PMP-MTA

Contribution to WFS Meeting, Erice, August 2010

Nuclear Trafficking: 20 Years in Review

Lyudmila Zaitseva
Division of Physics and Biophysics, University of Salzburg
Salzburg, Austria

Introduction

The main prerequisite for nuclear and radiological terrorism is access to the right material. Repeated expert assessments concluded that with enough weapons-usable uranium, a sophisticated terrorist group could build a crude nuclear device.[i] Constructing a radiological dispersal device (RDD) or an exposure device would present no major challenge to any terrorist organisation possessing radioactive materials. Unfortunately, there is a real risk that such materials could get in the hands of non-state actors, prepared to use the most violent and indiscriminate methods in pursuit of their objectives. The International Atomic Energy Agency (IAEA) summarized in its reference manual on combating illicit trafficking in nuclear and other radioactive material:

> "Advances in information technology and the availability of radioactive material have increased the likelihood that a terrorist or other criminal organization could obtain the necessary material, components and expertise to construct a nuclear explosive device or RDD". [ii]

Current knowledge on illicit trafficking in nuclear and other radioactive material results largely from the information stored in several nuclear smuggling databases operated by international organisations and research institutions. The most authoritative and best known of them is the IAEA Illicit Trafficking Database (ITDB), which collects and analyses state-confirmed illicit trafficking incidents, defined as follows:

> "Unauthorized acquisition, (e.g. by theft), supply, possession, use, transfer, or disposal of nuclear and other radioactive materials, whether intentionally or unintentionally, with or without crossing international borders." [iii]

This definition is intentionally broader than that it would be for drugs or weapons. It includes both "intentional" acts, such as a theft or an illegal sale of radioactive substances, and "unintentional" acts, such as a loss or an accidental find. These two words divide all nuclear trafficking cases into two basic categories – criminal acts and unauthorized acts resulting from negligence. Both types of incidents are important to track in order to prevent damage to human health and environment, which could result from misuse or mishandling of radioactive material. As of 31 December 2008, the IAEA ITDB contained 1,562 confirmed incidents reported by the participating States and some non-participating States since 1 January 1993.[iv]

The Database on Nuclear Smuggling, Theft, and Orphan Radiation Sources (DSTO), which in addition to government-confirmed cases recorded in the ITDB also collects unconfirmed incidents derived from open-source reports, adopted the same approach to analysing illicit trafficking cases as the IAEA, by not excluding the incidents without criminal intent. The database was established at Stanford University's Center for International Security and Cooperation in 1999 in an effort to create a more comprehensive global dataset relying on a lot of open source information. Since 2004, it has been operated at the University of Salzburg. The DSTO covers the period from 1991 to date and contains over 2440 cases.[v] It includes 1674 incidents of thefts, illegal movement, and border detections of radioactive materials, 736 cases of the so called orphan sources, which have been lost, accidentally found or misrouted on the way to the recipient, and 35 malevolent acts, such as intentional irradiation of persons and contamination of their residencies and belongings. Similarly to the ITDB, t

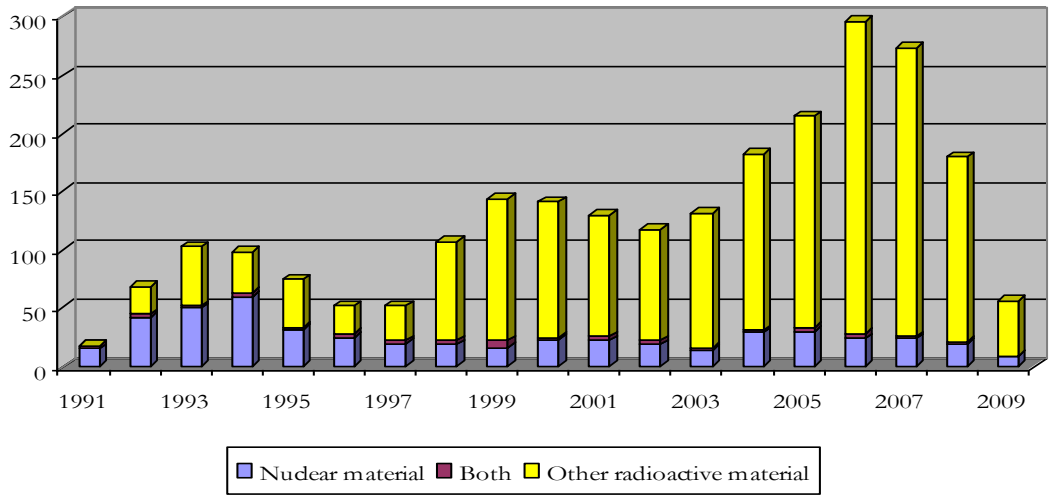
he scope of the DSTO covers all types of nuclear materials (i.e., uranium, plutonium, and thorium), all naturally occurring and artificially produced radioisotopes, and radioactively contaminated materials.

DSTO: Basic Facts and Trends

First cases of nuclear trafficking started to appear in 1991 and 1992, soon after the collapse of the former Soviet Union. Radioactive materials were smuggled into Eastern and Western Europe from Russia and other Soviet republics. The political crisis and the severe economic downturn, which hit these countries at the time, made their vast nuclear infrastructure very vulnerable to diversion, theft, and vandalism. Poverty, lawlessness and corruption were the precursor to the wave of nuclear smuggling cases that swept over Europe in early 1990s. It is then that national and international agencies and organizations started tracking the trafficking cases.

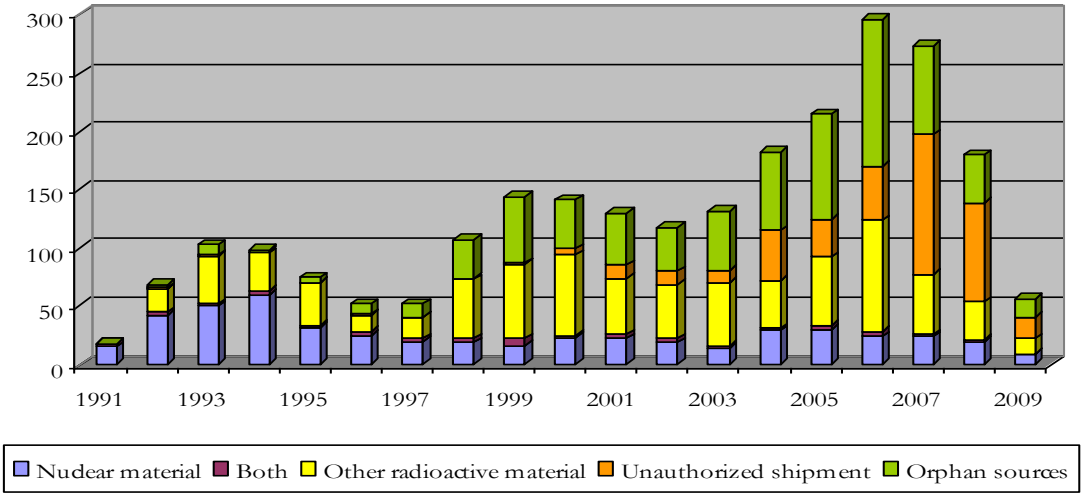
The basic trends that can be identified on the chart below, which shows the number of nuclear trafficking incidents reported globally since 1991, are the decrease of cases involving nuclear material since mid 1990s and the overall increase of incidents over the last decade. Indeed, the number of cases recorded between 2001 and 2009 has virtually doubled as compared to the previous decade – from 860 to 1582.

Fig. 1: Illicit Trafficking Cases Recorded in DSTO from January 1991 to December 2009



This rise is mainly due to increased global awareness of the potential nuclear terrorism threat after the September 11 attacks, improved detection capabilities at many international borders and points of entry, national campaigns to recover orphan radiation sources, and better incident reporting practices to the IAEA. In other words, it is a result of looking harder and doing more to prevent unauthorized activities involving nuclear and other radioactive material. If one separates all the orphan source incidents and inadvertent movement of radioactive scrap metal into categories of their own, shown in green and orange in Figure 2 below, one can clearly see which type of incidents contributed to the increase in cases involving other radioactive material.

Fig. 2: Illicit Trafficking Cases Recorded in DSTO from January 1991 to December 2009 with Separated Orphan Source and Unauthorized Shipment Categories.



Nuclear Material

Incidents involving nuclear material are relatively rare compared to those involving other radioactive material. They account for about 20 percent of all cases. Low-grade nuclear materials, such as natural uranium ore, yellowcake, depleted uranium, and thorium-232 account for almost 60 percent of some 500 cases involving nuclear material. These materials, in their existing form, cannot be used for making nuclear weapons. Uranium enriched to less than 20 percent in isotope U-235, or low enriched uranium (LEU), accounts for additional 30 percent. Incidents involving uranium enriched to 20 percent and above, called highly enriched uranium (HEU), and plutonium-239 – weapons-usable nuclear materials – are very rare. DSTO contains a total of 50 such cases, of which only 26, however, are considered credible.

Other Radioactive Material

About 80 percent of DSTO cases involve ionizing radiation sources, used in a variety of industrial, medical, research and military applications, or radioactively contaminated material. The most frequently occurring isotope is Cs-137, which accounts for a third of these cases (33 percent). It is followed by Am-241 (14%), Co-60 (7%), Ra-226 (7%), Ir-192 (6%), and Sr-90

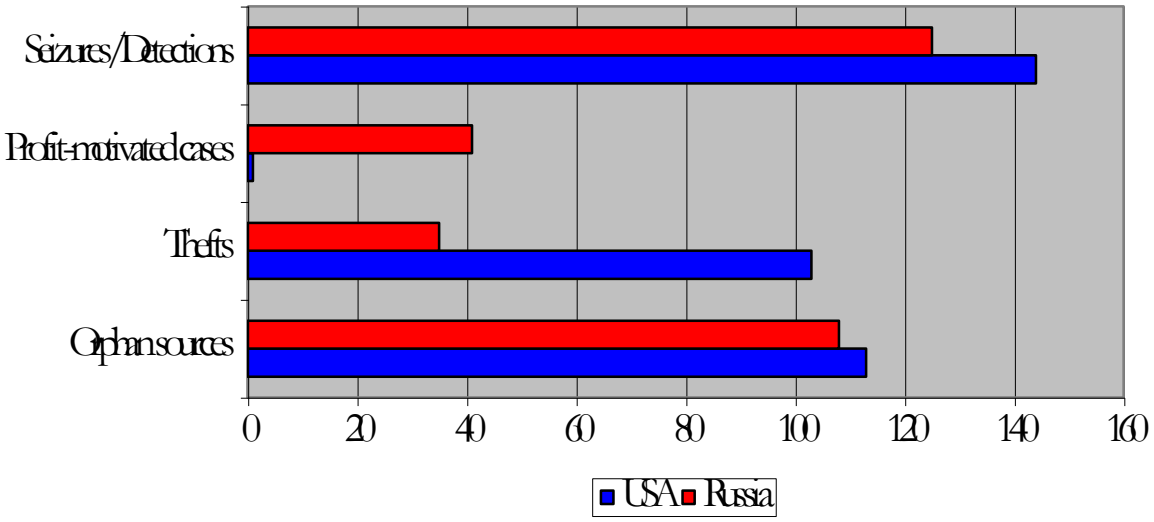
(5%). From the standpoint of their potential use for malicious purposes, radioactive sources range from "very dangerous" to "not dangerous". The number of cases involving very dangerous sources amount to less than 10 percent of all cases involving other radioactive material recorded in the DSTO. They correspond to Categories 1 (20 cases) and 2 (90 cases) of the IAEA categorization system, which assigns radioactive sources into one of five categories depending on the risks they pose.[vi]

Crime Motivation

There are several motives behind crimes involving radioactive materials, e.g., theft, illegal possession, illegal transfer. The expectation to profit from selling radioactive material on the black market is probably the best known/most common one. Profit-motivated cases (415) account for about 9 percent of all illicit trafficking incidents recorded in the DSTO database. They involved nuclear material in 241 cases (58 percent), other radioactive material in 155 cases (37 percent), and both types of material in 20 cases (5 percent). In many other cases, perpetrators steal radiation sources, because of their interest in their metal shielding, which can be sold for its scrap value. As a rule, they are not interested in the radioisotope inside the shielding, and some may not even be aware of it. Such cases are recorded primarily in countries with weak economies and insufficient regulatory control. However, thefts of radioactive sources are regularly reported in highy industrialized countries as well. For example, DSTO contains 48 such cases recorded in Canada in the period 2000 to 2008. Most of them involved portable gauges used in construction. The motive behind such thefts needs to be further researched. However, there is a guess that the perpetrators may be driven by the wish to avoid the costs of buying such sources and/or disposing of them in an apropriate manner. Therefore, mobile sources can be stolen from other companies, and, once their shelf-life has expired, they can be thrown out without much risk that they can be traced back to the last user. Using the ID numbers on the source, one can only trace it to the company that had purchased it and obtained a relevant license. Finally, radioactive material can be stolen or purchased for malicious purposes, e.g., intentional irradiation of individuals, contamination , demanding a ransom, building a radioactive dispersal device (RDD), or a nuclear weapon.

Different motives behind nuclear trafficking related crimes can be demonstrated using the example of two countries with comparable nuclear infrastructures, but different social, economic and geographic factors – the United States and Russia. In the period January 2000 to December 2009, 360 illicit trafficking cases were recorded in the US and 268 in Russia. The category "Seizures/Detections" in Figure 3 below reflects the cases in which radioactive material was either seized from criminals or detected at borders. The number of incidents in this category is comparable in both countries, with 144 cases recorded in the US and 125 cases in Russia. However, only two out of 144 cases in the US were profit-motivated, i.e., attempt to sell radioactive material on the black market, as compared to 41 in Russia. This striking difference between the two countries can be explained by the lack of any nuclear black market in the United States. Whereas the number of thefts recorded in the US is higher than in Russia, the motives behind them are quite different: selling the radioactive material on the black market vs. using the stolen radiations sources to avoid high licence and disposal fees. The number of orphan source cases is approximately equal in the two countries.

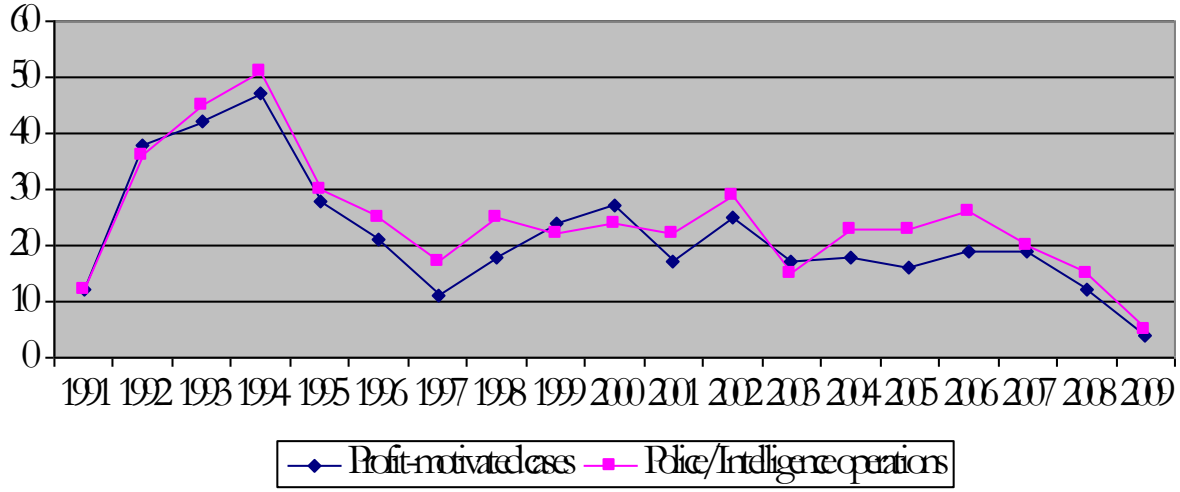
Fig. 3: Comparison of Trafficking Cases Recorded in the United States and Russia (2000-2009)



Detection and Interdiction

Cases disrupted by police and intelligence agencies comprise a fifth of all illicit trafficking cases recorded in DSTO. If one superimposes such cases on the curve reflecting profit-motivated incidents, we can see that the two curves virtually coincide (Fig. 4). This implies that the profit-motivated cases that have come to light have been interdicted almost exclusively through the work of law enforcement agencies. One of the most popular methods used by these agencies is the so called sting operations, in which their agents, acting on a tip-off, pose as buyers for the smuggled radioactive material.

Fig. 4: Comparison of Profit-Motivated Cases and Incidents Intercepted Through Work of Police or Intelligence Agencies (1991 - 2009)



The annual frequency of such operations was very high in early 1990s and peaked in 1994. Some of the sting operations conducted in Europe were rather controversial at the time. They were thought by many to provoke illicit trafficking of nuclear materials into Europe rather

than prevent it. Indeed, in October 1994 a Columbian national, who had sold a sample of nuclear material to a German undercover agent, brought more of the same material from Moscow to Munich on an ordinary Lufthansa flight. Soon after this case, all sting operations in Germany were banned. Since then, the number of stings per year has decreased by about a half.

Although a number os sting operations may have been provocative in nature, even to the point of causing people to commit crime, the majority of them were reactive, which means they were initiated on a tip-off that someone is trying to sell radioactive material. Such reactive operations have proven to be very effective in interdicting nuclear contraband. Proactive stings, in which undercover operatives approached nuclear facility employees with a request to deliver nuclear material they have access to, have also taken place, but their number was negligible in comparison.

Nuclear trafficking cases are also detected at national borders, using radiation monitoring equipment. In the recent years, the number of cases interdicted through border control has risen dramatically, from 64 cases in 1990s to 454 cases since 2000. The trend started rising in the late 1990s when the efforts to improve border control began in Russia and its neighbouring countries. In the next few years it picked up even more, because many other countries in the world installed radiation detectors at their borders and points of entry and started reporting a lot of incidents that would have previously gone unnoticed.

However, looking closer at these border interceptions, one discovers that they are much more effective in interdicting inadvertant movement of radioactive sources or contaminated materials than in catching real traffickers. There is a number of reasons for that, ranging from technical limitations in detecting alpha-emmiting uranium to difficulties in operating the equipment. But the most important of all is that human ingenuity has always beaten technology. And if one wants to avoid detection at the border, there are always ways to do it, from the history of drug and human trafficking has demonstrated again and again. Therefore, purely technical measures cannot deter smart traffickers.

Supply and Demand in Nuclear Trafficking

Unlike with other types of contraband, in nuclear trafficking one deals almost exclusively with the supply side of the nuclear black market, whereas the demand side remains largely a guess work. For example, in drug smuggling and arms trafficking, the demand side is well known due to much larger volumes and relatively open use of illegally acquired substances or weapons. Knowing the number of drug addicts in a particular city or country and the size of a single dose, one can easily estimate the amount of drugs, which has to be supplied daily, monthly, or annually. However, when sellers or couriers are arrested in possession of nuclear material, it is much easier to establish its origin than to identify with certainty its actual destination. Different couriers, unaware of what they actually smuggle, may take the material to several interim points along the way, until it reaches the final destination. The highly secretive nature of sophisticated nuclear contraband is such, that once the material has been delivered to its end-user, it is almost impossible find out, or prove, its whereabouts. An aspiring nuclear weapon state is highly unlikely to admit to possessing illegally obtained HEU or plutonium it intends to use for building a nuclear weapon. A sophisticated, technologically

advanced terrorist group would also likely keep the fact of material acquisition secret, possibly until it has managed to assemble and deliver a working explosive device.

In addressing the supply and demand in nuclear trafficking, the section below relies *exclusively* on the evidence collected from the actual theft and smuggling incidents interdicted over the last twenty years and recorded in the DSTO database. It does not discuss the possible intentions or express of interest by terrorist groups and aspiring nuclear weapons states outside of this evidence. The scope of this section is also limited to nuclear fissile material only.

Material Supply

In the 1990s, diversion of fissile material from nuclear facilities was much more common than in the following decade. Thus, DSTO lists 29 *thefts* of LEU, HEU and Pu-239 recorded between 1 January 1991 and 31 December 1999, whereas, only 8 such thefts have been reported since then. Therefore, for reasons already described above, supply of fissile nuclear material was definitely better in the first decade after the dissolution of the former Soviet Union, than in the second one.

In its Illicit Trafficking Database (ITDB), the IAEA documents 19 trafficking incidents involving HEU and plutonium, which have been confirmed by the dedicated national authorities (Table 1). They involved a total of a little more than eight kilogram (8250 g), 95 percent of which was HEU (7880 g) and the remaining 4.4 percent – plutonium (370 g).

Table 1: Incidents involving HEU and plutonium confirmed to the IAEA ITDB, 1993-2006

Incident	Date	Location	Material	Amount, g
Seizure	24 May 1993	Vilnius, Lithuania	HEU (50%)	150
Seizure	March 1994	St. Petersburg, Russian Federation	HEU (90%)	2972
Seizure	10 May 1994	Tengen-Wiechs, Germany	Pu	6.2
Seizure	13 Jun 1994	Landshut, Germany	HEU (87.7%)	0.795
Seizure	25 Jul 1994	Munich, Germany	Pu	0.24
Seizure	8 Aug 1994	Munich Airport, Germany	Pu	363.4
Seizure	14 Dec 1994	Prague, Czech Republic	HEU (87.7%)	2730
Seizure	Jun 1995	Moscow, Russian Federation	HEU (21%)	1700
Seizure	6 Jun 1995	Prague, Czech Republic	HEU (87.7%)	0.415
Seizure	8 Jun 1995	Ceske Budejovice, Czech Rep.	HEU (87.7%)	16.9
Seizure	29 May 1999	Rousse, Bulgaria	HEU (72.65%)	10
Theft	Dec 2000	Karlsruhe, Germany	Pu	0.001
Seizure	16 Jul 2001	Paris, France	HEU (72.57%)	0.5
Seizure	26 Jun 2003	Sadahlo, Georgia	HEU (89%)	~170
Loss	Mar-Apr 2005	New Jersey, USA	HEU	3.3
Loss	24 Jun 2005	Fukui, Japan	HEU	0.0017
Seizure	1 Feb 2006	Tbilisi, Georgia	HEU (89%)	79.5
Discovery	30 Mar 2006	Henningsdorf, Germany	HEU	47.5
Discovery	5 Oct 2009	Dordrecht, Netherlands	HEU (42%)	Unknown

Seven other credible cases involving weapons-usable nuclear material were reported in open sources, but have so far not been officially confirmed by the relevant states to the IAEA

(Table 2). All of them had also involved HEU, with the total amounting to 30.8 kg. From these numbers one can see that HEU, which is much more suitable for building a crude nuclear device than Pu-239, has been subject to diversion and smuggling far more frequently and in much larger quantities than plutonium.

Table 2: Additional highly credible cases involving HEU from DSTO, 1991-2009

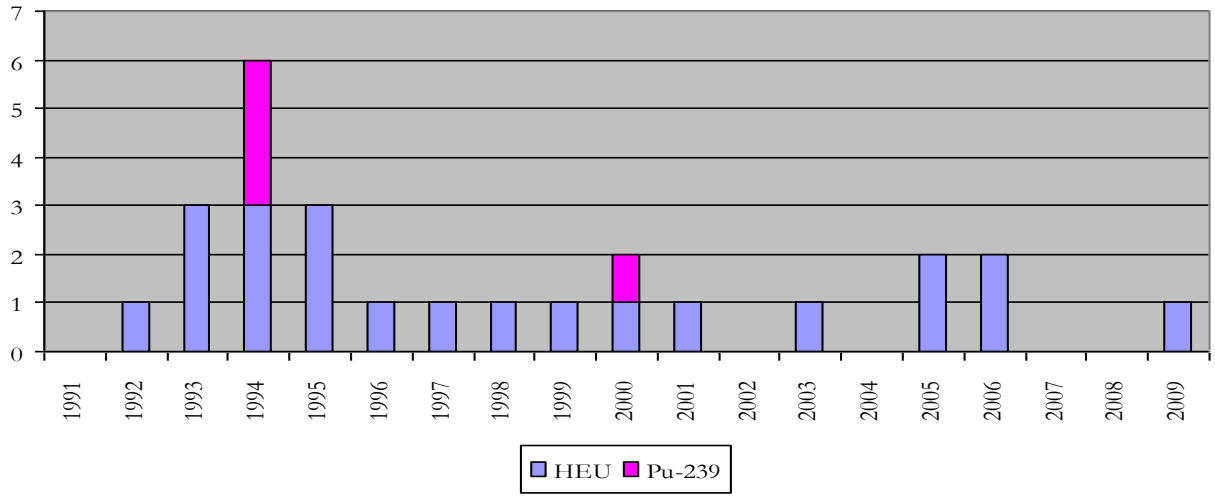
Incident	Date	Location	Material	Amount, g
Seizure	6 Oct 1992	Podolsk, Russian Federation	HEU (90%)	1500
Seizure	29 Jul 1993	Andreeva Guba, Russian Fed.	HEU (36%)	1800
Seizure	28 Nov 1993	Sevmorput, Russian Federation	HEU (20%)	4500
Loss	1996	Tomsk, Russian Federation	HEU (90%)	145
Loss	1992-1997	Sukhumi, Abkhazia, Georgia	HEU (90%)	655
Diversion attempt	1998	Chelyabinsk region, Russian Fed.	HEU (unknown %)	18500
Seizure	2000	Elektrostal, Russian Federation	HEU (21%)	3700

The total amount of the weapons-usable material that has been seized by authorities in the above 26 incidents is roughly 38 kilogram.[vii] All of this material is known or suspected to have been diverted from nuclear facilities in Russia, ranging from research and fuel fabrication facilities to submarine construction and fuel storage sites. Almost half of the confiscated material, 18.5 kg, was seized by the Russian Federal Security Service in a prevented diversion attempt by several employees of an undisclosed nuclear facility in Chelyabinsk region. Another 16 kg were stolen undetected from Russian nuclear installations and seized weeks, months, or even years later during attempt to sell them inside the country. As demonstrated by a number of successful diversions, such as those at Luch Scientific Production Association in 1992 (1.5 kg of 90% HEU) and Elektrostal Machine-Building Plant in 1994 (3 kg of 90% HEU) and 1995 (1.7 kg of 21% HEU), the security and control systems at source facilities failed to register the disappearance of significant amounts of weapons-usable material. In these cases, and in other diversions from civilian nuclear installations, the facility management was unaware of the missing materials until they were recovered by police and security services and traced back to the facilities. The remaining 3.5 kg were smuggled into Germany, Czech Republic, Bulgaria, France, and Georgia, where they were confiscated from criminals by the local authorities. All of the HEU and plutonium seized in these countries was traced back to Russia, although neither the origin nor the source facilities were ever confirmed by the Russian authorities.

The latest significant case, recorded in October 2009, in Dordrecht, the Netherlands, also involved HEU of Russian origin. A piece of metal contaminated with HEU (42%) was found in a load of stainless steel scrap transported from St. Petersburg, after it caused a radiation alarm at the gate of a Dutch scrap metal dealer.[viii] Although no apparent criminal intent was involved in this incident, the fact that such material could leave its facility and the country of origin without being detected raises many concerns. This was the second confirmed discovery of HEU in scrap metal, which had been imported into Europe. Three years previously, in March 2006, the German authorities detected trace amounts of HEU on a piece of tube found amidst scrap metal entering a steel mill in Henningsdorf.[ix] The cargo was reportedly also delivered from St. Petersburg, Russia.[x]

The majority of HEU and plutonium incidents were recorded in the first half of 1990s (Fig. 5). All the known thefts of Russian HEU were committed in this period as well. The lack of more recent diversions is clearly an indication of the success of all the national and international efforts to improve nuclear security in Russia. The HEU seized in a few cases over the last decade appears to be old material, which could have been stolen years ago, before the security at nuclear installations was upgraded. Although the overall risk of nuclear theft in Russia has been significantly reduced, vulnerabilities, such as corruption and insider threat, still remain.[xi]

Fig. 5: State-Confirmed and Other Highly Credible Cases Involving HEU and Pu-239



It is safe to assume that the interdiction of nuclear smuggling, both within the country of origin and at border-crossings, is unlikely to be one hundred percent successful. According to an assessment by the Russian Federal Security Service made in mid-1990s, law enforcement and security officials in Russia could then intercept roughly 30 to 40 percent of diverted nuclear materials. [xii] Therefore, it is quite plausible that more weapons-usable material was successfully diverted from Russian facilities, and possibly smuggled out of Russia, in the early and mid 1990s than has been recovered so far. All of the known diversions of weapons-usable material have involved kilogram amounts, not grams. Thus, confiscation of several samples of gram amounts of HEU over the last decade point to the likely existence of additional, larger amounts of stolen material, which have not been recovered yet. Besides, a number of incidents have been interdicted in recent years, in which culprits spent years trying to find a buyer for the material they had diverted back in 1990s.

Nuclear Black Market Players

In the absolute majority of the detected nuclear smuggling cases, criminals caught the attention of law-enforcement agencies in the process of looking for potential buyers. These cases represent the supply-driven side of the nuclear black market, because they are based on the availability of the material rather than a specific demand for it. And because such demand is limited to a relatively small number of potential end-users, be it aspiring nuclear weapons states or non-state actors, finding a customer for stolen material often proves to be a difficult and lengthy process. Therefore, this stage between the actual diversion and delivery of the material to the end-user is most vulnerable to disclosure.

The major players on the supply-driven market are the actual suppliers, i.e., employees of nuclear facilities, which produce or handle fissile material. These so-called insiders are perfectly suited for material diversion, because they have direct access to it and can avoid or overcome the existing security barriers due to their knowledge of the internal accounting and protection practices, as well as the people. As demonstrated by the thefts discovered in the past, such players can act alone or in collusion with other employees or security guards, upon their own initiative or on requests from others. All of the known thieves had the same motive – to profit from selling the stolen material, although their ideas on the size of the profit and ways to find a customer, if they did not have one already, varied. Most of the insiders were very successful in avoiding detection of the crime they committed by the management or security guards of their facilities. The improved economies and upgraded security at nuclear installations led to almost complete abandonment of diversion attempts in the former Soviet republics, where the absolute majority of the known thefts of nuclear fissile material took place in the 1990s (i.e., Russia, Kazakhstan, Ukraine, Lithuania).

Another category of players on the supply side of the nuclear black market is intermediaries, whose task is to find the customer and transfer the material to the end destination. This category is very broad, ranging from amateurish fortune-seekers and primitive criminals to metal-trading companies and organized crime groups. It is representatives of this category that get apprehended in the majority of the detected nuclear smuggling cases during their ill-concealed efforts to find a buyer or transport the material. The most unsettling type of intermediaries is members of international organized crime, who are best positioned to broker illegal nuclear deals between suppliers and end users. A good example of an organized criminal group participating in the supply-driven market is the Balashikha organization from Greater Moscow, which had engaged in a variety of criminal activities since the early 1990s. In December of 2001 several members of the group were arrested near Moscow in an attempt to sell a kilogram of low enriched uranium. The arrest was the result of a sting operation, which had apparently lasted for several years. An earlier example was recorded in 1998, when several members of an Italian mafia clan were arrested in Rome in connection with a seizure of a uranium fuel rod, which had been stolen from the research reactor in Kinshasa, the Democratic Republic of Congo, together with several others. Although only a few such incidents are known to date, where the evidence of organized crime involvement in nuclear trafficking was irrefutable, the actual degree of involvement of such groups may be far greater.[xiii]

Many doubt than organized criminal groups can be interested in nuclear trafficking, because its turnover and profitability are low and unreliable, compared to those in other criminal activities, such as drug trafficking or car theft. Indeed, the end-user market for radioactive substances is small and uncertain in comparison. However, the criminal underworld may well engage in nuclear smuggling as a sideline activity, either upon a specific order from a client or when they happen to obtain some material they think they could sell.

If organised crime were to engage in nuclear trafficking upon request from a potential customer, their operations would be difficult to discover and interdict, because the criminals would avoid the most vulnerable stage of trafficking - looking for a buyer. Border controls, even those with perfectly functioning radiation detectors and vigilant border guards, would also hardly pose an impervious barrier to organised criminal networks, such as those moving tonnes of drugs and weapons between continents. Once the material is stolen and handed over

to such a network, there is very little that can stop it, unless, of course, the theft is detected and the authorities are alerted. Unfortunately, the practice shows that most thefts of nuclear material go unnoticed at the source.

An example of such a targeted approach to smuggling was recorded in the summer of 2003 in Russia. An individual vising from St. Petersburg approached several employees of the Kirovo-Chepetsk Chemical Combine, Kirov Oblast. He sought to buy 15 kg of uranium he knew they could get from their plant. The employees diverted the material and agreed to sell it for about $3,000. The incident came to light only because a local businessman, invited to negotiate the deal, had informed the police about the forthcoming transaction.[xiv] If it wasn't for him, this episode would have likely remained undetected. How many similar incidents go unnoticed and what portion of the nuclear black market remains invisible remains anyone's guess.

Addressing the actual buyers presents a significant challenge due to the lack of hard evidence of their direct complicity in any nuclear material transfer cases detected so far. Such data is the weakest part of any illicit trafficking database. Although it is common knowledge that the potential end-users of the smuggled nuclear material are threshold states, terrorist organisations and extremist religious sects, no obvious links to them could be established in any of the database reports on intercepted cases. Nonetheless, the lack of hard implicating evidence about the demand side of the nuclear black market should not lead to the conclusion about the lack of the nuclear threat as such. Given the reported interest in nuclear weapons and some signs of demand by non-state actors, such as al Qaeda, one cannot dismiss the risk that the nuclear material available on the black market may finally reach the end-user.

Conclusion

Increased awareness of the threat from nuclear and radiological terrorism and improved control practices and detection capabilities led to a rise in the number of detected illicit trafficking cases over the last decade. At the same time, the number of significant cases, involving weapons-usable nuclear material, has decreased as compared to 1990s. No thefts of HEU and plutonium were recorded in Russia since the first half of 1990s and only a few seizures of these materials came to light over the past ten years. However, some amount of HEU and plutonium, stolen in early to mid-1990s from Russian nuclear facilities, may still remain undetected and, potentially, be available for sale on the nuclear black market. Nuclear trafficking cases detected so far represent almost exclusively the supply side of the black market for nuclear fissile material. The demand side, if it indeed exists, remains well concealed, with established networks of couriers, secure smuggling routes, and neutral interim destinations. No hard evidence implicating potential end-users in anything more than interest or intent to obtain nuclear material could be established in any of the cases detected so far.

Notes

[i] Bunn, Matthew. *Securing the Bomb 2010*. Cambridge, Mass. And Washington, D.C.: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School and Nuclear Threat Initiative, April 2010, pp. 16-17.

[ii] International Atomic Energy Agency (IAEA), Combating Illicit Trafficking in Nuclear and Other Radioactive Material. Reference Manual. IAEA Nuclear Security Series No. 6, Technical Guidance, Vienna 2007.

[iii] International Atomic Energy Agency (IAEA), "IAEA Illicit Trafficking Database (ITDB)," Fact Sheet. Vienna, 2009; URL: http://www-ns.iaea.org/downloads/security/itdb-fact-sheet-2009.pdf.

[iv] The data for 2009 has not been reported yet. IAEA ITDB Fact Sheet. Vienna, 2009.

[v] Friedrich Steinhäusler and Lyudmila Zaitseva, Database on Nuclear Smuggling, Theft, and Orphan Radiation Sources (Hereafter DSTO), University of Salzburg, Salzburg, Austria. For a recent analysis of the DSTO data, see "Illicit Trafficking in Radioactive Materials" in *Nuclear Black Markets: Pakistan, A.Q. Khah and the Rise of Proliferation Networks,* International Institute for Strategic Studies, Strategic Dossier, London 2007: 119-138; can be ordered from: http://www.iiss.org/publications/strategic-dossiers/nbm/.

[vi] IAEA, Categorization of Radioactive Sources: Revision of IAEA-TECDOC-1191, Categorization of Radiation Sources, IAEA-TECDOC-1344, Vienna, 2003.

[vii] About a kilo of HEU lost in Tomsk and Sukhumi (Table 2) has never been recovered.

[viii] Report by the Dutch authorities to the IAEA Illicit Trafficking Database (Case ID No.: 2009-11-002).

[ix] Report by the German authorities to the IAEA Illicit Trafficking Database (Case ID No.: 2006-04-007).

[x] DSTO.

[xi] Bunn, Matthew, *Securing the Bomb 2010, pp. 31-43.*

[xii] Rensselaer W. Lee, *Smuggling Armageddon: The Nuclear Black Market in the Former Soviet Union and Europe* (New York: St. Martin's Griffin, 1999), p. 2.

[xiii] Zaitseva, Lyudmila. "Organized Crime, Terrorism and Nuclear Trafficking," in James A. Russel, ed., *WMD and Transnational Networks* (Routledge, 2007), pp: 102-122.

[xiv] Ocharovannyy strannik [A charmed pilgrim], Komsomolskaya pravda, 19 July 2004 (in Russian).