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Briefing

RADIOACTIVE MATERIALS TRANSPORTED BY PLANE
The FedEx Package Accident: Highlighting the Lack of Controls for the Transport of Radioactive Materials

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Briefing FED1

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RADIOACTIVE MATERIALS TRANSPORTED BY PLANE
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1. Summary

A shipment containing radioactive sources sent from Sweden via Paris, arrived in the United States on 2 January 2002 with a leakage of radiation, most likely since its departure. At least two employees of the transporting company were exposed to doses exceeding largely the annual regulatory limit –one by a factor of 100 !- poses several questions as to the actual impact and consequences of this "leakage".

The chronology of this incident unveils an unacceptable situation in which millions of packages containing radioactive materials are transported throughout the world without efficient control, without appropriate radio-protection measures for employees and without protection guarantees for the public nor guarantees against their use by terrorists for the construction of "dirty bombs".

In its analysis of the incident, the French safety authority wrote on 9 January 2002: *"the public was not exposed"*. On 20 March 2002, its Director, Mr. Lacoste, answering a question put by WISE-Paris, affirmed: *"When the package arrived to Paris, it was in no way harmful nor dangerous"*.

However, according to the Safety authority's press communiqué released a few weeks later (2 May 2002), blood tests undertaken on two employees of the transporter, Federal Express (FedEx), revealed that one of them received a dose of 15 mSv (15 times higher than the 1 mSv legal annual limit for the public). One can only express astonishment at the delayed communication of this information, which was made available by the laboratory on 25 January 2002. Further, the dose level found by the laboratory was 30 mSv. The Safety authority, unilaterally and without further explanation, took the decision to revise downward this figure, estimating arbitrarily that half of the measured dose was due to preceding exposures.

A new communiqué from the French nuclear safety authority, dated 25 June 2002, six months after the incident took place, announced that a second FedEx employee had been exposed to 100 mSv, 100 times the annual limit set by regulation.

The B-type package contained 1,000 pellets of iridium-192 with a total activity of 366 TeraBequerels (or TBq), destined for industrial radiography use. Two means of transport were used, road and air, to carry the package from Sweden to its final destination in New Orleans. Following the opening of the internal containment of the package it began to leak significantly.

While the investigation permitted to show that the shipper was at fault in packaging the radioactive material, the question of the scope of the radiological impact on the workers and the public has not yet been resolved. Although at its departure no radiation leakage was detected –which doesn't definitely exclude a non-detected leakage– the lack of control around the package at different points of the route and especially during road transportation , and the absence of obligation for the transport personnel to wear dosimeters, prevented the detection of the leakage, which could have started in Paris. The leakage could have been much greater than the competent authorities have disclosed.

This incident revealed a failure in the notification system between the different national safety authorities, which may have considerably hindered the implementation of stricter procedures in the event of a more serious situation. Information between the authorities of the United States, France and Sweden took –to say the least- very strange routes. Despite the obligation of notification and the importance of a rapid response in the case of an incident or accident, no efficient system of permanent follow-up seems to be in place to deal with such situations, at least in France.

Finally, failures in the system of detection have fueled concerns linked to terrorist threats. Concerned about the lack of control revealed by this incident and the potential use of radioactive sources for the construction of radiological bombs by terrorists, Edward J. Markey, Member of the US Congress, and Hilary Clinton, Member of the Senate, drafted a bill at the end of June 2002 called "Dirty Bomb Prevention Act".

2. The transport of radioactive materials

Either for use in industry or for the medical and scientific sector, radioactive materials travel around the world every day. Although it represents only 2% of the transport of dangerous materials, the number of radioactive packages transported throughout the world every year is now 10 million[1].

Annually, more than 300,000 packages containing radioactive materials are transported in France, by road, rail, air or sea. The annual traffic by road was estimated in 1998 at *"5 million vehicles-kilometers (10,000 transports per year over an average distance of 500 km), transport by rail at 0.6 million wagons-kilometers (1,200 wagons, 500 km), transport by air at 2 million planes-kilometers (1,000 planes, 2,000 km) and transport by sea at 1.5 million ships-kilometers (300 ships, 5,000 km)."*[2]

The transport of radioactive materials is governed by specific regulations (***Annex 1***) that take into account the transport mode and the activity transported in the container. There are five categories of regulated packages according to thresholds and depending on the total activity of the package and the specific activity.

Given the above-mentioned statistics, *"for the French traffic, one may in theory expect a serious accident per annum involving a transport of radioactive materials by road, once every thirty years for rail transport, less than one for air transport, and once every eight years for sea transport"*[3]. This probabilistic approach of the transport accident risk is not reflected in the yearly statistics on incidents, which concern safety-related failures.

In 2000, the French nuclear safety authority[4] counted *"48 incidents or accidents"*[5], representing a slight decrease compared to 1999, after marked increases in 1997 and 1998 (***Annex 2***). Among these incidents, 18 were classified level 1 of the INES scale (graduated from 0 to 7) and concerned transports in the medical, scientific and industrial fields[6]. Although the use of air transport represents 31% of total traffic for material sources, as against 62% for road traffic (***Annex 2***), the incidents classified INES 1 for air transport are 8 against 5 by road. There were in particular numerous incidents linked to the handling of containers in the air transport (***Annex 3***). However, in the detailed figures published by the nuclear safety authority on the 1999 inspections, it appears that airports were controlled 4 times out of the 64 controls[7].

3. The "FedEx" incident

3.1. Chronology of the incident

The chronology and transport route, from Sweden to the USA, via France, are summed up in the figure presented in ***Annex 4***.

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1 IPSN, *Le transport des matières radioactives*, 2001.
2 IPSN, *Le transport des matières radioactives en France, les incidents et accidents*, January 1998.
3 Idem.
4 The control and expertise in terms of nuclear safety and radio-protection are governed in France by two decrees of 22 February 2002. The newly-created authority, the DGSNR (Direction générale de la sûreté nucléaire et de la radioprotection) and the supporting expertise body, the IRSN (Institut de radioprotection et de sûreté nucléaire) are the fruit of the restructuring within the DSIN (Direction de la sûreté des installations nucléaires), the IPSN (Institut de protection et de sûreté nucléaire) and OPRI (Office pour la protection contre les rayonnements ionisants).
5 DSIN, *Rapport annuel*, 2000.
6 WISE-Paris estimates, based on the DGSNR's figures, for 2000.
7 DSIN, *Rapport annuel,* 1999.

• *Departure from Sweden*

Specializing in nuclear and medical products, the Swedish company Studsvik Nuclear AB sent a package containing iridium-192, on 27 December 2001, to its client the US Source Production and Equipment Company, (SPEC). The type of container used in such a transport is presented in Annex 5.

The B-type container, called SAFKEG, was constructed by the UK company Croft, and approved by the British and American authorities. It *"contained 1,000 pellets of iridium-192 (...) of a total activity of 366 TBq*[8]*, meant for industrial use of radiography type. The pellets were contained in three capsules, put in an iron envelope. The capsules were disposed in a uranium cylinder, the radiological protection."*[9] This was put in a steel container, in the form of a barrel of 0.43 m by 0.54 m. The package was transported lying on its side, attached on a wooden pallet with a pair of hoops.

For Studsvik, it was a routine shipment, one of 500 other packages shipped or received yearly[10]. Nevertheless, the Swedish authorities had already spotted failures in safety procedures on the company's site. As a consequence, in December 2001, a few days before the incident in question, the authorities had a meeting with the management of the company concerning infringements of handling regulations on site[11]. Also, in its 8 February 2002 press release, Studsvik has discreetly revealed that *"a similar incident occurred in an earlier shipment, but without increased radiation being detected"*.[12]

The day the package was shipped, one person was in charge of controlling the handling as a matter of fact entrusted to two employees *"at the most"**** *explain]*. Only these two employees were in contact with the container[13]. According to the Swedish authority, Statens strålskyddsinstitut (SSI), the package did not show *"irregularities"*[14] before it left Studsvik. This assertion was confirmed by Studsvik, as they say that the buildings are equipped with *"several dosimeters",* which would have *"reacted"* in the case of a leakage[15].

The two drivers in charge of transporting the package by road from Studsvik to Arlanda via Norrköping, over 4 hours, were not equipped with dosimeters; a deficiency Sweden has called for it to be decided internationally[16].

Stored for two days at the Arlanda Airport near Stockholm, the package was then loaded onto a plane to Paris from where it was to be transported to Memphis, USA. The transport by air from Sweden to the Memphis airport, via Paris was entrusted to Federal Express (FedEx), who were also in charge of the transport by road to New Orleans.

• *Transit via Paris*

When it arrived at the Roissy Charles-de-Gaulle Airport at *"5 pm",* on 29 December 2001, the package was downloaded and remained *"in the storage area about 5 hours",* before it was again loaded in a plane[17]. FedEx declared that it undertook *"measurements when the container was loaded, between the pilots' cabin and in the deck"*, but no high level of radioactivity was detected.[18]

The pilots had dosimeters that showed no abnormal doses. But the distance separating the package from the cabin as well as other packages in the plane may have prevented the dosimeters from recording the radiation leakage.

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[8] Terabecquerels (1 TBq = 10^{12} Bq).

[9] *Institut de protection et de sûreté nucléaire* (IPSN), press release, 10 January 2002. Most of the press releases can be found in ***Annex 6***.

[10] Studsvik, telephone interview, 14 January 2002.

[11] *Nucleonics Week*, 18 July 2002.

[12] Studsvik, press release, 8 February 2002.

[13] Studsvik, telephone interview, 14 January 2002.

[14] Statens strålskyddsinstitut (SSI), press release, 10 January 2002.

[15] Studsvik, telephone interview, 14 January 2002.

[16] Lars-Erik Holm, Director of the SSI, in *Nucleonics Week*, 18 July 2002.

[17] Jaques Aguilar, DSIN, telephone interview, 10 January 2002.

[18] Idem.

Given the fact that the packages were not controlled individually in the plane and that the FedEx employees at the airport are not equipped with dosimeters, the package could have presented a radiation leakage in Paris without being detected, as the French nuclear safety authority seemed to have explained to its Swedish counterpart[19]. In other words, none of the control systems put in place could permit to conclude to the dangerous nature of the container during its transit at the Paris airport.

• *Arrival to the United States*

Following its arrival to the Memphis airport, the package was transported in a truck over a distance of 660 kilometers to New Orleans, where on 2 January 2002, SPEC, the consignee of the package, sent an employee to fetch it. During a control, the employee discovered that his control instrument was *"stuck"*[20].

Believing that the instrument was malfunctioning, he took the container without further control. Once at SPEC, a radiation leakage, with no radioactive material flowing out, was *"localized at the level of the upper lid of the container: with a dose flow of 10 millisiverts per hour (mSv/h) measured at 6.5 m of one of the sides of the package"*[21]. *"The transport regulation authorizes a maximum dose flow for such type of containers of no more than 2 mSv/h on the surface of the container and 0.1 mSv/h at 1 meter distance"*. The container was immediately isolated.

On 4 January 2002, the SSI revoked the radioactive material transport license granted to Studsvik. This was limited a few days later to type-B containers, then in February to iridium-192.

On 7 January 2002, the SSI[22] classified the incident at level 3 on the INES scale.

On 8 January 2002, FedEx declared that they *"examined all of the persons likely to have been concerned in Sweden, France and USA"*, but no case of contamination was reported.

On 7 February 2002, SPEC opened the package in order to determine the causes of the incident to discover finally that the lids of two capsules containing the iridium (***Annex 6***) inside the container were open, letting the content to flow out of the first confinement barrier[23]. FedEx representatives, and of course the US authorities were present, as well as the Swedish authorities; but French authorities were not represented.

3.2. French management of the incident: one priority, to minimize

• *First reflex: reassure?*

The French safety authority, the *Direction générale de la sûreté nucléaire et de la radioprotection* (DGSNR, which replaced the *Direction de la sûreté des installations nucléaires*, or DSIN), affirmed that it was notified of the incident on 7 January 2002 –that is 9 days after the package arrived at Paris. Due to the holiday period there were many more passengers than normal. The DSIN organized on 9 January 2002, in collaboration with the Civil Aviation Division (Direction générale de l'aviation civile (DGAC)) and the Office in charge of the protection against ionizing radiation (Office de protection contre les rayonnement ionisants (OPRI)), *"an inspection at the FedEx site at the Roissy airport"*[24].

In the inspection follow-up letter[25] from 24 January 2002 to the safety director of the FedEx European sorting center, the DSIN affirmed: *"while waiting for complementary elements on the expertise for the*

[19] SSI, Press release, 10 January 2002.
[20] Nuclear Regulatory Commission (NRC), preliminary notification, 3 January 2002.
[21] IPSN, press release, 10 January 2002.
[22] SSI, press release, 7 January 2002.
[23] NRC, preliminary notification, 8 Fevruary 2002.
[24] DSIN, Press release, 9 January 2002.
[25] Letter from J. Aguilar, in charge of the Sub-direction « fuel cycle, transport », DGSNR, to the Director of Federal Express International, European sorting center, Safety Department. DSIN/SD1/0059/02, 24 January 2002.

concerned package, the analysis of all of the data gathered permits, according to OPRI's analysis, to confirm that the FedEx personnel at Roissy could not have been exposed to an efficient dose exceeding a few millisiverts (a few dozens of millisieverts in the worst cases)".

Although the safety authority found out that it was impossible to give a more precise estimation due to a lack of control devices, the letter indicated: *"Corrective actions required: None"*. Concerning the dosimetry evaluation carried out by FedEx, the DSIN asked the company to *"complete"* it and to transmit the conclusions, without referring to the necessity of additional tests.

• *Confirmation of the hypothesis of a faulty handling*

On 10 January 2002, the Institute for nuclear protection and safety (Institut de protection et de sûreté nucléaire (IPSN)) put forward the hypothesis of movements of the *"internal structures"* that might have caused the radiation leakage[26]. Neither did OPRI exclude *"a faulty handling"* from the beginning nor even *"a handling incident"*[27].

On 7 February 2002, in the presence of representatives of Studsvik and SSI, SPEC opened the package to determine the causes of the incident. They discovered that the lids of two of the capsules containing the iridium (***Annex 2***) inside the container, were open, letting their content flow out of the first confinement barrier[28].

The position of the container, lying on its side, which is normal according to both the shipper[29] and the constructor[30], transformed it into a gun creating a radiation beam. Further, the vibrations and movement during handling, are likely to have accelerated and aggravated the dispersion of the pellets out of the confinement barrier.

In its 8 February 2002 communiqué, Studsvik admitted a *"faulty handling of the radioactive material, due to the fact that the inner containers for the shipment from Studsvik were not sealed in the proper manner"*[31]. This reinforced the hypothesis that the radiation leakage began early in the transport route, particularly before its arrival to Paris.

• *Delays, deficiencies… and manipulated figures?*

On 20 March 2002, during the presentation of the annual report of the Nuclear safety authority, M. Lacoste, General Director of the DGSNR, answering a question put by WISE-Paris, firmly confirmed: *"at the moment the package arrived to Paris, it was in no way harmful or dangerous"*. The person in charge of transport at the DGSNR, Mr. Aguilar, explained –without giving details- that according to the information from the USA, the problem of the radiation leakage started during the final phase of the transport, on the American territory.

First turn of events, a DGSNR communiqué dated 2 May 2002, indicating that the blood tests undertaken on the FedEx agents showed *"that the dose received would be of the order of 15 millisievert and that the package had a failure when it passed the Roissy Airport"*[32].

The tests were undertaken by the IRSN analysis laboratory, which takes about 20 biological tests yearly. Questioned on the 15 mSv dose announced by the DGSNR, Mr. Voisin, who is in charge of the laboratory, declared to WISE-Paris: *"those were not our figures",* the results obtained *"don't correspond to the data made public*"[33]. He nevertheless refused to give the laboratory's results, in the name of the medical secrecy.

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[26] IPSN, press release, 10 January 2002.
[27] Jean-François Lacronique, OPRI, telephone interview, 9 January 2002.
[28] NRC, preliminary notification, 8 February 2002.
[29] Studsvik, telephone interview, 14 January 2002.
[30] Croft, telephone interview, 28 February 2002.
[31] Studsvik, press release, 8 February 2002.
[32] DSIN, press release, 2 May 2002.
[33] Mr. Voisin, Head of laboratory, IRSN, telephone interview, 2 May 2002.

But he confirmed that for the doses recorded by such tests, *"one can't get as low as 15 mSv"* (i.e. this value is too low to be revealed) and that *"dosimetry will still have a long way to go before"* one can do it.

Philippe Saint-Raymond, Assistant General Director of the DGSNR, declared to WISE-Paris that the dose identified by the IRSN lab was 30 mSv. The difference can be explained according to him by the fact that it is possible to reconstitute the dose that is attributed to the incident of the Swedish package according to different characteristics of the chromosome[34]. In other words, the cell would have kept a visible print of the date and origin of the exposure. This can be imagined in theory, but, at doses that are already hardly adequate, to say the least, such a precise analysis appears to be excluded.

When asked to explain this difference, Michel Bourgignon, other Assistant General Director of the DGSNR and former OPRI director, declared to WISE-Paris that he had no time –because it would have taken him *"at least one hour"*- to explain how it is possible to determine in the calculated dose of a blood test the share contribution of the FedEx incident[35].

It appears that the Safety authority has concluded, from its own calculations based on its January inspection in Roissy, that members of the personnel of FedEx in the airport could receive up to 13.9 mSv per year, even if there is no deficient package. However, the method of analysis and the precision of the estimate have not been explained.

The 15 mSv dose reconstituted by the Safety authority is 15 times as high as the annual limit of the exposition for the public, which is 1 mSv, applicable to the FedEx employees. But it presents the advantage of remaining below the annual exposition limit for the nuclear industry workers, 20 mSv. Yet by applying such calculation, the DGSNR did not explain what caused the remaining 15 mSv dose (the other half of the dose that is not due to the FedEx package).

The 2 May 2002 communiqué does not specify when these test were undertaken that led to these results. It indicated however that given the results *"the Nuclear safety authority asked FedEx to proceed to additional medical tests on the members of its personnel"*. However, in the beginning, FedEx was supposed to have undertaken tests on *"all of the persons likely to have been involved in Sweden, France and the USA"*[36].

When asked, the same day, by WISE-Paris, the Safety authority declared that the test had been conducted in January at FedEx initiative[37]. According to the authority, it is not before the evening of 30 April that it was informed of the test results. However, the method of biologic dosimetry involved only takes two or three weeks: communicated or not, the results were in theory available as soon as February.

• *The late discovery of a second victim*

Six weeks after the first announcement, a second turn of events: a DGSNR communiqué, dated 25 June 2002, revealed, nearly six months after the incident, that a second FedEx employee, who does not seem to have been tested originally –for unknown reasons–, was exposed to a dose of the order of 100 mSv, that is 100 times above the limit for a member of the public.

The communiqué presented these results as stemming from *"additional tests on other employees of the company"* already referred to on the 2 May press release. However, when WISE-Paris asked the DGSNR when the tests were required from FedEx, it answered *"14 May"*[38]. Moreover, WISE-Paris asked whether *"other tests of biological dosimetry [were] under way"* and *"if yes, what personnel and how many persons [were] concerned"*. The DGSNR answered simply that *"other tests were required"*. As of mid-October, there had been no release of information on these additional tests and

[34] Philippe Saint Raymond, Assistant Director, DGSNR, telephone interview, 17 May 2002
[35] Michel Bourgignon, Assistant Director, DGSNR, telephone interview, 21 May 2002
[36] IPSN, press release, 10 January 2002.
[37] Olivia Penichou, spokeswoman, DGSNR, telephone interview, 2 May 2002.
[38] Exchange of emails between WISE-Paris and Olivia Penichou, DGSNR spokeswoman; questions addressed by WISE-Paris on 26 June 2002, answers by DGNSR on 1 July 2002. See ***Annex 7***.

their results. However, Dr. Gourmelon, from IRSN, declared in August that no unusually high dose had been found in the results of these tests.[39]

To the question put forward by WISE-Paris on the *"function and post of the FedEx employee"* having been exposed to 100 mSv, the DGSNR indicated, with no further details, that he *"worked on the package loading platform (between the storage area and the plane)"*[40]. This means that the exposition time of the employee was very short.

In these conditions, it seems impossible to exclude that other people were exposed to significant levels, in particular during the transport by truck in the USA.

WISE-Paris also asked the DGSNR whether *"clever calculations"* were applied – those which, in the first case, permitted to get from 30 mSv to 15 mSv- or whether the 100 mSv figure was the measured dose of the laboratory. According to the DGSNR, *"the dose corresponds to the results of the laboratory"*[41]. No further explanation was given to justify the application of two different methods to the two concerned cases.

• *Minimization of the consequences in France and Sweden*

Although they came late, the investigations conducted in France resulted in the discovery of two cases of irradiation well above public protection limits. Also, the French Safety authority concluded – without questioning this worrying situation– that FedEx employees could receive more than 13 times the yearly dose limit, even in normal operation!

The French authorities have globally kept a very reassuring attitude all along, even, as it appears, towards the concerned personnels. In a 25 June 2002 declaration, FedEx claimed: *"the French authorities' conclusions regarding the blood tests continue to support our contention that the levels of exposure connected with this shiment pose no health risks to our employees. These were the conclusions stated by a representative of the (DGSNR) to two employees tested during a CHCST meeting yesterday"*.[42]

SSI announced as soon as 10 January 2002 that *"blood samples taken the 8th of January from 15 persons who have been in contact with the package have been analysed and show normal values"*.[43] The tests conducted, which produce quick results, are of the same type that the first tests in France, which were used by the French authorities to conclude in the absence of leakage in Paris.

Curiously enough, despite the French developments of the case, highlighting the usefulness of more detailed blood tests, the Swedish safety authority did not see it necessary to require other blood tests on the Swedish workers who handled the container. The Director of the SSI, Lars-Erik Holm, declared on 25 June, while confirming that he was aware of the latest results in France: *"This really doesn't change anything in Sweden. The leakage could have started here, but we have no evidence of that"*.[44]

Mr. Holm, went so far as to explain that more investigations would unnecessarily worry the persons concerned[45] and declared himself satisfied with the blood tests undertaken on the Swedish employees, even if they were not as complete.

[39] *Nucleonics Week*, 22 August 2002.
[40] Idem.
[41] Exchange of emails between WISE-Paris and DGSNR, op. cit.
[42] *Nucleonics Week*, 27 June 2002.
[43] SSI, press release, 10 January 2002.
[44] *Nucleonics Week*, 27 June 2002.
[45] *Nucleonics Week*, 18 July 2002.

4. Failures in control

4.1. Lack of measures around the package

On 7 January 2002, the SSI, by classifying this incident at level 3 of the INES scale, in fact added that it implied that *"acute radiation health effects [could] not be ruled out"*[46].

Although it was not detected earlier on the transport route of the package (***Annex 5***), it is now established that a radiation leakage existed before it arrived at the Roissy Charles-de-Gaulle airport and that the FedEx workers were exposed to doses exceeding largely the annual exposition limit for the public near nuclear facilities, fixed at 1 mSv in Europe.

In reality, this result was predictable. In fact, Studsvik recognized its responsibility in the incident and explained that the opening of the package showed a faulty handling from the very beginning[47]. The bad conditioning was the cause of the radiation leakage, which started at least during the transit in Paris. Yet, the lack of control by the transporting company meant they failed to detect this leakage.

The absence of customs control at the borders is also to blame. For instance, nowhere is it required in the US regulation that radiation detectors are placed in airports. The fact that only 4,000 customs officers in the USA are equipped with dosimeters and that controls are not systematic, implies that there was little chance that the radiation leakage could be detected, at least at its arrival in the USA[48]..

This failure is also that of the principles used as guidelines for the control of the transportation. For instance, according to the International Atomic Energy Agency (IAEA) requirements, the suspicion of a leakage must normally lead to the limitation of the access to the package and the undertaking of the evaluation of "*the scope of the contamination and the intensity of radiation"*[49]. As the Agency adds, *"damaged containers or those with radioactive leakage exceeding the permitted limits for normal transport conditions can be transferred provisionally to an acceptable area under control, but must not be transported as long as they are not fixed or put back in their original state and decontaminated"*.

In the case of a leakage of radioactive material from a container, the evaluation of the contamination is not limited to the package only; it also concerns the transport means, loading and unloading areas and consequently the storage areas, even other packages that could have been in contact with the container. These measures are meant to protect the persons and environment and reduce *"the least possible the consequences of the leakage and the damage"*[50].

The type of protection measures described above would not be implemented when a package is apparently intact. That is why visual control alone reveals largely unsufficient, and a real radiological control, all along the transportation, is necessary to spot packages which pose an invisible danger, as the iridium-192 package transported by FedEx.

4.2. Limits of the safety authority's control

The protection of persons, goods and the environment against the effects of radiation during the transportation of radioactive materials, is ensured by confining the radioactive content and controlling the external radiation.

The DGSNR has been responsible since 12 June 1997 for the safety of the transport of radioactive materials for civil use and the control of the implementation of the related regulation. In 1999, 45 controls out of the scheduled 64 concerned the shippers, considered as the first responsible party for the safety of the containers, while 4 controls only were organized at the level of the airports.

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[46] SSI, press release, 7 January 2002.
[47] Studsvik, press release, 8 February 2002.
[48] NRC, answer to Ed Markey, 19 February 2002.
[49] IAEA, *Règlement de transport des matières radioactives*, 1996 French Edition, Prescription N° ST-1 (translation by WISE-Paris).
[50] IAEA, op. cit.

The controls of the transport entrusted to specialist companies such as FedEx, are planned through inspections organized in cooperation with the *Directions Régionales de l'Industrie, de la Recherche et de l'Environnement* (DRIRE). Concerning the DGSNR, these inspections are limited to the handling and its conformity to safety regulations. Hence, the DGSNR does not control packages containing radioactive materials and in the case of *"extraterritorial air transport, there is no control at all"*[51].

The IPSN explains however that *"the transit of such packages in a French storage area requires the notification of approval certificates used by the competent authorities of the concerned countries, in France the Direction de la Sûreté des Installations Nucléaires (DSIN). Such a notification must include the description of the 'inner structures' of the container, guaranteeing the radiological protection"*[52]. In other terms, the control –if one may call it so- for such transports is limited to a simple notification.

Further, in this particular case, the type of container used, was approved by the USA and the UK, but there doesn't seem to be any approval issued by the French authorities.

Repeating transportation incidents involving radioactive packages in Paris airports indicate a level of safety and radioprotection that is all but satisfying. One more accident, on 17 August 2002, when a portion of service road was contaminated after a package of Iodine-131, fallen from a truck was crashed by other vehicles, raised even more questions about the management of such an event. Jean-Luc Pasquier, head of the IRSN Vesinet site, declared this accumulation of accidents demonstrates "there's a dysfunction in transfer of radioactive materials at Roissy".[53]

4.3. Security and safety: the lessons to be drawn

• *Reinforcing safety and radioprotection controls*

Beyond the limitations of transport, definitely levied on 25 April 2002[54], and the legal action introduced by the SSI against Studsvik for infringement of regulation –procedure also envisaged by the US Department of Transport, Sweden intends to reinforce the inspection of the transport of radioactive materials. The General Director of the SSI, Lars-Erik Holm, explained that *"given the number of transports, it is possible that it happens again soon"*[55]. In fact, about 100,000 containers with more or less dangerous materials go through Sweden every year, most of them stored near highly populated areas of Stockholm.

According to Mr. Holm, wearing of dosimeters for road transports should be agreed internationally in order to control the levels of radioactivity constantly on the packages.

The fact that the radiation leakage remained undetected at any moment of the route, shows clearly that the exiting measures are not appropriate for this type of package remains intact in appearance. In fact, *"no incident was signaled during the transportation of the package, which seemed intact by looking at its exterior"*[56], As a consequence, a more efficient protection would undoubtedly be brought by the wearing of dosimeters for employees in charge of this kind of transportation. WISE-Paris asked the DGSNR, on June 26, whether *"the FedEx employees concerned (...) are now equipped with dosimeters"*. The DGSNR affirms that *"yes, or are about to be equipped with dosimeters. This is part of the radio-protection program"*[57].

It is to be noted that the FedEx workers are not considered as workers under radiation but must *"undergo an appropriate training concerning the radiological risks and the precautions to take to limit their exposition and that of other persons that may be exposed to the effects of their actions"*[58].

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[51] Jean-François Lacronique, OPRI, telephone interview, 9 January 2002.
[52] IPSN, press release, 10 January 2002.
[53] *Nucleonics Week*, 22 August 2002.
[54] Studsvik, press release, www.studsvik.se, 25 April 2002.
[55] *Nucleonics Week*, 18 July 2002.
[56] IPSN, press release, 10 January 2002.
[57] Exchange of emails between WISE-Paris and DGNSR, op. cit.
[58] IAEA, op. cit.

The training lasts about one week for the handling and is supposed to teach the employees the basic actions for packages labeled *"radioactive materials"*. But the *"forty hour"* -training program[59] prescribed for employees of a transporting company such as FedEx, as complete as it could be, could not help them detect a radiation leakage invisible to the human eye, without the use of an adequate radiometry and dosimetry apparatus.

• *Trans-border transport and nuclear security*

Reacting to the 2 January 2002 package incident, Ed Markey, Member of the US Congress, addressed a letter to the American nuclear safety authority, the NRC, to the customs services, and to the main international freight transport companies in the USA, among which FedEx, requiring explanations especially regarding the circumstances of the incident and the eventual radiological consequences.

The NRC and FedEx's answers revealed among other things, serious failures in the system of control of the safety of radioactive materials. However, as FedEx insisted upon[60], the control measures that it has implemented –although they appear sadly unsufficient in the light of the Iridium package incident– are in many cases set beyond the regulations' requirements.

They also unveiled imperfections in the regulations to prevent the expedition of nuclear materials by terrorists [61].

Exports and imports of packages transported by freight transport companies such as FedEx are not systematically submitted to controls by the customs services[62]. Under these conditions, non-authorized imports of nuclear materials cannot be excluded.

Contrary to FedEx's statement according to which it does not accept packages of radioactive materials from *"unknown shippers"*[63], fraudulent traffic is in theory possible. It is one of the reasons that led the Nuclear Regulatory Commission (NRC) to plan *"additional security measures"*[64].

Judging the situation unacceptable, Ed Markey, and Hilary Clinton, Member of the Senate, drafted a bill at the end of June 2002, called Dirty Bomb Prevention Act[65]. The initiative aims at creating a *"task force"* meant to elaborate and implement a control methodology, for the follow up, recovery and storage of radioactive sources. Audits and inspections would be made and the physical protection increased. The basis of a new efficient control system would be a mechanism of consignment for each user of radioactive sources[66].

5. Radiological impact

5.1. The danger of the transport of radioactive materials

The transport of radioactive materials presents a risk of ionizing radiation exposure for people. In fact, the process of energy transmission of radioactive sources, in an electromagnetic form or in the form of particules, display directly or indirectly ions capable of going through matter. The cells of living tissues undergo injuries that may lead to serious biological consequences.

The radiological risk implies therefore the implementation of a set of measures of safety and radio-protection applied by the competent authorities, in order to prevent accidents and limit the impact on the workers and population.

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[59] Jean-François Lacronique, OPRI, telephone interview, 29 January 2002.
[60] FedEx, answer to Ed Markey, 31 January 2002.
[61] Ed Markey, 5 March 2002, www.house.gov/markey.
[62] NRC, answer to Ed Markey, 19 February 2002.
[63] FedEx, answer to Ed Markey, 31 January 2002.
[64] NRC, answer to Ed Markey, 19 February 2002
[65] Draft bill available at : http://www.house.gov/markey/iss_nuclear_bill020626.pdf
[66] Ed Markey, press release, 26 June 2002

As a consequence, the IAEA prescribes decreased limits to the exposure to ionizing radiation resulting from the nuclear activity linked to the transport of packages. These limits must not exceed 1 mSv/year for the public and 5 mSv/year for workers, depending on the distance of separation from the container and the intensity of the radiation[67].

If some radiation can easily be stopped by certain obstacles, however, iridium-192 releases particularly penetrating electromagnetic radiation, called gamma rays, that can only be stopped by thick shields of concrete or lead.

5.2. Estimation of the radiological impact

In the hypothesis of a radiation leakage which started from the departure of the package, other FedEx workers and the public may have been exposed to higher doses that the authorized limit for the public which is 1 mSv in Europe and 3 mSv in the USA.

Officially, the FedEx pilots, the only personnel equipped with dosimeters, and who transported the container from Paris to Memphis, were exposed to doses of 0.75 mSv and 0.05 mSv, on a three-month period[68]. FedEx did not specify whether the pilots were at a certain moment close to the package nor whether they were in charge of any control on the deck.

The driver who transported the package by road from Memphis to New Orleans (***Annex 6***) over a distance of 660 km in 7 hours[69], is said to have been exposed to *"approximately 5.87 mSv"*[70] according to the information released by the NRC in February 2002.

The SPEC driver, who was in presence of the package for only around ten minutes, between the moment he picked it up in New Orleans and his arrival to his company's site, was exposed to a dose of 3.6 mSv according to the NRC.

In terms of contamination, the transport between Memphis to New Orleans is the one which presented at first sight the most risks if one assumes the hypothesis that the iridium pellets due to the swaying, and other vibrations throughout the transportation and the position of the package on its side- were largely thrown out of their capsules.

Given the fact that, by its nature, the radiation released by the iridium-192 couldn't have been stopped by the sheet iron of the truck, an eventual exposure of the public to radiation cannot to be excluded.

One can also imagine a situation in which the truck was stuck in a traffic jam, exposing passengers of vehicles around the truck.

According to the WISE-Paris estimates, based on the indicated flow of 10 mSv/h at a distance of 6.50m, a person of the public standing directly on the axis of the leakage could have been exposed to a dose exceeding the annual limit for the public dose to the USA, that is 3 mSv, in 18 minutes. The time would only be 6 minutes to reach the annual limit in France, established at 1 mSv. This time is shorter should the person be closer to the package.

5.3. Reliability of the tests

As various organisms announced soon after the accident, blood tests were made early January 2002 on FedEx employees, but the tests revealed no abnormality. However, such medical exams, soon after the incident as this one, do not permit to identify severe radiation cases.

According to Jean-François Lacronique, then Director of OPRI, when they don't reveal *"chromosome alterations"* that would correspond to such cases, they are in fact *"of no reliability"*[71], because they do not measure the health impact deferred in time.

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[67] IAEAop. cit.
[68] NRC, answer to Ed Markey, 19 February 2002.
[69] WISE-Paris estimates.
[70] NRC, answer to Ed Markey, 19 February 2002.
[71] Jean-François Lacronique, OPRI, telephone interview, 9 January 2002.

OPRI's first estimations concerning the dose (whole body) the worker, who transported the package at Paris, was exposed to, was *"largely below the millisievert"*.[72]

Safety authorities have thus concluded from the first tests that no serious irradiation had occurred during the Swedish and French parts of the transportation. It eventually appeared that contrary to OPRI's estimates, a FedEx agent has been exposed to an equivalent dose of 15 to 30 mSv, and a second one to 100 mSv, both in Roissy-Charles-de-Gaulle. These results were obtained through additional tests conducted in France. Similar tests have not been implemented in Sweden, where the safety authorities only decided, after the first French announcement of 2 May 2002, to have the first blood samples tests re-checked.

According to Michel Bourguignon, Assistant General Director of the DGSNR, the second FedEx employee dose estimate, that is 100 mSv, is an estimate with a 95% confidence range of 30-170 mSv.[73] The threshold for detection used in the French laboratory is well below the threshold for detection with traditional cell-count methods used in other countries, which is about 150 mSv. The Finnish radioprotection authority, STUK, that conducted the medical dosimetry for SSI, confirmed that it didn't conduct the detailed blood count that allows readings under this threshold.[74]

The IRSN type tests are actually very difficult and costly, which explains why authorities didn't want to extend such tests to a large number of FedEx employees. But the cell-count method, even detailed, is facing two drawbacks: the tests can not distinguish the irradiation that is searched for from other irradiations that may have occurred through the same period, and their precision is quickly declining with time. Detection is actually said to become impossible after a six months period.

5.4. The eventuality of a loss of package

Between 1998 and 2001, about ten losses of package were counted in France. The most spectacular of these incidents, classified at level 1 of the INES scale, was the loss on 19 July 2000 of nine packages *"of radioactive materials (...) lost by the Alitalia air company during the transportation between the Roissy (Val-d'Oise) and Tunis (Tunisia) airports. The packages were discovered on 9 August 2000 in a storage area",* belonging to the air company.

The packages were sent by the company CIS-Bio International, to Tunisian hospitals, via the Rome Airport. *"among the nine packages missing at Tunis, six contained iodine-131, two contained thallium 201 and one gallium 66. Their activity represented a total of about 34 GBq".*

The loss of the FedEx package between 27 December 2001 and 2 January 2002 could have aggravated the risk of radiation exposure to the public. With such a scenario, an increase in the radiation leakage could be feared, even its aggravation by a handling accident.

6. Failures in the notification

The FedEx package incident finally revealed a failure in the exchange of information between the different safety authorities, which could have hindered implementation of much stricter procedures needed to meet much more serious situations.

The exchange of information between the authorities of the USA, France and Sweden, was not straight forward as it should.

The NRC[75] confirms that the Department of Transport, the competent authority for notification, informed the Swedish authorities on 3 January 2002 and the French authorities on 4 January 2002. But

[72] Idem.
[73] *Nucleonics Week*, 27 June 2002.
[74] Idem.
[75] NRC, answer to Ed Markey, 19 February 2002

according to the press communiqué released on 9 January 2002, the DGSNR was officially notified on 7 January 2002 by the American and Swedish authorities, and by FedEx.

According to Jacques Aguilar of the DGSNR[76], an email was sent to the French Safety authority by its Swedish counterpart on 4 January 2002 in the evening, that is two days after the discovery of the incident. But the absence of a *"direct contact",* the email was discovered only on Monday the week after, that is on 7 January 2002 in the morning. Hence, the *"time lag"* was used to explain the delay in notification and therefore the beginning of the investigations, at least in France, on a package that could have caused *"acute"* health problems for those who handled it. Therefore there is no guarantee that the procedure would have functioned in a more satisfying way in a more serious situation –for instance in the case of a leakage of radioactive materials, where a transiting container results in the contamination of the area.

Despite the obligation of notification and the importance of a rapid reaction in the case of an incident or accident, no efficient system of permanent follow-up seems to be put in place for such situations, at least in France.

While, it is clearly stipulated in the 1986 Convention on the assistance in nuclear accident or radiological emergency situation[77], ratified by France on 2 June 1989, that Member States have to indicate to the IAEA the contact points of the competent authorities and that the latter must remain *"permanently accessible"*.

[76] Jaques Aguilar, DGSNR, telephone interview, 10 January 2002

[77] Convention on assistance in case of nuclear accident or radiological emergency situation, signed in Vienna, 26 September 1986.