cogema, has commented that “other reasons than the desire for efficient and rational management of an electricity system must therefore be found.”[81] These countries undoubtedly have access to other energy options more in keeping with their capacities and needs, and without the same risks.

The real intentions of countries entering into the cooperation proposed by France should therefore be considered with caution. Similarly, the far from negligible potential for political destabilisation in these countries, including the risk of terrorist groups getting hold of sensitive material or equipment, or indeed of hostile political movements gaining control of the installations, must be taken into consideration. By pretending to be unaware of these problems, the French authorities are pursuing an irresponsibly inflammatory policy towards the risk of proliferation.

[81] J. Syrota, “L’avenir du nucléaire civil”, *Politique étrangère*, 2008/1, spring 2008, pp. 161-171.

Focus 13 Plutonium stockpiling, a signal for proliferation

Like every other country that has developed this technology, France became involved in reprocessing irradiated nuclear fuel in order to produce the plutonium necessary to develop a military arsenal. These countries then continued the activity for civil purposes to supply their breeder reactor programmes. While the USA abandoned civil reprocessing in 1976-77 because of the technology's very high risk of proliferation, France embarked on a programme of reprocessing of the fuel from its pressurised water reactors at La Hague, confirmed and extended in the mid-1980s with the launching of a programme to reuse the plutonium separated in the same reactors in the form of MOX fuel.

Large-scale separation of military plutonium began in 1958 and finished between 1991 and 1993, by which time about six tonnes had been produced in total.[82] Allowing for the quantities used up in tests and processing losses, the present stock can be estimated at around five tonnes. The civil nuclear programme brings much bigger quantities into play. The total quantity of civil plutonium stored in France, including all forms, stood at 294.2 tonnes at the end of 2006, according to France's latest official declaration to the IAEA (Table 12). This constantly changing total has probably exceeded 300 tonnes since that date.

This stock includes in particular unprocessed plutonium in the stocks of unreprocessed irradiated fuel, stored to await future reprocessing, and also separated plutonium stored to await reuse. It includes a proportion of plutonium of foreign origin in each category – though this proportion is falling rapidly as the reprocessing contracts with foreign electricity companies gradually come to an end. The most worrying point is the growth in the stock of separated unirradiated plutonium, theoretically awaiting reuse but actually piling up on the shelves. Although the official doctrine, ever since MOX fuel was first introduced into EDF's reactors in 1987, has been to preserve a "balance of flows" between the amounts coming from reprocessing and the amounts being reused, the un-reused stock, which stood at zero at the time, has grown more or less continuously to a total of 52.4 tonnes at the end of 2006. To this must be added a total of 29.7 tonnes of separated plutonium belonging to foreign customers.

The nuclear industry has long allowed this plutonium to build up while rejecting any concerns about the potential military implications of this stockpile. Areva used regularly to state that this plutonium could not be used to make a nuclear weapon, but this relied on semantics: according to the classification introduced by the USA, this plutonium is considered to be of "reactor grade", as opposed to the plutonium known as "weapons grade" used for weapons. The difference lies in the isotopic composition and in particular the level of odd-numbered isotopes responsible for the fission reaction (plutonium 239 and plutonium 241).[83] While this difference means that it is preferable to use the latter, it does not at all imply that it is impossible to use the former.

The IAEA, responsible for non-proliferation inspection on behalf of the UN, has expressed its position on this point very clearly, stating that it considers "any plutonium derived from fuel irradiated at a high burn-up, and of whatever composition except for plutonium containing over 80% of plutonium 238, to be usable in a nuclear weapon".[84] Pressed on this point during the national public debate on nuclear waste management in 2005-06, the directors of Areva admitted for the very first time, in a reply to the experts of Global Chance, that it was technically possible to use the plutonium separated at La Hague for military purposes. Claiming to have "no specific competence in the design or production of nuclear weapons", Areva referred to an article by the former Assistant Director General of the IAEA, Bruno Pellaud, to recall that not one of the more than 2,000 nuclear explosions carried out worldwide since 1945 had used reactor-grade plutonium, while admitting that it "could in principle be

[82] This figure is an average of available estimates which run from 4.3 to 7.8 tonnes.

[83] Plutonium derived from the reprocessing of irradiated fuel from modern reactors is "degraded" by the high burn-up fraction. Weapons-grade plutonium, which contains over 90% of fissile isotopes, is made from fuel that has been only slightly irradiated.

[84] Hans Blix, then Director of the IAEA, in a letter of 1 November 1990 replying to Paul Leventhal, President of the Nuclear Control Institute.

used to produce a bomb but [that] the practical difficulties are considerable".[85] The criticisms advanced over many years have never said otherwise.

The IAEA estimates the "significant amount" of plutonium, in other words the rough amount from which, taking account of the conversion processes, it cannot be technically ruled out that a bomb could be produced, to be 8.5kg. The stock of plutonium stored at La Hague in oxide powder form, which would be the most readily usable for this purpose, is around 50 tonnes, equivalent to nearly 5,900 bombs.

Table 12 Development of stocks of plutonium stored in France (1996-2006)

State of stock (at 31 December of the year)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1. Separated plutonium in the reprocessing plants	43.6	48.4	52.0	55.0	53.7	51.1	48.7	48.6	50.7	49.8	48.6
2. Separated plutonium being manuf./in half-finished products[a]	11.3	12.2	11.8	13.0	14.8	14.1	15.0	13.3	12.7	14.4	12.7
3. Plutonium contained in unirradiated fuel/manuf. products[a]	5.0	6.3	6.8	8.2	9.2	9.9	12.7	13.2	12.8	15.9	19.6
4. Separated plutonium stored in other installations[a]	5.5	5.4	5.3	5.0	5.0	5.4	3.5	3.5	2.3	1.1	1.2
Total unirradiated plutonium stored in France[c]	**65.4**	**72.3**	**75.9**	**81.2**	**82.7**	**80.5**	**79.9**	**78.6**	**78.5**	**81.2**	**82.1**
(i) Of which plutonium belonging to foreign organisations	30.0	33.6	35.6	37.7	38.5	33.5	32.0	30.5	29.7	30.3	29.7
(ii) Plutonium in one of the above forms (1 to 4) abroad	0.2	0.2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Total unirradiated plutonium belonging to France[c]	**35.6**	**38.7**	**40.3**	**43.5**	**44.2**	**47.0**	**46.4**	**48.1**	**48.8**	**50.9**	**52.4**
1. Plutonium in spent fuel/ reactor sites[b]	65.0	66.7	74.9	80.0	82.6	89.4	91.6	94.1	96.4	99.1	94.6
2. Plutonium in spent fuel/ reprocessing plants[b]	88.0	88.8	83.4	79.2	81.3	83.3	89.8	96.5	101.8	105.9	110.9
3. Plutonium in spent fuel/ other sites[b]	0.0	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	6.6
Total plutonium stored in spent fuel in France[c]	**153.0**	**156.0**	**158.8**	**159.8**	**164.4**	**173.2**	**181.9**	**191.1**	**198.7**	**205.5**	**212.1**
Total stored plutonium (irradiated and unirradiated)[c]	**218.4**	**231.1**	**234.7**	**241.0**	**247.1**	**253.7**	**261.8**	**269.7**	**277.2**	**286.7**	**294.2**

a. Rows 2 and 3 essentially correspond respectively to the plutonium held in the manufacturing plants and the power stations (other than in the reactors); row 4 includes plutonium separated for research purposes.

b. Rows 1, 2 and 3 essentially correspond respectively to the plutonium in discharged fuel still at power station sites, transferred to a reprocessing plant, and stored in research facilities.

c. Totals calculated by WISE-Paris, not given in the official declarations.

Sources: 1994–95 – French Secretary of Industry, 1997 ; 1996–2006 – declarations to the IAEA (InfCirc), 1997–2008

85 Response to the questions of independent experts in the context of the Groupe de Travail sur l'Accès à l'Information (working group on access to information), reproduced in the report on the work of this group, *op.cit*.

In the first instance, the size of the stocks and of the plutonium flows resulting from the adoption of reprocessing and MOX presents a direct risk of proliferation associated with the danger of diversion. The misappropriation of only a thousandth of the quantities handled in a year by the reprocessing plant at La Hague and the MOX fuel manufacturing plant at Marcoule would give the perpetrators more than this 'significant amount'. The authorities have provided no details as to the accuracy of the flow measurements in these plants, that would enable us to know whether such a misappropriation would be detected, or after how long. Various precedents worldwide, and even in France (namely the inventory of the former ATPu MOX plant at Cadarache), have shown that "materials unaccounted for" (the discrepancies noted in the account of material coming in and going out) can reach this order of magnitude. On each occasion, the explanation given blames an accounting error or an undetected technical accumulation during some stage of the process. Nevertheless, when questioned as part of the 2005–06 public debate, the director of the department responsible for this monitoring within the IRSN stated that if a genuine loss was ever detected, this information would not be made public.

Beyond this direct risk, the stockpiling of 'civil' separated plutonium sets a very bad example internationally. The national electricity provider EDF, which legitimises a nonetheless technically and economically questionable reprocessing policy, bears a large share of the responsibility for this. The operator is undoubtedly the foremost producer of separated plutonium in the world today, and holds a stock of 26 tonnes, or over 3,000 times the 'significant quantity', stored in oxide powder form at the La Hague site. By completely covering up this aspect of proliferation in France, while promoting the extension of reprocessing internationally, the French authorities and nuclear industry are sending out an extremely dangerous signal on the international stage.