ARTICLES

30 Years of APS Congressional Fellows: Looking Back and Looking Forwards

based on remarks during the APS April 2003 meeting

Sherri G. Stephan

The American Physical Society Congressional Fellowship Program celebrated its 30th Anniversary the same way fellows participate on Capitol Hill: modestly, with due appreciation of the past and an optimistic view of the challenges ahead.

I began my fellowship in September 2000 in the middle of a heated presidential race. I joined the Senate Governmental Affairs Subcommittee on International Security, Proliferation, and Federal Services on the staff of the ranking Democrat on the Subcommittee, Senator Daniel K. Akaka of Hawaii. I worked on all things of interest to the Subcommittee that dealt with science, engineering, technology, and math. This included, but was not limited to, missile defense, geographical information system issues, weapons of mass destruction proliferation, defense, and terrorism, disaster mitigation and management, stockpile stewardship, nuclear testing, and space weapons.

I was an active member of the staff and contributed to many pieces of legislation. I also learned the quirks of Congress and how science and policy intersect. I gained an appreciation for the importance of procedure and politics in forming our national policies, and, in the end, I realized that Congress works just the way it was designed. It is not pretty or efficient, but that is the way it was meant to be.

The fellowship program has added a science perspective to this process. Current and former fellows work as ambassadors, raising the profile of science policy to scientists and the importance of science to policy makers. While current fellows provide most of the in-house scientific expertise available on the Hill, past fellows are now high in the ranks of policy leaders, including Congressman Rush Holt in the House of Representatives and Jane Alexander in the Office of Naval Research.

The greatest challenge ahead for all Congressional science fellowship programs and Society policy offices is to decide upon the long-term policy goals of the science community. We need to look beyond increased funding for physics research. One comprehensive long-term goal is to change the way science is perceived in the legislative process. Currently, the science community is but one special interest. While Congressional staff has respect for scientists and their presumed intelligence, they still are seen to represent their own, rather than society's, interests. As a community, we should take steps to make science as fundamental to any policy debate as economics or national security. Imagine if along with the question, "What did the Congressional Budget Office say it will cost?" staff also asked, "What do the scientists say?"

To expand our interests in physics funding to include broad policy concerns, the science community will have to use some of their limited lobbying time on Capitol Hill to raise the appreciation of all science to policy makers. Scientists also need to increase science literacy efforts in the general public, the constituency base of every politician.

Both are difficult tasks. Some 30 % of Americans still believe that astrology is somewhat scientific and not enough people understand what a molecule is or are capable of defining fundamental scientific terms and concepts (National Science Board, *Science and Engineering Indicators 2000).* Science literacy is more than definitions and specific theories. Scientists must help the public appreciate what science is, how it is done, and what it can do for society.

James Randi, in *The Mask of Nostradamus*, describes science as the "careful, disciplined, logical search for knowledge about any and all aspects of the universe, obtained by examination of the best available evidence and always subject to correction and improvement upon the discovery of better evidence." Science is done through a never-ending search for better data and a better fit of our theories to the data. However, it is this uncertainty and ongoing quest for better evidence that makes the public and policy makers uneasy. The science community must do a better job at explaining uncertainty and the constant validation of current theories to lay audiences to help them recognize it as something to embrace rather than fear.

The public will need to understand uncertainty if they are to have reasonable expectations of what science can do for them and society. In a survey of scientists, policy makers, and the general public on attitudes towards science and its impact on society, close to 40 % of the general public agreed with the statement that science is becoming dangerous and unmanageable (National Science Board, *Science and Engineering Indicators 2000*). Thankfully, close to 80 % of scientists and 70 % of policy makers disagreed with this statement. The difference is telling--some of the public's mistrust of science is due to the popular media's unfortunate portrayal of scientists, especially physicists. The science community must share some of the blame. We need to put a face on science, reaching into the community and helping people understand what science is and how it is done.

The Fellowship Program and other policy groups within APS reach out to policy makers and legislators but need the assistance of Society members to make long-term and lasting changes to science policy. Physicists need to build a relationship with their Representatives and Senators. This requires a firm understanding of the difference between science and science policy. To illustrate the distinction using the analogy from George Philander (*Science*, vol. 294, 12/7/01, pg. 2105), suppose we are in a raft, drifting towards a waterfall. To avoid calamity, we must answer two questions: how far is the waterfall, and when should we get out of the water? The first question is a matter of science. The second is a matter of policy. Answering the latter question becomes more difficult when the answer to the former has some uncertainty. There are additional considerations and there may be other questions. We may need to ask if we should get out of the water or off the raft at all. What if someone on the raft cannot swim or there is something more dangerous on the shore? All these other considerations, the politics and the procedures required in order to make a decision form the world of the policy maker. The first question, the science, is very important, but it may not be the deciding factor.

Through understanding these issues, scientists can appreciate the complex policy process and communicate effectively with legislators and their staff. Congress has 535 members and just as many points of view. Statements judging a member of Congress' understanding of science widen the gap between scientists and Congress. Indeed, there are many people on the Hill who understand these issues: some are scientists, many are lawyers, others may be economists, historians, or physicians. Congressional staff are intelligent, dedicated, poorly paid, motivated by a desire to do good and deserve your respect.

I left the Subcommittee in March 2003, serving one year as a fellow and another year and a half as a professional staff member. I would offer that there is no "typical" tenure on Capitol Hill, but my two and a half years were full of historic, albeit some horrific, events. Through all these times, I was grateful to work for a terrific Senator and with a great staff. I am proud to say the personal and Subcommittee staff I worked with now have an increased awareness of science and what it can do for them.

I find the policy world becoming more complex and less predictable with every new corner I discover. However, like many of my colleagues and fellow Fellows, I enjoy sharing my experiences and offering advice on communicating with Congress and other policy makers. We hope this 30^{th} anniversary celebration of the Fellowship Program will build interest in science policy and encourage others to take the plunge.

Dr. Sherri Stephan
Former Professional Staff

Senate Governmental Affairs Committee
Subcommittee on International Security,
Proliferation and Federal Services
442 Hart Senate Office Building
Washington, DC 20510
phone: 202-224-5443
fax: 202-224-2271
*email*Sherri_Stephan@yahoo.com

Revolving Door Scenario for Congressional Fellows*

David Hafemeister

I am grateful to have participated in the Science Congressional Fellowship program. This experience profoundly affected my professional (and personal) life. In particular, I am thankful for the guidance and friendship of Dick Scribner, who, as the founding Director of the AAAS Science Congressional Fellowship Program launched a thousand science and public policy careers.

In 1973, Scribner told the new fellows that there are two preferred paths in order to maximize the effectiveness of the program:

-- stay in Washington and rise in the system to continually affect the system, or

-- return to your home university or company and transfer to those institutions what you have learned of science and public policy.

I will describe a third path, which is a combination of Scribner's two desired paths. Namely I would like to address a "DC-Academia revolving door" scenario which alternates between presence and absence in Washington. In my case, I adopted this hybrid by spending about 1/2 of my time at my campus and 1/2 in Washington at university science and public policy programs.

My 12 years in Washington was divided among the Senate Offices of Senator John Glenn, the Foreign Relations Committee and the Governmental Affairs Committee, and among the Department of State Offices of the Under Secretary of State (T), Office of Nonproliferation Policy (OES/PM) and the Office of Strategic Nuclear Policy (SNP/PM), the Bureau of Strategic and Eurasian Affairs (START) of the Arms Control and Disarmament Agency, and as a study director for the Committee on International Security and Arms Control of the National Academy of Sciences. In addition two years were spent at MIT, Stanford, Princeton and Lawrence-Berkeley Laboratory, working on national security and energy matters. For those who love acronyms, it has been my pleasure to work on EPCA, ECPA, NNPA, Glenn-Symmington, INFCE, NASAP, terminating Clinch River and Barnwell, spent-full return, IAEA, ABM/D&S, INF, START, CFE, TTBT/PNET, Open Skies, CWC, NPT, verification and compliance, minimum deterrence, verifiability of the CTB, stockpile stewardship, warhead monitoring, triad planning (1976-93), plutonium and HEU in Russia, Nunn-Lugar, and authorizations for ERDA(DOE) and ACDA.

Good Aspects of This Revolving Door:

One might ask whether the revolving door is a good path for a Congressional Fellow? As I see some of my friends rise in the system, I have wondered whether it wouldn't have been better to stay put, become an "expert" and get promoted to "boss-in-charge." Since we can't do our life experience twice, I can only write on what happened to me and not what might have been. First of all, the good side of my revolving door:

<u>Flexibility, variety and timeliness</u>: I have been able to work on what I thought was current and important. In most of my Washington offices, I have been the only technically trained person, given opportunity to quantify the issues at hand. By working on a great variety of arms and energy issues, I have had the luxury of often working at the steepest part of the learning curve, and thus I have been continually challenged. Since I have often been brought into the government to address a new topic for a "big push," or to create the idea for such a push, this has often given a timeliness to the work.

<u>What you write is what you sign</u>: In Washington, it appears that those who write, don't have the status to sign, and those who have the status to sign, don't write the major portion of their signed products. When back at the university, we must take responsibility for what we write by signing our names. Many of the Congressional Fellows have learned a public policy issue that should have been written up, but, alas, they haven't had the time and/or the freedom to

put their thoughts to paper. And, of course, re-entry to the university allows the teaching of courses on science and public policy.

Lies and damn Lies: Each one of us can write a list of science and public policy issues which have been distorted by "politics" and bad press. A revolving door allows one to address these "damn lies" both in the government and outside the government. If a busy executive branch desk officer does not know the relevant "open" literature which goes above and beyond a current interagency study, then a revolving door can bring this data into the process. The biggest "fibs" I witnessed while in the executive branch were on SDI, treaty compliance issues, and the military significance of potential cheating by the former Soviets. On the other hand, public debate in the university or professional societies can lack the reality of decisions based on all the issues; it is the obligation of people such as former congressional fellows to bring a sense of reality to the campus. The biggest "fibs" I witnessed while on the campus were on discussions of relative risks in society and the neglect of practical economics.

An independent, but loyal voice: Congressional fellows are, by definition, hand-maidens to the powerful above them. When part of a government bureaucracy, it does not help ones career to be too contrary to what is perceived as the conventional wisdom. If one has a tenured position in another city, this can give one confidence to speak up when your Senator or Under Secretary is about to do something that you perceive is less than wise. It is the duty of the former congressional fellows to maintain the highest levels of honesty and objectivity in order not to be corrupted by the party line of the home university or government office.

Downsides to Becoming a Revolving Door:

What might have been: 'Aw shucks, we all might have been Under Secretary if we had only stayed the course. It takes about two weeks to adjust to the lack of phone calls from Washington.

Out of date, out of loop: Upon re-entry to the government, have we missed or forgotten those details which used to be at our fingertips? The challenge is get back on the learning curve to "get up to speed."

-<u>Family chaos</u>? Moving back-and-forth every few years can be stressful. Do you and your spouse flourish in two environments, one in Washington and one at your home university? If you have children, does change prepare them for real life, or is an incubation in a quaint college town a preferred route? (In my family, my wife has been mostly supportive and very adventuresome.)

Jargon in DeeCee:

Rather than write an essay on the interaction of NPT renewal with CTB negotiations and IAEA enhancement, I would like to close by examining some Washington, DeeCee jargon:

Pipelines in are pipelines out,

Loose cannon on the deck,

Nice up and nasty down,

OBE.

<u>Pipelines in are pipelines out</u>: In the interagency process on arms control, essentially all the working papers are marked "secret," no matter how trivial the essay. When a former congressional fellow arrives into the inner sanctum of the interagency process, he is initially viewed with suspect because he has too many contacts with the Congress and the public. Some in the Executive Branch have (accurately) referred to Capitol Hill as the "torture place" since they perceive it as an overly politicized body. However, the Constitution wisely gave the Congress the power to oversight the Executive Branch since concentrated power can go astray. With this power the Congress can assist the Executive branch to consider the wider issues, for example a CTB, rather than a more limited testing ban. Ultimately, good government has to have pipelines that flow in two directions. If the Congress and the public are surprised by sudden executive branch policy shifts without consultation, there is bound to be a great deal of trouble. On the other hand, telling EVERYTHING very crucial. Good government requires flow in both directions.

<u>Loose cannon on the deck</u>: When carrying on negotiations with foreign delegations or with the Congress, it is not useful for a negotiator to raise issues incorrectly or outside a planned

framework (unless it is a walk in the woods) because then the negotiating partner can use this error or exaggeration as a means to derail useful discussion. This kind of negotiator is called a “loose cannon on the deck” because his/her heavy movements can splinter the wooden structures of the ship of state, much as loose cannons have done on real ships.

Nice up and nasty down: The road map of power in the Congress and the Executive Branch is a starting point to see how science enters into public policy making. These flow charts are often treated with too much respect. When you get inside a bureaucracy, you often see that effective power, influence and jurisdiction don't quite follow these neat boxes and flow diagrams. Furthermore, other -- less than nice -- bureaucratic behavior often influences the way work gets done. For example, these diagrams imply a status between an under secretary and an office of policy and planning. If the director of an office takes too much credit for the work done by his office and if he is overly fond of those above him and not very nice to those in his office, he is then referred to as "nice up and nasty down." I met very few office directors who actually gained leadership this way, because these kinds of people are ultimately thrown overboard at sea.

OBE: This paper may be OBE by the time you read it, that is it probably will be "overtaken by events." In that case, please bring it up to date.

*This is updated, Chapter 10, *From the Lab to the Hill*, edited by Tony Fainberg, AAAS. Washington, DC. 1994.

David Hafemeister

Physics Department

California Polytechnic State University

San Luis Obispo, CA 93407

dhafemei@calpoly.edu

Illicit Trafficking of Weapons -Usable Nuclear Material: Facts and Uncertainties

Lyudmila Zaitseva and Friedrich Steinhausler

1. The danger of perceived vs. actual threats

In the recent past the issue of covert trade in nuclear material gained public prominence when it was erroneously claimed by British intelligence sources that the former Government of Iraq under Saddam Hussein had tried to obtain uranium from Niger. The far reaching consequences of such assessments for society were clearly demonstrated by US President George W. Bush in his speech on January 28, 2003, using this incorrect information as one of the reasons why terrorists and countries belonging to the "Axis of Evil" posed a potential nuclear threat.[i] In view of the occurrence of such significant errors even in the intelligence community, it is not surprising that information in the media on the topic of illicit trafficking of nuclear material is frequently flawed by errors. Examples of such errors include failure to differentiate nuclear weapons-usable material[ii] from other radioactive material, incorrect use of physical units of activity and dose rate, and misquotation of isotopic characteristics and enrichment levels.

Since the terror attacks on September 11, 2001, many publications envisaged doomesday terrorism scenarios, including the deployment of a nuclear device as a potential threat to society. Although this possibility can no longer be excluded, the probability for it to actually happen is relatively low and, in any case, significantly lower than that for a radiological dispersal device to be used in a future terror attack.[iii]

Nevertheless, the issue of losing control over weapons-usable nuclear material has gained prominence in the debate on national security in several countries. Positions in this debate are frequently based on questionable intelligence rather than facts. This undesirable situation is largely due to the fact that information on illicit trafficking of nuclear material is often associated with a high level of secrecy.

In addition, there is a noticeable lack of sharing of relevant information among all parties involved due to the security-sensitive nature of the data and the justified concern by the security community not to reveal any weakness in the physical protection system for nuclear material.

The probability for losing control over nuclear material depends on the amount of material to be secured, the number of storage sites, and the level of physical protection provided by the facility operators.

Large quantities of nuclear weapon-usable material are stored at each of several hundred facilities worldwide. About 1,665 tons of highly enriched uranium (HEU) and 147 tons of plutonium are stored for military uses worldwide.[iv] Comparable amounts are stored at facilities under civilian control. Physical protection practices at these facilities vary significantly, ranging from dedicated nuclear weapon storage facilities under military control, to commercial reprocessing facilities under civilian control, and some research reactors with completely inadequate control.[v]

In order to avoid the pitfalls of evaluating important security-related decisions from questionable sources of information, this paper discusses only the most reliable currently available data on illicit trafficking of weapons-usable nuclear material, contained in the Database on Nuclear Smuggling, Theft, and Orphan Radiation Sources.

2. Illicit trafficking of weapons-usable nuclear material

The Database on Nuclear Smuggling, Theft and Orphan Radiation Sources (DSTO), which combines state-confirmed information with unconfirmed open source data, contains 25 highly-credible trafficking incidents involving weapons-usable nuclear material, i.e., highly-enriched uranium (uranium enriched to 20% U-235 and more) and plutonium-239. Seventeen of these incidents were confirmed by member states to the International Atomic Energy Agency (IAEA)

(Table 1). Eight other highly-credible cases were not officially reported to the IAEA Database Program for reasons unknown to the authors, although they have been publicly confirmed by state officials and described in detail by non-proliferation experts and investigative journalists (Table 2).

Table 1. Government-confirmed cases involving weapons-usable material[vi]

Date of Seizure	Location of Seizure	Type and Amount of Material
24 May 1993	Vilnius, Lithuania	100 g of 50% HEU
10 May 1994	Tengen, Germany	6.2 g of Pu-239 (99.75%)
June 1994	St. Petersburg, Russia	2.972 kg of 90% HEU
13 Jun 1994	Landshut, Germany	795 mg of 87.7% HEU
25 Jul 1994	Munich, Germany	240 mg of Pu-239
10 Aug 1994	Munich airport, Germany	363 g of Pu-239
14 Dec 1994	Prague, Czech Rep	2.73 kg of 87.7% HEU
6 Jun 1995	Prague, Czech Rep.	415 mg of 87.7% HEU
7 Jun 1995	Moscow, Russia	1.7 kg of 21% HEU
8 Jun 1995	Ceske Budejovice,Czech Rep	17 g of 87.7% HEU
28 May 1999	Rousse, Bulgaria	4 g of 72.65% HEU
2 Oct 1999	Kara-Balta, Kyrghyzstan	1.49 g of Pu
19 Apr 2000	Batumi, Georgia	920 g of 30 (±3)% HEU
16 Sep 2000	Tbilisi airport, Georgia	Pu (0.4 g)
2 Jan 2001	Liepaja sea port, Latvia	6 g of Pu in Pu/Be sources
28 Jan 2001	Tessaloniki, Greece	3 g of Pu-239 in anti-stat devices
22 Jul 2001	Paris, France	2.5 g of 72.57% HEU

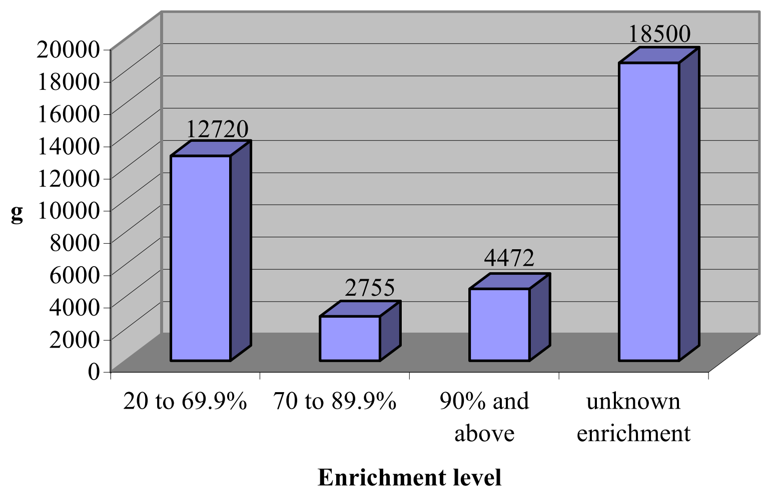
Table 2. Other highly-credible cases involving weapons-usable material

Date	Name of Incident	Type and Amount of Materia
3 Feb 1992	Munich, Germany	Pu (115 mg) in smoke-detector
6 Oct 1992	Podolsk, Russia	1.5 kg of 90% HEU
29 Jul 1993	Andreeva Guba, Russia	1.8 kg of 36% HEU
27 Nov 1993	Sevmorput, Russia	4.5 kg of 20% HEU
1992-1997	Sukhumi,Abkhazia, Georgia	655 g of 90% HEU
1998	Chelyabinsk region, Russia	18.5 kg of HEU
2000	Electrostal, Russia	3.7 kg of 21% HEU
2001	Erlangen, Germany	0.8 g HEU

According to the IAEA state-confirmed reports, the total amount of weapons-usable material seized by law-enforcement authorities is about 9 kilograms. In other credible cases, it amounts to 30 more kilograms. Thus, a total of 39 kg of HEU and plutonium were intercepted during illicit transit, sale, and diversion attempts since 1992. In addition, a cache of 90% HEU reportedly disappeared from a research facility in Abkhazia, a break-away province of Georgia, during the military hostilities between 1992 and 1997. According to different accounts, between 655 g and 2 kg of HEU had been present on site before the conflict broke out and the staff had to leave the facility unguarded. When the specialists from the Russian Ministry of Atomic Energy were finally allowed to enter the facility in 1997, they found no HEU remaining on site. The whereabouts of the material are still unknown and concerns have been raised whether it could have fallen into the hands of criminals or terrorists.

It should be noted that since 1992 HEU has been subject to diversion and smuggling to a much higher degree than plutonium. Intercepted plutonium accounts for less than one percent of the 39 kg. About 380 g of this material were seized since 1992, of which 363 g were part of a mixed uranium oxide batch, 10 g were contained in radioactive sources, and only 6 g were weapons-grade material with a purity of 99.75%. The enrichment level of the remaining 38.6 kg of HEU varies from case to case (Figure 1). At least 4.5 kg were weapons-grade (enriched to 90% and more), which would be insufficient for building a nuclear weapon. However, if the 18.5 kg of HEU intercepted during the attempted diversion from one of the Russian nuclear weapons laboratories in the Chelyabinsk region in 1998 were weapons-grade, this batch alone might have been enough for an advanced nuclear device.

Figure 1. Amounts of seized uranium with various enrichment levels (in gram)



As demonstrated by several known thefts (*Luch-Podolsk 1992*, *Electrostal-St. Petersburg 1994*, *Electrostal-Moscow 1995*), significant amounts of fissile nuclear material disappeared from Russian facilities without being noticed by the facility accounting systems. Therefore, it is possible that more nuclear material has been successfully diverted since the collapse of the former Soviet Union in 1991. It is also likely that gram amounts of HEU and plutonium seized in a number of cases (*e.g., Tengen 1994, Rousse 1999, Paris 2001*) were only samples of larger quantities of already diverted material. Such a possibility was demonstrated by the four linked cases involving 87 % HEU (*Landshut 1994, Prague 1994, Prague 1995, and Ceske Budejovice 1995*). A small sample of the HEU was handed over to a German undercover policeman in Landshut, and a follow-up investigation led to the seizure of a large cache (2.73 kg) and two more samples of uranium in the Czech Republic. Subsequent analysis revealed that the material seized in all four cases was identical and likely of the same origin. A similar scheme was used in Germany in 1994, when a 240 mg sample of plutonium transferred to an undercover German intelligence agent in July, was followed by 363 g of the same material delivered on an ordinary Lufthansa flight from Moscow in August. The arrested smuggler claimed he could deliver several more kilograms of already stolen plutonium from Russia. Additional amounts of HEU and plutonium were reportedly promised in several other cases, although the validity of such claims is difficult to corroborate. Therefore, the cumulative amounts of the seized weapons-usable HEU and plutonium may represent only a fraction of the material already diverted from nuclear installations. In this sense, nuclear smuggling is often compared to drug trafficking. For example, the US law enforcement authorities admit to being able to stop between 10 to 40 % of the drugs illegally imported into the country.[vii] These figures are likely to be even lower in developing countries due to poorer border protection. Assuming that the detection rate for HEU and plutonium before they reach the end-user is similar to that of drugs, the quantity of the material that has been successfully diverted and possibly smuggled to the final destination may be 3 to 10 times higher than what has been interdicted so far.

In most of the 25 incidents, the material was stolen or is suspected to have originated from nuclear facilities in Russia. Nuclear research institutions, fuel production facilities, and naval fuel depots have been the most frequent sites for successful material diversion. Russian weapons laboratories located in closed nuclear cities appear to have been guarded better over the past decade. There was only one diversion attempt that can be referred with a certain degree of confidence to a closed nuclear city, and it was successfully interrupted by the Russian security services in the Chelyabinsk region in 1998.

The first theft of weapons-usable material was noted in Russia in 1992, soon after the collapse of the former Soviet Union, accompanied by an economic downturn and impoverishment of the nuclear sector. An engineer involved in the material weighing and accounting procedures at Luch Scientific Production Association diverted almost daily gram amounts of 90% uranium, which were below the detection limits. Over a four month period he had accumulated 1.5 kg of the material. He was arrested by pure chance at a train station in Podolsk on his way to Moscow, where he intended to find a buyer for the HEU. The thief admitted that he had hoped to sell the material for about US$500, so he could buy a new stove and a refrigerator. Once an elite of the Soviet society, nuclear scientists were suddenly faced with dramatically decreased funding, low wages delayed for months, and bleak prospects for the future. As a result, the security of nuclear material became very vulnerable to the so-called "insider" threat from facility employees, who wanted to improve their financial situation by stealing the material and trying to sell it. In all credible thefts of weapons usable material known to date (*St. Petersburg 1994*, *Moscow 1995*, *Podolsk 1992*, *Andreeva Guba 1994*, *Sevmorput 1994*, *Erlangen 2001*), the material was diverted by insiders with access to fissile nuclear material acting both on their own initiative and upon requests by other individuals (e.g., relatives, middlemen). It should be noted that although the identities of the individuals apprehended in the 1998 diversion attempt in the Chelyabinsk region have not been revealed to the public, Minatom officials in Russia confirmed that they were conspiring facility employees. In five out of the six cases, the material was stolen with the purpose of selling it for profit, although, like in the Podolsk case, the perpetrators had only vague ideas as to where to find a buyer.

Involvement of organized crime groups could be a key factor in a successful transfer of diverted weapons-usable material to the end-user in view of their logistical capabilities in the smuggling of weapons, drugs, and people. Therefore, it is very encouraging that no apparent links to organized crime have been identified in any of the 25 smuggling cases. Also, no hard evidence has been found to link any of these cases to specific end-users, such as rogue nations or terrorist organizations, which remain the least known link in the nuclear smuggling chain.

3. Inherent uncertainties in the current knowledge about illicit trafficking

In order to judge the validity of the current threat assessment, it is essential to also address the inherent uncertainties in the data used for the analysis, such as:

- *Corruption to defeat the physical protection system:* The black market value of weapons-usable nuclear material ranges from a few hundred to several thousand US dollars per gram, which is the equivalent of at least several months' wages for nuclear scientists and security guards in the former Soviet Union or in developing countries. Since corruption is officially acknowledged as a serious problem in many of these countries, it is safe to assume that corruption among personnel guarding and working at nuclear facilities cannot be excluded.
- *Flaws in the material accounting system:* Accounting practices for nuclear material face two major limitations: (a) The mass of radioactive material is derived indirectly from counting events of radioactive decay with its inherent statistical uncertainties. This is generally acknowledged in the fuel production by defining a certain percentage of the nuclear material involved in the process as "material unaccounted for" (MUF) – a potential loophole for covert diversion of material which has already been successfully used in Russia; (b) containers holding nuclear material are equipped with seals of various degree of sophistication. Irrespective of the type of seal, these seals can be successfully faked, i.e., material can be diverted without any apparent tampering with the seal.[viii] Provided that material accounting practices rely predominantly on checking the integrity of such a seal rather than the actual content of the container, diversion of nuclear material may remain undetected for extended periods of time.
- *Inadequate equipment for detecting trafficking:* The characteristic radiation emitted by nuclear material (mainly alpha particles, together with neutrons) is of a type that most border guards and customs officers cannot detect. Provided that they are equipped with a detection device at all, it is usually a simple gamma radiation detector. The situation is more dire still in case of traffickers familiar with the technical specifications of suitable radiation shielding, since their knowledge enables them to successfully bypass even the checkpoints equipped with alpha- and neutron radiation detectors.
- *Limited prevention of illegal border crossings:* Despite major technological and logistical efforts, no country has been able to stop the illegal flow of drugs, immigrants, weapons, or stolen art across its borders. Since the physical amount of nuclear material subject to smuggling is comparatively small, it can be safely assumed that illicit trafficking of the amount of nuclear material needed for a crude nuclear device – about 50 kg of 90% HEU – can be achieved by transporting it across borders on foot or boat using the services of illegal immigrants.
- *Deliberate underreporting of diverted material:* Any report about diversion or interdiction of nuclear material highlights the fact that local and national authorities had lost control over the material due to inadequate material accounting and/or physical protection. This fact in itself may be sufficient reason for some countries not to report each and every such incident. Table 2 above shows several incidents involving HEU that had happened in Russia, but were not officially reported to the IAEA. This suggests that there might have been other such incidents, which were not reported by states and therefore went unnoticed by the general public.

4. Conclusions

Until now, only 25 highly-credible cases of illicit trafficking in nuclear material have become known since recording of such incidents was started in 1991. By comparison, there have been over 800 cases involving illicit trafficking in *other nuclear and radioactive material*, such as low-enriched uranium, yellowcake, medical and industrial radiation sources, during the same period of time. The inherent uncertainties in our current knowledge on nuclear smuggling make it difficult to judge whether trafficking in weapons-usable nuclear material is really such a relatively rare phenomenon, or whether it was and still is carried out in such a clandestine, professional – in criminal terms – manner, that it remains largely undetected. In either case, it is essential to improve our current understanding of the true magnitude of illicit trafficking in nuclear material, since national security and international stability heavily depend on the correct threat assessment.

Lyudmila Zaitseva established- jointly with the co-author Friedrich Steinhausler- the Database on Nuclear Smuggling, Theft and Orphan Radiation Sources (DSTO) as a Visiting Fellow at the Center for International Security and Cooperation (CISAC), Stanford University.

E-mail: lyudmilazaitseva@yahoo.com

Friedrich Steinhausler, Chair of Biophysics and Physics at the University of Salzburg, Austria, is Director of the Government Radiological Measurements Laboratory Salzburg. He is currently chairing the NATO CLG Expert Group "Nuclear Terrorism" . He dealt with nuclear safety related issues as a Senior Officer at the International Atomic Energy Agency (IAEA Division of Nuclear Safety, Vienna) and served as member of the International Commission for Radiological Protection (ICRP) on Committee 4.

E-mail: friedrich.steinhaeusler@sbg.ac.at

---

[i] US President George W. Bush, "…The British Government has learned that Saddam Hussein recently sought significant quantities of uranium from Africa…" , quote from the State of the Union address, 28 January 2003.

[ii] Fissile material with an enrichment level of 20% or more is considered usable for a nuclear weapon according to the definition by the International Atomic Energy Agency (IAEA). However, it should be pointed out that the actual amount of nuclear material needed for building a "crude" nuclear device increases significantly with enrichment levels below 90%.

[iii] Steinhausler, F., "What It Takes to Become a Nuclear Terrorist". American Behavioral Scientist, 1 February 2003, vol. 46, no. 6, pp. 782-795(14), Sage Publications.

[iv] Institute of Science and International Security (ISIS) at www.isis-online.org.

[v] Bunn, G., Steinhausler, F., "Guarding nuclear reactors and material from terrorists and thieves," Arms Control Today, Vol. 31, No. 8, October 2001, pp. 8-12.

[vi] IAEA Office of Physical Protection and Material Security, "Comprehensive List of Incidents Involving Illicit Trafficking in Nuclear Materials and Other Radioactive Sources: Confirmed by States".

[vii] Phil Williams and Paul Woessner, "Nuclear material trafficking: An interim assessment", Working Paper 95-3, Ridgway Viewpoints (Matthew B. Ridgway Center for International Security Studies, University of Pittsburgh: Pittsburgh, Pa., 1995), p. 2.

[viii] Johnston, R., "Effective vulnerability assessment for physical security devices, systems, and programs," Austrian Military Journal (OMZ), Special Edition "Nuclear Material Protection" (2003), pp. 51-55.