

COMBATING NUCLEAR TRAFFICKING IN THE FORMER SOVIET UNION & EASTERN EUROPE:
U.S. NONPROLIFERATION ASSISTANCE AND THE ILLICIT NUCLEAR TRADE, 1997-2009

A Graduate Thesis
Submitted to the Faculty of the
Graduate School of Arts and Sciences
of Georgetown University
in partial fulfillment of the degree requirements for the
degree of
Master of Arts
in Security Studies

By

Sarah G. Weiss, B.A.

Washington, DC
April 15, 2011

Copyright 2011 by Sarah G. Weiss
All Rights Reserved

COMBATING NUCLEAR TRAFFICKING IN THE FORMER SOVIET UNION & EASTERN EUROPE:
U.S. NONPROLIFERATION ASSISTANCE AND THE ILLICIT NUCLEAR TRADE, 1997-2009

Sarah G. Weiss, B.A.

Thesis Advisor: Genevieve A. Lester, M.A.

ABSTRACT

The illicit trafficking of fissile and radioactive materials emerged as a prominent threat following the collapse of the USSR. In the aftermath of September 11th, the issue has received renewed attention due to the increasing concern that terrorists could acquire the necessary materials to develop an improvised nuclear device (IND) or radiological dispersal device (RDD, also known as a dirty bomb). This study first addresses the challenges to working with nuclear trafficking data and conducts a comparative analysis of trends in open vs. restricted-access databases of nuclear smuggling incidents. The study then turns to its main focus: utilizing open-source data to examine the relationship between U.S. funding for threat reduction and border security programs and nuclear smuggling in the former Soviet Union (FSU) and Eastern Europe. In doing so, it seeks to answer two key questions: First, is U.S. funding appropriately targeted to address known smuggling routes? Second, how has U.S. assistance impacted the number of nuclear trafficking incidents in the FSU and Eastern Europe? In the process of answering these questions, the study also identifies and describes a probable Eastern smuggling route through Siberia to South and East Asia.

Table of Contents

I. Introduction	1
II. Definitions	6
III. Scope	8
Dataset Development.....	9
IV. The Reliability of Nuclear Trafficking Data	10
Nuclear Trafficking Data Challenges	11
Database Availability.....	11
Data Quality	12
Implications	17
Nuclear Trafficking Trends in Open vs. Restricted-Access Databases	18
Incidents Over Time	20
Nuclear Material Type	24
Smuggling Routes.....	27
Implications	32
V. The Relationship Between U.S. Assistance and Nuclear Trafficking Incidents	33
U.S. Funding Prioritization and Nuclear Smuggling Routes.....	34
The Shift to the Southern Route	35
Eastern Route	37
Impact of U.S. Funding on Nuclear Trafficking Incidents	38
Region-wide Analysis.....	40
Sub-Regional Analysis	42
VI. Conclusions and Policy Implications	44
Nuclear Trafficking Trends	45
The Relationship Between U.S. Funding and Trafficking Incidents	46
The Eastern Smuggling Route	48
Areas for Future Research	49
VII. Appendix: Incidents Involving Weapons-Usable Nuclear Material	51
VIII. Bibliography	52

I. Introduction

In the aftermath of the Soviet Union's disintegration, the risk of unsecured nuclear and radiological materials being sold on the black market became a major concern for Russia and the West. With the collapse of the economy and the breakdown of security at nuclear facilities throughout the former Soviet Union (FSU), impoverished nuclear scientists and military officers had both incentive and opportunity to divert nuclear materials for personal gain. Beginning in the early 1990s, nuclear and radioactive materials reportedly originating from former Soviet facilities, including uranium and plutonium as well as other radiological sources, began appearing in smuggling incidents in Europe and the FSU. Since 1991, the International Atomic Energy Agency (IAEA) has recorded over 1500 confirmed incidents in its Illicit Trafficking Database (ITDB), including over 300 attempts to illegally sell or transport nuclear or radioactive substances.¹ While the majority of these incidents involve low-threat materials, the ITDB has recorded over a dozen incidents involving weapons-grade uranium or plutonium,² and reports indicate an even higher number involving high-risk radioactive material that could be used to create a radiological dispersal device (RDD, also known as a dirty bomb).

Black market nuclear smuggling is a critical potential acquisition pathway for aspiring nuclear states or terrorist groups. In the immediate aftermath of the Cold War, scholars and policymakers were primarily concerned with "loose" nuclear weapons and

¹ International Atomic Energy Agency, "Illicit Trafficking Database Factsheet," September 2009.

² For a full list of confirmed and credible incidents involving weapons-usable material, see the Appendix.

material that could be used to accelerate the nuclear ambitions of states such as North Korea, Pakistan, Iraq, and Iran. For example, Graham Allison argued in 1996 that:

The defining danger of proliferation of nuclear weapons is not Iran's purchase of civilian nuclear reactors that may assist Iranian nuclear ambitions a decade hence; it is the threat that today, or tomorrow, Iran will purchase nuclear weapons or fissile material from some fragment of the current Russian nuclear system.³

At that time, the possibility of terrorist groups obtaining nuclear capabilities was considered, but generally only as an afterthought. Over the past decade, however, the prospect of nuclear terrorism has become the more prominent concern. This shift was primarily driven by two factors: 1) New indications of terrorist interest in nuclear and radiological weapons (particularly from al Qaeda and affiliated groups), and 2) Growing evidence that aspiring nuclear states prefer to build full nuclear programs by acquiring dual-use capabilities. While trafficking in nuclear materials could potentially provide immediate access to fissionable material, relying on this mechanism would leave a country wholly reliant on smuggling rings for access to nuclear materials. The A.Q. Khan network, a sophisticated scheme for illicitly transferring dual-use nuclear technology, clearly demonstrated that nations seeking nuclear weapons prefer to develop self-sustaining nuclear programs rather than depend on criminal elements for access to weapons-usable nuclear material. In contrast, terrorist organizations have been deemed less likely to require independent, scalable nuclear programs and more likely to seek quick access to nuclear or radioactive materials via the black market.

³ Graham Allison, *Avoiding Nuclear Anarchy: Containing the Threat of Loose Russian Nuclear Weapons and Fissile Material*, Cambridge: MIT Press, 1996, 7. See also Rensselaer Lee, *Smuggling Armageddon: The Nuclear Black Market in the Former Soviet Union and Europe*. New York: St. Martin's Press, 1998, 23-5.

Indeed, the illicit trafficking of nuclear and radioactive materials has received renewed consideration in the aftermath of September 11, and in particular in the latter half of the decade. The importance of this concern was clearly demonstrated in 2007, when approximately 300 participants from 60 countries came together for a major international conference on nuclear trafficking.⁴ The issue rose to even greater prominence under the Obama Administration, taking center stage during President Obama's high-profile April 2009 speech in Prague. During this address, President Obama highlighted the threat of nuclear trafficking as a key motivating factor for his initiative to secure all nuclear materials in four years.⁵ In accordance with this effort, the leaders of 47 nations gathered in Washington, D.C. for the 2010 Nuclear Security Summit, at which nuclear trafficking was an important topic of discussion.⁶

Though recent years have seen a renewed focus on nuclear security issues, the United States has overseen an extensive financial and technical assistance effort since the early 1990s to help secure nuclear materials at their source and detect illicit materials in transit. These initiatives include, for example, the Cooperative Threat Reduction (CTR) program (also known as Nunn-Lugar), the Department of State Export Control and Related Border Security (EXBS) program, and a variety of programs under the National Nuclear Security Administration (NNSA), a semi-autonomous agency within the Department of Energy. Through such endeavors, the U.S. government works closely

⁴ "Proceedings of the International Conference on Illicit Nuclear Trafficking: Collective Experience and the Way Forward," International Atomic Energy Agency, 2008.

⁵ Office of the Press Secretary, "Remarks by President Obama," The White House, 5 April 2009, <http://www.whitehouse.gov/the-press-office/remarks-president-barack-obama-prague-delivered>.

⁶ Office of the Press Secretary, "Key Facts about the Nuclear Security Summit," The White House, 13 April 2010, <http://www.whitehouse.gov/the-press-office/key-facts-about-national-security-summit>.

with partners around the world to prevent and respond to nuclear trafficking incidents. Combined, the United States devotes over a billion dollars to these efforts each year, with over 80% of this amount dedicated to enhancing nuclear site security and interdicting nuclear smuggling.⁷ In total, the U.S. has spent over \$18 trillion on nuclear security initiatives since 1991.⁸

This study will utilize open-source data to examine the relationship between U.S. funding for threat reduction/border security programs and illicit nuclear trafficking incidents in the FSU and Eastern Europe. In doing so, this study will endeavor to answer two key questions: First, how reliable is the available data on nuclear trafficking incidents, particularly the data contained in open databases? Second, what correlations can be drawn between U.S. nonproliferation assistance and nuclear trafficking incidents?

The answers to these questions will constitute a unique contribution to the existing literature on nuclear trafficking and nonproliferation programs. In publications such as the International Institute for Strategic Studies' dossier on *Nuclear Black Markets*, analysts have previously compared trafficking trends between two restricted-access databases, the IAEA Illicit Trafficking Database (ITDB) and the Database on Nuclear Smuggling, Theft, and Orphan Radiation Sources (DSTO), a proprietary

⁷ Matthew Bunn, *Securing the Bomb 2010: Securing All Nuclear Materials in Four Years*, Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard University, April 2010, 85.

⁸ Project on Managing the Atom, *Securing the Bomb Interactive Budget Database*, Belfer Center for Science and International Affairs / Nuclear Threat Initiative. Available online at http://www.nti.org/e_research/cnwm/charts/cnm_funding_interactive.asp.

database maintained by researchers at the University of Salzburg.⁹ However, the academic literature has yet to compare these datasets to trends contained in the Newly Independent States (NIS) Nuclear Trafficking Database maintained by the James Martin Center for Nonproliferation Studies (CNS), a fully open database available on the Nuclear Threat Initiative (NTI) website.¹⁰ Furthermore, while previous research has addressed trends in nuclear trafficking incidents and the details of U.S. funding for nuclear security programs, no analysis has yet been conducted that ties these two datasets together to identify correlations or causal relationships. Current government and non-governmental assessment metrics for these assistance programs are limited to calculating completion percentages or adherence to a set standard for “meeting key requirements.”¹¹ While such measurements are useful performance metrics, they fall short of considering such programs’ impact on nuclear trafficking—the core phenomenon they are intended to halt. This study endeavors to address this critical gap by directly examining the link between U.S. assistance programs and known nuclear trafficking incidents. It does not purport to produce the definitive work on this subject; rather, this study aims to undertake an initial analysis while setting the stage for further research on these complex questions.

⁹ Mark Fitzpatrick, ed., *Nuclear Black Markets: Pakistan, A.Q. Khan and the rise of proliferation networks* (London: International Institute for Strategic Studies, 2007), 121-5.

¹⁰ James Martin Center for Nonproliferation Studies (CNS). *NIS Nuclear Trafficking Database*. Nuclear Threat Initiative. Available online at <http://www.nti.org/db/nistraff/index.html>.

¹¹ See, for example, the metrics included in the *Securing the Bomb* series from 2004-2008, or those provided by the National Nuclear Security Administration in its congressional budget justification: NNSA, “FY 2011 Congressional Budget Request,” Department of Energy, February 2010, http://nnsa.energy.gov/sites/default/files/nnsa/inlinefiles/nnsa_fy2011_budget_request.pdf, 353-4.

II. Definitions

The following key terms will be used throughout this study:

- **Discrete incident:** A specific seizure or theft of nuclear or radioactive material. Such individual incidents are thus distinguished from bulk statistics that reference a collection of incidents taking place over months or years.
- **Nuclear materials:** Materials usable in the nuclear fuel cycle or nuclear weapons, including plutonium (Pu), uranium (U), and thorium (Th). This incorporates natural and depleted uranium as well as plutonium radiation sources used in commercial devices, such as smoke detectors. As such, not all materials in this category are weapons-usable or even toxic; for example, neither natural nor depleted uranium poses a weapons or public health risk.
- **Nuclear trafficking / nuclear smuggling:** In the context of this study, these terms will be used as a catch-all to refer to the illicit movement and sale of both fissionable nuclear materials and other radioactive materials, including radioisotopes commonly used in industrial and commercial applications.
- **Open database:** A database that is fully accessible by the general public. The only open database of nuclear and radiological trafficking data is the NIS Nuclear Trafficking Database maintained by CNS.
- **Orphan sources:** Radioactive materials without any identifiable owner or responsible party. Many such orphan sources are believed to have been abandoned in military and industrial facilities following the USSR's collapse. When relying on media reports, a particular source's status as "orphan" is

subject to interpretation. This study used a conservative interpretation, only categorizing materials as orphan when they were clearly abandoned, not simply discovered outside the immediate possession of their owner.

- **Other materials:** Materials that, while neither nuclear nor radioactive, are sold or offered for sale as part of a scam or hoax. Two common examples are osmium-187 and so-called “red mercury.”¹²
- **Other radioactive materials:** Non-fissionable radioisotopes that pose a potential public health risk through passive contamination or incorporation into an RDD. Prominent examples include cesium-137, cobalt-60, americium-241, and strontium-90.
- **Radioactively contaminated materials:** Non-radioisotopes that emit radiation due to proximity or exposure to ionizing radiation. Such materials are most often radioactive scrap metal, but other examples include radioactively contaminated food, tools, and objects.
- **Restricted-access database:** A database that is not fully available to the general public due to classification or proprietary ownership. The IAEA ITDB and the University of Salzburg’s DSTO both fall into this category, as do the databases maintained by Interpol, the WCO, and the US National Labs. As noted above, however, broad trends and statistics may still be available for restricted-access databases, as they are for the ITDB and DSTO.

¹² Kenley Butler and Akaki Dvali, “Nuclear Trafficking Hoaxes: A Short History of Scams Involving Red Mercury and Osmium-187,” CNS, April 2004, http://www.nti.org/e_research/e3_42a.html.

III. Scope

This study will examine nuclear trafficking in the FSU/Eastern Europe and U.S. assistance measures designed to secure nuclear materials and halt smugglers trafficking in radioactive substances. The analysis will focus on the years 1997-2009, and will include incidents involving materials originating in or trafficked through any former Soviet republic.

The type of nuclear smuggling examined in this study is distinct from the black market networks that facilitated the proliferation of nuclear dual-use technologies to countries like Pakistan, North Korea, Libya, and Iran. These networks, while also a vital component of proliferation, are largely characterized by different materials, actors, and goals. Rather than trafficking in radioactive materials, the Khan network—for example—primarily focused on importing (and later exporting) the technologies necessary to enrich uranium and reprocess plutonium to produce weapons-usable material. As such, this operation involved networks of front companies and middlemen through which Khan purchased dual-use materials from legitimate businesses in Europe and Asia.¹³ In contrast, nuclear trafficking is traditionally believed to involve insiders with access to nuclear material and criminal middlemen responsible for the movement and sale of the stolen material.¹⁴ The goals and long-term implications of these two activities are similarly disparate: as noted earlier, obtaining weapons-usable material through nuclear trafficking is a potential “quick fix” for aspiring nuclear countries that

¹³ Fitzpatrick 2007, 23-31.

¹⁴ Lyudmila Zaitseva and Kevin Hand, “Nuclear Smuggling Chains: Suppliers, Intermediaries, and End-Users,” *American Behavioral Scientist* 46, no. 6 (February 2003): 822-32.

nonetheless leaves them dependent on smugglers. In contrast, trading in dual-use technology allows a country or organization to build a self-sufficient nuclear program, but entails a complex development process that takes years to produce usable material.

Based on this distinction, this study will not consider U.S.-funded programs that primarily or exclusively aim to halt dual-use trafficking, such as the Proliferation Security Initiative (PSI) or NNSA's International Nonproliferation Export Control Program (INECP). Rather, it will focus on threat reduction and border security programs, which are designed to secure nuclear materials at their source and to enhance radiation detection capabilities, thereby ensuring that smuggled materials are identified and seized at key transit points, such as border crossings, ports, and airports.

Dataset Development

The dataset of nuclear trafficking incidents used in this research was compiled from incident reports contained in the NIS Nuclear Trafficking Database.¹⁵ It includes incidents that took place between October 1996 and December 2009, to allow for analysis of the years 1997-2009 based on both calendar year and fiscal year. In accordance with the scope as described above, the following types of incidents were excluded from the dataset:

- Incidents involving nuclear dual-use technologies or parts.
- Incidents involving material that neither originated in nor was trafficked through the FSU or Eastern Europe.

¹⁵ The dataset is available in read-only form online at <http://bit.ly/TraffickingDataset>. To obtain a full version of the dataset in Microsoft Excel format, contact the author at: sw368 at georgetown dot edu.

- Incidents that could not be assigned to a specific year.
- Entries with bulk statistics for a given time period. Given that these statistics were not available for each country or jurisdiction, including such figures would drastically skew the results.
- Incidents where legally transported materials were mistakenly seized.
- Unconfirmed reports regarding the theft, loss, or sale of nuclear weapons.¹⁶

Each incident included in the dataset was assigned to a specific country. Thefts were assigned to the country where the theft took place (i.e. the country of origin), while seizures were assigned to the country where the material was seized. For incidents that took place in Russia, the oblast or city was recorded as well to facilitate a more detailed analysis of nuclear smuggling routes.

IV. The Reliability of Nuclear Trafficking Data

Analysts researching nuclear trafficking face significant obstacles to obtaining accurate data on stolen and/or smuggled nuclear and radiological materials. These issues, which are discussed in depth below, guarantee that any compilation of trafficking incidents will include uncertain information. Furthermore, reports of discrete incidents likely comprise a small percentage of actual incidents, while the total number of known thefts and intercepted materials likely represents only a fraction of all nuclear smuggling operations. This section will first examine these data challenges before considering their

¹⁶ On multiple occasions, reports have surfaced claiming that nuclear weapons had been sold by or stolen from former Soviet states. None of these reports has been confirmed, and the implicated governments have flatly denied all such reports. These incidents were therefore excluded to avoid skewing the data on cases involving nuclear materials.

impact on the trends shown across nuclear trafficking databases. In doing so, this study aims to determine the extent to which the NIS Nuclear Trafficking Database can serve as a robust foundation for research into the relationship between nuclear smuggling and U.S. assistance programs.

Nuclear Trafficking Data Challenges

Though widely acknowledged among researchers in the field, the limitations of nuclear trafficking data are rarely discussed in any prominent or in-depth manner in nuclear trafficking literature. One notable exception is William C. Potter and Elena Sokova's 2002 article on "Illicit Nuclear Trafficking in the NIS: What's New? What's True?", which provides a discussion and examples of the limited reliability of nuclear trafficking data due to underreporting, over-reporting, concealment and intentional distortion of information, and conflicting information.¹⁷ This section builds on their work to provide a comprehensive evaluation of the challenges of working with nuclear trafficking data and the implications for research in this field.

Database Availability

Numerous national, international, and non-governmental entities have developed databases of nuclear trafficking incidents. These databases are primarily maintained by government or international organizations, such as the IAEA, INTERPOL, the World Customs Organization (WCO), or the U.S. national laboratories.¹⁸ Access to these

¹⁷ William C. Potter and Elena Sokova, "Illicit Nuclear Trafficking in the NIS: What's New? What's True?" *Nonproliferation Review* 9, no. 2 (Summer 2002): 113-20.

¹⁸ Fitzpatrick 2007, 120.

databases is restricted to official government personnel due to the confidential nature of the reports they contain. Two additional databases are based out of academic institutions or think tanks and rely primarily on open sources: the DSTO and the NIS Nuclear Trafficking Databases. Although an academic institution maintains the DSTO, the database is considered proprietary based on the sensitive nature of some of its contents. As such, access is restricted to the researchers who maintain it and a small number of collaborators.¹⁹ Thus, the only database openly available to the general research community is the NIS Nuclear Trafficking Database, which is substantially smaller than other databases. For example, the NIS Nuclear Trafficking Database contains 333 incidents between 1997 and 2005,²⁰ compared to over 600 in the ITDB and over 1000 in the DSTO.²¹

Data Quality

Regardless of the number of incidents they contain, all nuclear trafficking databases suffer from data quality and data reliability issues. Underreporting is a common occurrence, even for databases based on restricted government reporting, like the ITDB. As Potter and Sokova note, information sharing between governments—and with international organizations like the IAEA—remains limited with regard to nuclear smuggling incidents; often, very few details about the specifics of smuggling cases are

¹⁹ Author's correspondence with Lyudmila Zaitseva, Division of Physics and Biophysics at the University of Salzburg, 11 November 2010.

²⁰ Based on the dataset developed for this study.

²¹ Approximate values for the ITDB and DSTO based on the charts in Fitzpatrick 2007, 121-2.

known or shared, even for incidents where the perpetrators face prosecution.²² In a paper presented at the 2007 Edinburgh conference on Illicit Nuclear Trafficking, Galya Balatsky and William Severe emphasized that “in addition to the information on trafficked materials and the facilities they came from, we need information on perpetrators, their motivation and trafficking behavioural patterns” to enable an adequate analysis of trafficker intent; such details are frequently lacking from smuggling incident reports.²³

Moreover, governments are often slow to inform the IAEA about trafficking incidents, with most reports trickling in 2-3 years after the actual occurrence²⁴ — if they are submitted at all. National governments may also have an incentive to over-report incidents to the IAEA in order to appear cooperative or to overstate their success in interdicting smuggled nuclear materials. As an example, Potter and Sokova highlight an alleged Russian seizure of highly enriched uranium (HEU) in 1994, during which 3 smugglers were arrested. Some analysts question whether this incident was exaggerated or invented, based on its lack of corroboration by other sources and the fact that the supposed perpetrators do not appear to have been prosecuted.²⁵

These cases of both over-reporting and underreporting highlight the selection bias inherent to nuclear trafficking data. All of the available databases on nuclear smuggling

²² Potter and Sokova 2002, 117.

²³ G.I. Balatsky and W. Severe, “Assessing the Phenomenon of Nuclear Trafficking,” *Illicit Nuclear Trafficking: Collective Experience and the Way Forward*, Conference Proceedings (Vienna: International Atomic Energy Agency, 2008): 95-6.

²⁴ International Atomic Energy Agency (IAEA), “IAEA Illicit Trafficking Database (ITDB),” Fact Sheet, 1 September 2010, <http://www-ns.iaea.org/downloads/security/itdb-fact-sheet.pdf>.

²⁵ Potter and Sokova 2002, 117.

rely heavily on incidents that have been self-reported, either to the IAEA, the media, or directly from a government official to the database owner.²⁶ In countries with robust freedom of the press, this effect might be partially mitigated by the possibility that investigative journalists would uncover an incident the government attempted to hide.²⁷ As a result, the databases based on open-source media reports—though subject to their own limitations, as discussed below—may be less vulnerable to selection bias than the consolidated figures published based on the ITDB, which are entirely dependent on self-reporting.²⁸

However, even if governments fully and openly reported all incidents to both the IAEA and the media, the data contained in nuclear trafficking databases would be unlikely to accurately encompass the entirety of nuclear smuggling operations. Although border security and materials protection, control, and accounting (MPC&A) programs have undoubtedly improved governments’ ability to detect the theft and movement of nuclear and radioactive materials, many (if not most) smuggling operations likely circumvent such controls.²⁹ Furthermore, “there is a high probability...that the sample [of nuclear trafficking cases] we have discerned is unrepresentative of the larger universe of incidents.”³⁰ Indeed, the totality of known incidents likely skews heavily towards less

²⁶ Balatsky and Severe 2007, 96.

²⁷ For further discussion of this point, see Emily S. Ewell, “NIS Nuclear Smuggling Since 1995: A Lull in Significant Cases?” *Nonproliferation Review* 5, no. 3 (Spring-Summer 1998): 122.

²⁸ Although the ITDB includes incidents derived from media reports, only incidents confirmed by a participating government partner are included in published statistics.

²⁹ Fitzpatrick 2007, 126-7.

³⁰ Potter and Sokova 2002, 116.

sophisticated smuggling networks that possess fewer mechanisms for avoiding detection.³¹

Questions of data reliability become even more prevalent when drawing primarily or exclusively on open-source information. Governments may have many motivations for reporting or not reporting incidents in the open press: while halting an attempt to smuggle material into the country reflects well on that government's interdiction capabilities, other incidents could reflect negatively on the government—for example, the theft of nuclear material, or the seizure of material whose theft or transit into the country went undetected. Russia, for instance, has displayed an inconsistent approach to reporting nuclear incidents; on some occasions it has denied the very possibility that material could be stolen from Russian facilities, while at other times officials have acknowledged security shortfalls and the occurrence of numerous thefts or attempted thefts.³² Unsurprisingly, the information governments report to the IAEA does not always match the information released to the public.³³ The degree of government

³¹ See Ewell 1998, 122-3 and Rensselaer Lee, "Why Nuclear Smuggling Matters." *ORBIS* 52, no. 3 (Summer 2008): 434-8. Lee has similarly addressed the distinction between the "visible" and the "shadow" nuclear trafficking market in previous works, including "Nuclear Smuggling: Patterns and Responses," *Parameters* 33, no. 1 (2003): 95-111 and *Smuggling Armageddon: The Nuclear Black Market in the Former Soviet Union and Europe*, New York: St. Martin's Press, 1998.

³² See, for example, "Ministry Denies Nuclear Material Thefts From Closed Complex," NIS Nuclear Trafficking Database, 11 April 1997, <http://nti.org/db/nistr Traff/1997/19970211.htm>; "Fissile Materials Have Never Been Missing From Russian Nuclear Facilities," NIS Nuclear Trafficking Database, 16 March 2005, <http://www.nti.org/db/nistr Traff/2005/20050100.htm>; "Rosatom Head Assesses Security at Russian Nuclear Facilities," NIS Nuclear Trafficking Database, 16 September 2004, <http://www.nti.org/db/nistr Traff/2004/20040460.htm>; "Gosatomnadzor Head on Accounting Anomalies, Radiation Source Theft," NIS Nuclear Trafficking Database, 10 December 2003, <http://www.nti.org/db/nistr Traff/2003/20030830.htm>; "Minatom Official Discusses Attempted Thefts of Fissile Material," NIS Nuclear Trafficking Database, 28 September 2000, <http://www.nti.org/db/nistr Traff/2000/20000730.htm>.

³³ *Ibid*, 117.

transparency in a given country likely has a strong influence on the percentage, types, and accuracy of incidents reported to the media.

Moreover, of the total incidents that governments record, only a small fraction are reported individually in the press or accounted for as individual incidents in trafficking databases. For example, Russia's Federal Customs Service announced in December 2007 that, between January and November of that year, it intercepted approximately 850 attempts to illicitly traffic materials with elevated levels of ionizing radiation.³⁴ The NIS Nuclear Trafficking Database, however, records only 14 discrete incidents in Russia during that same time period. While the database may not include every media report published on the subject, a discrepancy of this magnitude is more likely due—at least in part—to selective reporting by journalists. Nuclear trafficking has been a common topic of discussion since the early 1990s, with hundreds of incidents occurring each year; as such, it is reasonable to expect a degree of reporting fatigue within the media.

Many of the incidents that do receive media attention are reported inaccurately or inconsistently. Whether due to honest confusion or deliberate sensationalizing, the press has a tendency to incorrectly report incidents as involving weapons-grade uranium or plutonium rather than less dangerous nuclear material or other radioactive isotopes. This type of exaggeration was most pronounced in the first half of the 1990s, but it continues to occur on a regular basis—especially in initial reports filed before the authorities can

³⁴ “Russia's Federal Customs Service Releases Trafficking Statistics,” NIS Nuclear Trafficking Database, 21 December 2007, <http://www.nti.org/db/nistraff/2007/20070360.html>.

conclusively identify the relevant radioactive materials through testing.³⁵ For example, a February 2004 seizure of radioactive material on the Ukrainian-Hungarian border was initially reported to involve enriched uranium and weapons-grade plutonium. Subsequent reports, however, revealed that the only nuclear material seized was depleted uranium (which is neither weapons-usable nor dangerous).³⁶ Beyond confusion as to the type of nuclear or radioactive material seized or stolen, news stories often contain inconsistent details regarding the quantity or value of materials involved, the alleged perpetrators, or even the location of the incident.³⁷ Depending on which sources they use, different databases may thus record different details pertaining to the same incident. Each database is, therefore, only as accurate as the sources it relies upon; the NIS Nuclear Trafficking Database, for instance, includes an explicit warning to this effect:

These abstracts are taken from open press sources and unclassified government documents and are presented on an as-reported basis. The James Martin Center for Nonproliferation Studies cannot vouch for the accuracy or veracity of these reports, nor can it verify reported facts in the abstracts.³⁸

Implications

Based on these factors, the various established databases will have different strengths and weaknesses depending on the sources they use to populate their database. Those that primarily rely on self-submitted, official government reports—like the ITDB and the databases maintained by the WCO and Interpol—are often hampered by delayed notification and are limited to the information provided by their government partners,

³⁵ Potter and Sokova 2002, 117.

³⁶ “Ukrainian Police Detail Radioactive Contraband Seizure,” NIS Nuclear Trafficking Database, 24 February 2004, <http://www.nti.org/db/nistr Traff/2004/20040050.htm>.

³⁷ Potter and Sokova 2002, 118.

³⁸ NIS Nuclear Trafficking Database, <http://www.nti.org/db/nistr Traff/>.

who may not be acting from a policy of full disclosure. On the other hand, databases that rely primarily on open-source reports will incorporate new incidents more quickly, but may be limited by the inaccuracies, inconsistencies, and penchant for exaggeration the media traditionally displays when covering nuclear trafficking issues. Ultimately, all nuclear trafficking databases must be assumed to contain questionable and/or inconsistent data. Therefore, any conclusions based on such data—including those drawn in subsequent sections of this study—must be considered tentative.

Nuclear Trafficking Trends in Open vs. Restricted-Access Databases

The challenges associated with nuclear trafficking data would, on the surface, lead one to expect the various databases to contain entirely inconsistent information. There is some evidence to support this expectation; for instance, a 1998 article in *Nucleonics Week* discussed the lack of harmonization between the ITDB and the databases maintained by the WCO and Interpol.³⁹ Yet, a 2007 analysis of the ITDB and DSTO showed that the two databases generally displayed the same broad trends, despite the probable inconsistencies between the specific data points they contain.⁴⁰

That comparative analysis, however, did not include data from CNS's NIS Nuclear Trafficking Database. This comparison is particularly critical, as the CNS database is the only compilation of nuclear trafficking incidents openly available to most academic researchers or journalists focusing on the subject. This section will compare

³⁹ Mark Hibbs, "IAEA, WCO, Interpol May Try to Harmonize Contraband Data," *Nucleonics Week* 39, no. 40 (1 October 1998), 18.

⁴⁰ Fitzpatrick 2007, 121-4.

data from the NIS Nuclear Trafficking Database to published trends from the ITDB and DSTO in order to determine whether the same trends hold true across open and restricted-access databases. As the previous analysis makes clear, the challenges to working with trafficking data implies that no database may accurately incorporate the entirety of nuclear smuggling incidents. However, consistency across databases allows comparability with existing research and—for broad trends—may indicate an accurate approximation of the visible nuclear trafficking landscape. As such, a reasonable level of consistency is necessary to move forward with further analysis based on the NIS Nuclear Trafficking Database. Thus, this study will test the following baseline hypothesis:

Hypothesis: Open databases on nuclear trafficking incidents should show the same general trends as restricted-access databases.

To perform this analysis, I utilized the dataset compiled for this project based on data from the NIS Nuclear Trafficking Database, as described above. In accordance with the scope of this research project, the dataset covers the years 1997-2009; as such, it does not provide an exact match for the years analyzed in prior publications (such as *Nuclear Black Markets*, which covered the period from 1992-2005).⁴¹ However, the existing overlap from 1997-2005 provides sufficient basis for a comparative analysis in three areas: incidents over time, nuclear material type, and smuggling routes.

⁴¹ Although the IAEA has continued to publish yearly reports with summary data from the ITDB, the reporting methodology changed after 2005. From 2006-2010, incidents are now divided based on type (seizure, theft, or orphan/other) rather than by material type. As such, it was not possible to extend the data from *Nuclear Black Markets* to cover the years from 2006-2010.

Incidents Over Time

To develop a chart of nuclear trafficking incidents over time, each incident in the dataset was assigned to a calendar year and a category based on the type of material involved: Nuclear, Nuclear and Other Radioactive, Other Radioactive, Orphan, Radioactively Contaminated, and Other.

All three databases show a similar overall trend between 1997-2002, when the total number of incidents is generally steady with a slight rise in the early 2000s. However, the data indicates a considerable discrepancy between databases beginning in 2003-2004. In 2004, the NIS Nuclear Trafficking Database shows a notable drop in incidents (from 53 in 2003 to 31 in 2004), while the number of incidents in the ITDB doubled in the same time period (from approximately 57 in 2002 to approximately 130 in 2004). According to the IAEA, the prominent spike in incidents recorded in 2003-2004

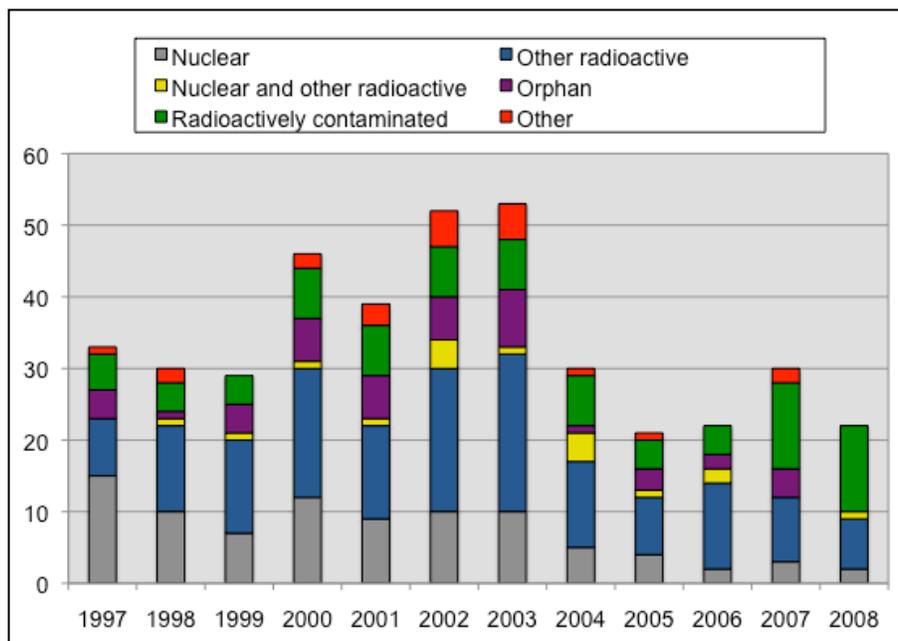


Figure 1: NIS Nuclear Trafficking Database incidents, 1997-2009

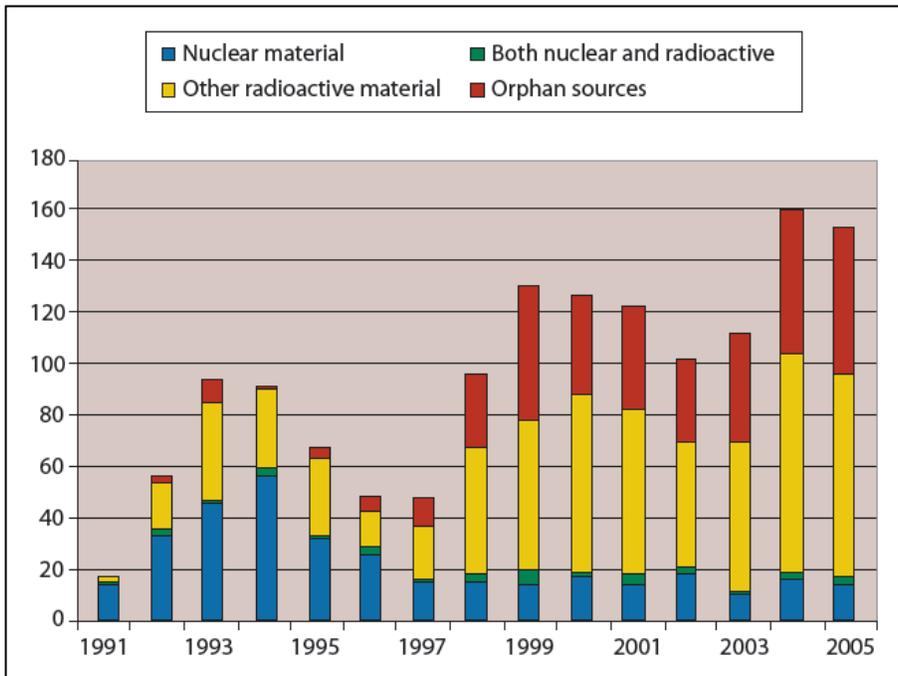


Figure 2: DSTO incidents, 1991-2005⁴²

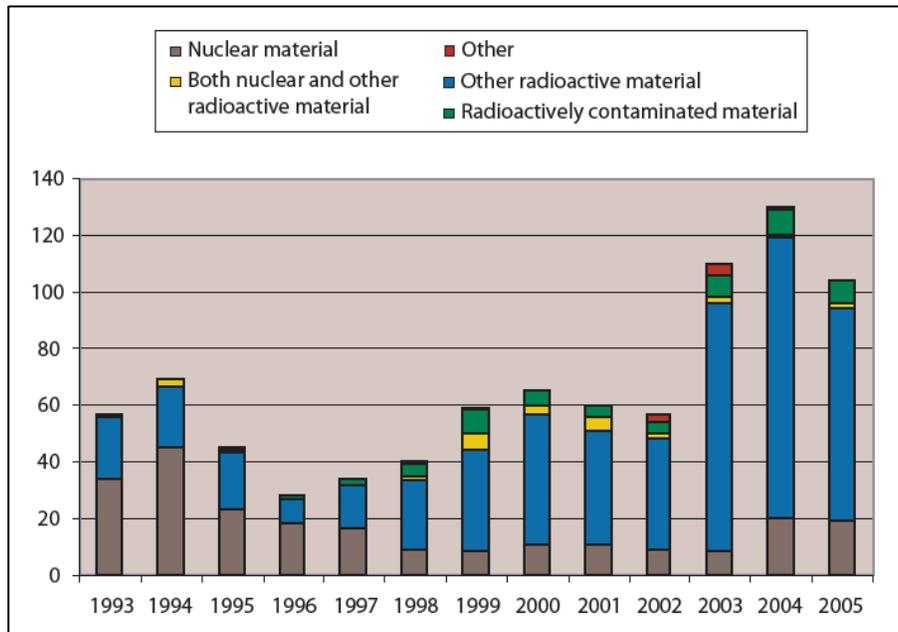


Figure 3: ITDB incidents, 1993-2005⁴³

⁴² Fitzpatrick 2007, 122.

⁴³ Fitzpatrick 2007, 121.

may be due to improved reporting from IAEA member countries rather than an actual increase in nuclear trafficking activity.⁴⁴ However, the DSTO also indicates a rise in incidents beginning in 2004, though the increase is less extreme (from approximately 100 in 2002 to 160 in 2004) than that shown by the ITDB. Though not included in Figure 2 above, the DSTO continues to show a rise in incidents through 2007, and in fact indicates that “the number of cases recorded between 2001 and 2009 has virtually doubled as compared to the previous decade.”⁴⁵ This discrepancy between the NIS Nuclear Trafficking Database and the other two databases could result from the shifting geographic origin of smuggled material; in contrast to the dataset used for this study, the ITDB and DSTO both include data from worldwide incidents rather than just the FSU and Eastern Europe. Alternatively, the drop in incidents could indicate that the NIS Nuclear Trafficking Database may not accurately reflect the real-world trend in nuclear smuggling cases after 2003. Rather, this trend may instead result from methodological or personnel changes in the management of the database, such as alterations to project staff, the sources used, or the approach to gathering incident reports.

The number of incidents involving nuclear materials is roughly consistent across databases between 1997 and 2003, with all three finding approximately 10-20 cases per year involving uranium, plutonium, or thorium (a less well-known element that can also serve as nuclear reactor fuel). The seizure of any type of nuclear materials is likely to

⁴⁴ IAEA, “IAEA Illicit Trafficking Database (ITDB),” Fact Sheet, 31 December 2004, http://www.iaea.org/newscenter/features/radsources/pdf/itdb_31122004.pdf.

⁴⁵ Lyudmila Zaitseva, “Nuclear Trafficking: 20 Years in Review,” Paper presented at the World Federation Of Scientists International Seminars on Planetary Emergencies, 43rd Session, Erice, Italy, 19-25 Aug 2010.

draw significant media attention; such incidents would also be high priorities for governments to report to the IAEA. Thus, it is reasonable that databases would show greater consistency in the number of reported incidents involving nuclear material than those involving other types of radioactive material. This finding also supports Potter and Sokova's conclusion that the media more often confused nuclear and other radioactive materials in the early 1990s. If the media continued to regularly report radioactive materials as nuclear materials, one would expect the NIS Nuclear Trafficking Database and the DSTO to show a significantly higher number of nuclear incidents than the ITDB.

The ITDB has not consistently distinguished orphan radioactive materials separately from other radioactive sources. The DSTO, however, reports substantially more orphan cases than the NIS Nuclear Trafficking Database; orphan cases also constitute a much higher percentage of cases in the DSTO. This difference is likely due to two factors: database size and data interpretation. As discussed in the Database Availability section, the DSTO is significantly larger than the NIS Nuclear Trafficking Database, with four or five times the number of incidents—if not more—in any given year. Furthermore, as noted earlier, it is often unclear whether seized radioactive material is truly orphaned or simply discovered in the absence of its owner. In categorizing the material type involved in each incident, using a less conservative definition of “orphaned” radiation sources could have a considerable impact on the number of cases identified as such.

Nuclear Material Type

In order to allow a more detailed analysis of the fissionable isotopes involved in smuggling incidents, each case entailing nuclear material was assigned a more specific designation of material type based on isotope and enrichment level.

As Figures 4 and 5 show, the percentages of nuclear material types involved in incidents in the NIS Nuclear Trafficking

Database generally align with the DSTO.⁴⁶ Both databases show similar percentages of plutonium in sources (7% in the NIS Nuclear Trafficking Database vs. 6% in the DSTO); HEU (6% vs. 7%); LEU (27% vs. 29%); and natural uranium, depleted uranium, and thorium (30% vs.

39%). In the absence of an explicit category for incidents that involved uranium of an unknown enrichment level, DSTO incidents of this type were placed into the “unidentified” category.⁴⁷ This segment, which represents 16% of

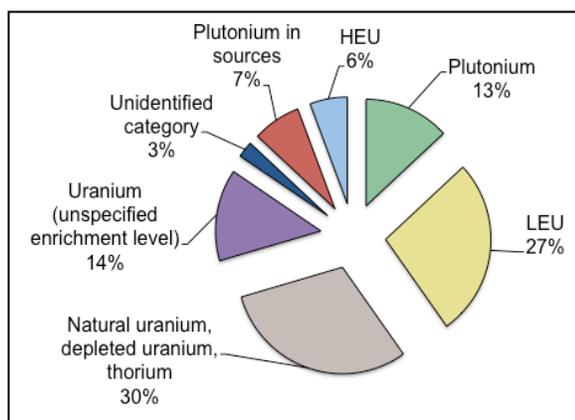


Figure 4: Nuclear material type, NIS Nuclear Trafficking Database, 1997-2009

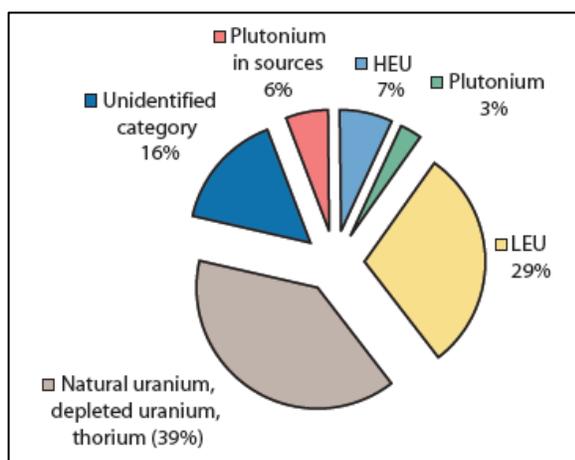


Figure 5: Nuclear material type, DSTO, 1991-2005

⁴⁶ DSTO and ITDB data from Fitzpatrick 2007, 123.

⁴⁷ Author's correspondence with Lyudmila Zaitseva, Division of Physics and Biophysics at the University of Salzburg, 4 April 2011.

nuclear incidents in the DSTO, constitutes a similar percentage to the combined categories of “unidentified” and uranium (unspecified enrichment level) in the NIS Nuclear Trafficking Database (3% and 14% respectively, for a total of 17%).

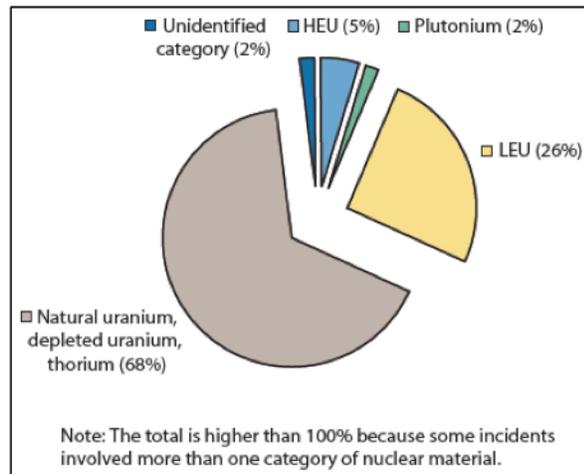


Figure 6: Nuclear material type, ITDB, 1993-2005

The one disparity between these two databases is the percentage of incidents involving plutonium; such cases represented only 3% of nuclear incidents in the DSTO, compared to 13% of nuclear incidents in the NIS Nuclear Trafficking Database. None of the plutonium seizures recorded in the NIS Nuclear Trafficking Database occurred between 2006 and 2009; as such, this disparity is not merely an effect of the different time periods. The discrepancy is most likely the result of exaggerated media reports mistakenly identifying seized radioactive material as plutonium. As discussed earlier, there are numerous instances where initial news stories reported the discovery of smuggled plutonium, only to have later reports reveal that no plutonium was involved. For example, in December 1996 Bulgarian police seized a set of containers that were initially reported to contain “highly radioactive materials, including uranium, plutonium, radium, iridium, and cesium-137.”⁴⁸ However, a report four days later revealed that five of the containers were empty, while the remaining eight contained only iridium and

⁴⁸ “Isperikh Radioactive Containers Originated Abroad,” NIS Nuclear Trafficking Database, 16 December 1996, <http://nti.org/db/nistraff/1996/19962150.htm>.

cesium-137, with no evidence that plutonium was or ever had been present.⁴⁹ Similarly, in a 2003 incident on the Russian-Finnish border, the seizure of radioactive gemstones was reported as a possible plutonium trafficking incident in the Finnish press; a follow-on report disclosed that, while the stones may have contained a small amount of natural uranium, they posed no risk to public health or security.⁵⁰ As Potter and Sokova noted, follow-on reports of this type typically receive far less media attention than the inflammatory initial story. Taking into account its larger size and broader scope, the DSTO may be in a better position to identify such retractions and corrections.

In contrast to the two databases that rely primarily on open-source information, Figure 6 shows that the ITDB includes only a miniscule percentage of incidents involving unidentified material—as would be expected, given the probability that most governments wait to report an incident to the IAEA until they conclusively identify the type of material involved. Based on the charts above, it appears likely that most open-source cases involving unidentified materials or an unspecified type of uranium are ultimately confirmed to be natural uranium, depleted uranium, or thorium. Furthermore, the ITDB data provides additional evidence that, among the cases involving nuclear materials, media stories over-report plutonium as the trafficked substance. Indeed, the ITDB shows only 2% of cases involving any type of plutonium, compared to 20% of nuclear incidents in the NIS Nuclear Trafficking Database and 9% of nuclear incidents in

⁴⁹ “Investigation Of Stolen Radioactive Containers Reported,” NIS Nuclear Trafficking Database, 20 December 1996, <http://nti.org/db/nistraff/1996/19962170.htm>.

⁵⁰ “Murmansk region customs officials prevent attempt to transport radioactive materials,” NIS Nuclear Trafficking Database, 23 August 2003, <http://www.nti.org/db/nistraff/2003/20030540.htm>.

the DSTO. While the previous section of analysis confirmed that the news media has become less inclined to mistake other radioactive isotopes for fissionable materials like uranium or plutonium, this evidence indicates that there remains a significant probability that open-source reports will misidentify other nuclear materials as plutonium.

Discounting the apparent over-reporting of plutonium smuggling cases, the NIS Nuclear Trafficking Database is largely consistent with the ITDB and DSTO regarding major cases of HEU and Pu trafficking. Of the cases that fall within the scope of the dataset used in this study, the NIS Nuclear Trafficking Database includes all four incidents reported by the IAEA and both of the “additional highly credible cases” contained in the DSTO.⁵¹

Smuggling Routes

In the years immediately following the fall of the USSR, nuclear trafficking incidents were heavily concentrated in Europe, as traffickers obtained nuclear and radiological materials from the FSU and brought them west in search of buyers. Beginning in the late 1990s, however, European officials in countries like Germany and Norway began to see a marked drop in trafficking cases.⁵² At the same time, officials in Turkey, the Caucasus, and Central Asia noted a sharp upswing in incidents.⁵³ Writing in 2002, Lyudmila Zaitseva used DSTO data to confirm this shift, arguing that:

⁵¹ See the Appendix.

⁵² “Nuclear Smuggling from East Reportedly Diminishing,” NIS Nuclear Trafficking Database, 15 October 1997, <http://www.nti.org/db/nistraff/1997/19971190.htm>; Mark Hibbs, “Crime Agencies in 1997 Detected No New HEU, Plutonium Smuggling,” *Nucleonics Week* 39, no. 2: 11-13.

⁵³ See, for example, “The Trade for Materials for WMD,” NIS Nuclear Trafficking Database, 1 March 1999, <http://www.nti.org/db/nistraff/1999/19990160.htm>; “Turkey Detects Nuclear Material Trafficking,”

This pattern suggests that nuclear trafficking from the former Soviet Union may now be flowing southward and that the reduction in smuggling incidents observed in Europe is indicative, at least in part, of this shift rather than an improvement in the situation overall.⁵⁴

In order to determine whether the NIS Nuclear Trafficking Database demonstrated this same trend, all incidents involving the seizure of smuggled material (including both trafficking in actual nuclear/radioactive materials and scams, but excluding orphan radiation sources) were coded for a smuggling route. Incidents in Europe or in Russian oblasts on or near the border with Europe were designated part of the Western route. Similarly, incidents in the Caucasus, Turkey, Central Asia, or in Russian oblasts on or near the border with those regions were designated part of the Southern route. Incidents in central Russia (such as Moscow) were not included in either category because the smuggling route could not be readily determined.

As Figure 7 shows, the NIS Nuclear Trafficking Database confirms the presence of a notable rise in incidents along the Southern route from 1997 to 2003. In fact, this database indicates that the Southern route overtook the Western route in 1998, and generally shows more cases of nuclear smuggling along the Southern route than the Western route during this time period. However, it should be noted that the total number of European incidents in the NIS Nuclear Trafficking Database between 1997 and 2003 is significantly lower than in the DSTO.⁵⁵

NIS Nuclear Trafficking Database, 1 August 2001, <http://www.nti.org/db/nistraff/2002/20020420.htm>;
Douglas Frantz, "Nuclear Booty: More Smugglers Use Asia Route," *New York Times*, 11 September 2001, <http://www.nytimes.com/2001/09/11/international/asia/11NUKE.html>.

⁵⁴ Lyudmila Zaitseva, "Illicit Trafficking in the Southern Tier and Turkey," *Nonproliferation Review* (Fall-Winter 2002): 170.

⁵⁵ Zaitseva 2002, 169.

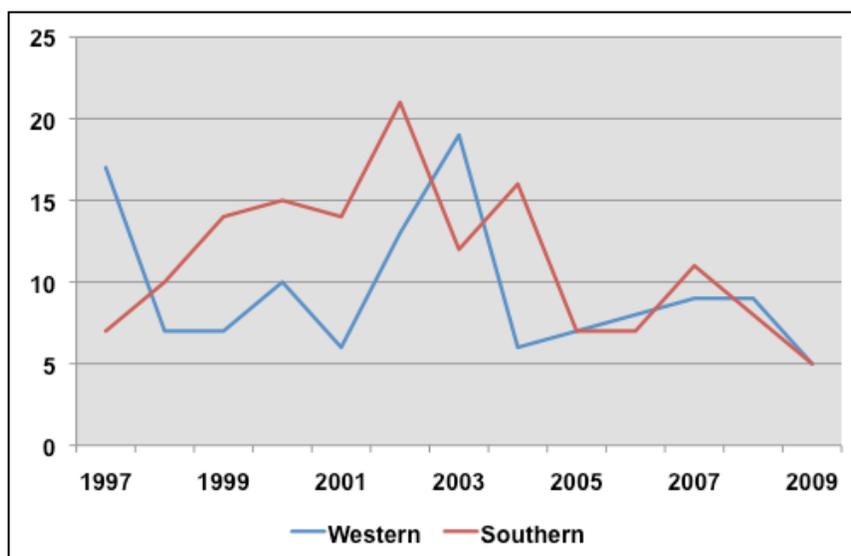


Figure 7: NIS Nuclear Trafficking Database incidents by route, 1997-2009

Between 2003 and 2009, the trend is less conclusive, though incidents along both routes appear to stabilize at the same approximate level. This stabilization could indicate that the Southern route—while still prominent—has lost its favorable edge among smugglers, perhaps due to increased efforts to combat illicit trafficking in the region over the past decade. The reduction in incidents along both routes between 2004 and 2009 reflects the overall drop in incidents recorded by the NIS Nuclear Trafficking Database during that time period.

While compiling the dataset of trafficking incidents, a concentration of smuggling incidents in the Russian Far East became apparent, indicating a probable Eastern smuggling route running through Siberia to East Asia.

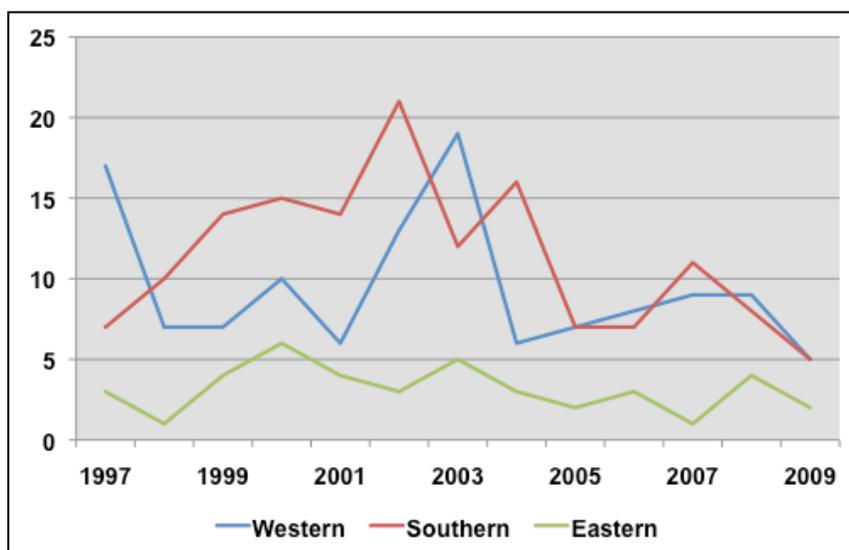


Figure 8: NIS Nuclear Trafficking Database incidents by route, 1998-2009

Though this route appears less heavily transited than the Western or Southern routes, it displays a consistent level of traffic. Despite this trend, the Eastern route has gone largely unnoticed in the academic literature. Several sources have noted that trafficking along the Southern route can include South and Southeast Asia as destinations; however, the route from Siberia to China and East Asia was neither acknowledged nor discussed.⁵⁶

Based on the incidents recorded in the NIS Nuclear Trafficking Database, the Kamchatka Peninsula is an important eastern location for the movement of radioactive materials, as is the port of Vladivostok. There have also been repeat incidents on Sakhalin Island and in Primorsky Maritime Province, Chita Oblast, and Amur Oblast along the Chinese border. Although many of the incidents along the Eastern route

⁵⁶ See, for example, G.M. Solaiman, "Illicit Nuclear Trafficking in Asia and How to Prevent It," *Illicit Nuclear Trafficking: Collective Experience and the Way Forward*, Conference Proceedings (Vienna: International Atomic Energy Agency, 2008): 261-71; Andrew Prosser, "Nuclear Trafficking Routes: Dangerous Trends in Southern Asia," Center for Defense Information, 22 November 2004, <http://www.cdi.org/PDFs/TraffickingSmuggling.pdf>.

involve the transport of radioactively contaminated cargo, there have also been 9 incidents involving nuclear materials (including 4 incidents involving LEU) and 9 incidents involving cesium-137 or strontium-90, both of which are considered “high risk” sources due to their potential use in an RDD. In March 1997, Russian police seized 5.2kg of uranium near Novosibirsk, arresting seven individuals who had been attempting to sell the material for USD 100,000. The material reportedly originated in Ust-Kamenogorsk, Kazakhstan, and was destined for buyers in China or Pakistan.⁵⁷ As it is highly unlikely the material was pure U-235, as several reports implied,⁵⁸ the enrichment level of the seized uranium remains unclear. Nonetheless, the incident demonstrates the potential viability of the Eastern route for transporting nuclear materials through Siberia to South and East Asia.

A relatively large subset (17.5%) of recorded incidents in the Russian Far East are allegedly perpetrated by members of the Russian military or involve material stolen from a military facility. This trend most likely results from the concentration of military personnel and facilities in Eastern Siberia, due to Vladivostok’s status as the base of the Russian Pacific Fleet and the presence of Vilyuchinsk submarine base on Kamchatka Peninsula. For example, in January 2001, three suspects were arrested in Kamchatka Oblast for attempting to sell two “radioisotope monitoring instruments” containing 60g of strontium-90 and yttrium-90. The instruments were stolen from a military base by one of

⁵⁷ “Agents Prevent Sale of Uranium Stolen From Plant,” NIS Nuclear Trafficking Database, 3 April 1997, <http://nti.org/db/nistraff/1997/19970180.htm>.

⁵⁸ Ibid. See also “Sidite, Razlagayete Molekuly Na Atomy,” NIS Nuclear Trafficking Database, 5 April 1997, <http://nti.org/db/nistraff/1997/19970195.htm>.

the suspects, a lieutenant in the Russian military, who intended to sell the devices in China.⁵⁹

The number of discrete incidents reported along the Eastern route is very low, typically under 5 a year. However, several reports of broad statistics from the Far East branch of the Russian Customs Service indicate that these incidents represent a miniscule fraction of the whole. In 2005, the branch announced that it had intercepted 200 “attempts to illegally ship radioactive items across the border” between 1995 and 2005.⁶⁰ There are also indications that traffic along this route is growing; from this average rate of 20 incidents per year from 1995-2005, the volume of cases rose to 74 illicit trafficking incidents in 2008 and 84 in the first nine months of 2009.⁶¹ It remains to be seen whether this upward trend will produce a similar upswing in the number of discrete incidents reported with individual details in the local or national Russian media.

Implications

Despite the many challenges to obtaining accurate data on nuclear trafficking incidents, a comparison of the NIS Nuclear Trafficking Database to the ITDB and DSTO reveals that similar trends are apparent across open and restricted-access databases. In particular, the databases show general consensus on the rate of incidents in the late 1990s

⁵⁹ “Kamchatka Residents Arrested While Trying to Sell Radioactive Instruments,” NIS Nuclear Trafficking Database, 31 January 2001, <http://www.nti.org/db/nistraff/2001/20010040.htm>.

⁶⁰ “200 Attempts to Illegally Transfer Radioactive Items Have Been Blocked by Customs Officials in the Russian Far East over the Last Ten Years,” NIS Nuclear Trafficking Database, 4 May 2005, <http://www.nti.org/db/nistraff/2005/20050180.htm>.

⁶¹ “Customs Officials in the Far East Identify 84 Cases of Smuggling of Radioactive Objects in the First 9 Months of the Year,” NIS Nuclear Trafficking Database, 26 October 2009, <http://www.nti.org/db/nistraff/2009/20090250.html>.

and early 2000s, the types of nuclear material involved in smuggling cases, and the shift in smuggling routes from the Western route to the Southern route in the late 1990s.

Two primary discrepancies between databases were revealed: 1) Over-reporting of incidents involving plutonium in the NIS Nuclear Trafficking Database, and 2) Divergent trends in the number of incidents per year beginning in 2004. The first of these discrepancies most likely results from the media's tendency to sensationalize incidents, especially by reporting the involvement of weapons-usable material. The second discrepancy may be due to the NIS Nuclear Trafficking Database's regional focus, though it could also indicate methodological changes in how the database is maintained. Thus, while the NIS Nuclear Trafficking Database displays a sufficient degree of overall consistency with the ITDB and DSTO, it may be difficult to produce conclusive findings based on the trends shown after 2004.

V. The Relationship Between U.S. Assistance and Nuclear Trafficking Incidents

The relationship between U.S. funding for threat reduction and border security programs and nuclear and radiological smuggling is extremely complex. It is characterized by bidirectional chains of cause and effect, with the amount of funding affecting the number, type, and location of trafficking incidents even as smuggling trends impact the size and targeting of U.S. appropriations. These causal loops play out through the actions and reactions of innumerable actors, from Congress and U.S. government officials to partner countries and members of smuggling rings the world over.

This study does not attempt to describe each of these myriad processes; rather, it focuses on examining the data for correlations associated with two specific feedback mechanisms. First, it will evaluate the influence of smuggling incidents on U.S. funding by determining whether U.S. assistance allocations shift in response to changing trends in trafficking routes. Second, it will assess the impact of U.S. assistance on smuggling incidents by examining how the number of trafficking incidents changes following an increase in funding.

U.S. Funding Prioritization and Nuclear Smuggling Routes

Since the fall of the USSR, the United States has expended trillions of dollars on initiatives to secure nuclear materials and enhance border security in the FSU. Initially, the U.S. focused on nuclear security measures in Russia, which was deemed to pose the greatest threat of loose nuclear weapons and materials. However, the U.S. quickly began to expand its threat reduction programs to address additional former Soviet states. In doing so, the Departments of Defense, State, and Energy have had to make calculated judgments on how best to allocate funds and focus their efforts. As noted above, nuclear traffickers have shown distinct preferences for specific smuggling routes that have evolved over time. In order for U.S. programs to achieve both effectiveness and efficiency, they should be targeted to focus on the regional areas of greatest concern for nuclear trafficking. Moreover, as these areas of concern shift, U.S. funding should shift accordingly.

Hypothesis: U.S. threat reduction and border security funding should shift its regional focus over time in response to known trends in nuclear smuggling routes.

Two of the primary U.S. nonproliferation initiatives—the Department of State’s EXBS program and the DoD CTR program—provide country-by-country funding breakdowns in their Congressional Budget Justifications.⁶² Data for these programs is available from FY 2000-2009 and FY 1998-2009 respectively, allowing a more detailed examination of funding priorities for specific regions and smuggling routes. As in the previous section, European countries were assigned to the Western route; Turkey, the Caucasus, and Central Asia were designated as the Southern route; and East Asia was considered the Eastern route. Because funding totals for Russia do not break down the specific targeted oblasts, appropriations for Russia could not be associated with a particular route and therefore were excluded from this analysis. As the only appropriations for FY 1998-1999 were designated for projects in Russia, this section focuses only on funding for the period from FY 2000-2009.

The Shift to the Southern Route

As discussed in the previous section, the NIS Nuclear Trafficking Database, the DSTO, and anecdotal evidence from regional officials all indicate an increase in incidents along the Southern route in the late 1990s and early 2000s; this trend was widely acknowledge by both analysts and government officials to represent a shift from the Western route that dominated nuclear trafficking in the early-mid 1990s. Therefore, U.S. funding to countries along the Southern route should show a similar increase. Given the

⁶² For DOD budget justifications, see http://comptroller.defense.gov/defbudget/fy2000/budget_justification/; for State Department budget justifications, see <http://www.state.gov/s/d/rm/rls/cbj/>.

complexity of the federal budget process, it would be reasonable for this funding shift to show a delay of 2-3 years after the identification of the trend.

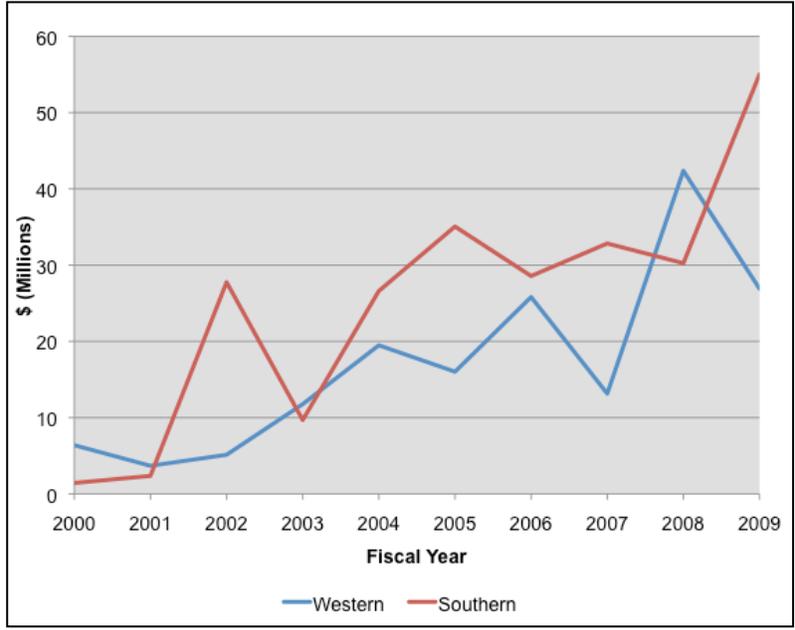


Figure 9: CTR and EXBS funding by route, FY 2000-2009

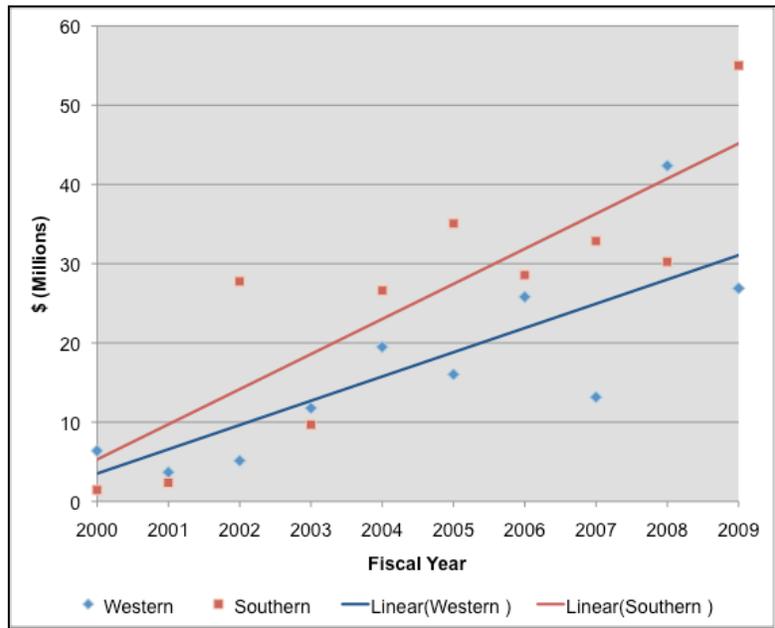


Figure 10: Trendlines for CTR and EXBS funding by route, FY 2000-2009

As expected, U.S. funding to the Southern route shows a notable upward trend beginning in the early 2000s. Though the available funding data did not include the late 1990s, extrapolating the trend shown from 2000-2002 backwards may indicate that funding to the Southern route overcame funding to the Western route for the first time in the early 2000s (Figure 9). Irrespective of this extrapolation, however, Figure 10 clearly shows that while funding increased overall from 2000-2009, it increased at a greater rate for countries along the Southern route than those along the Western route.

It is notable that funding to the Southern route countries made its first major spike in 2002, approximately three years after officials in the region began to note the upswing in incidents. This finding is consistent with the hypothesis that any shifts in funding would take place 2-3 years after the shift in route became apparent.

Eastern Route

Although the Eastern smuggling route has been largely overlooked in academic literature, it has received increasing attention and funding from U.S. government programs like EXBS. In keeping with the lower number of incidents along the Eastern route, funding levels remain an order of magnitude lower than those for the Southern and Western routes. However, appropriations to East Asia show a strong upward trend, most likely a response to the region's growing importance for traffickers over the past decade, including as a destination for nuclear and radiological materials originating in the FSU. As the location of multiple major transshipment points, East Asian countries are also prominent partners in the NNSA Megaports program. Although region-specific funding

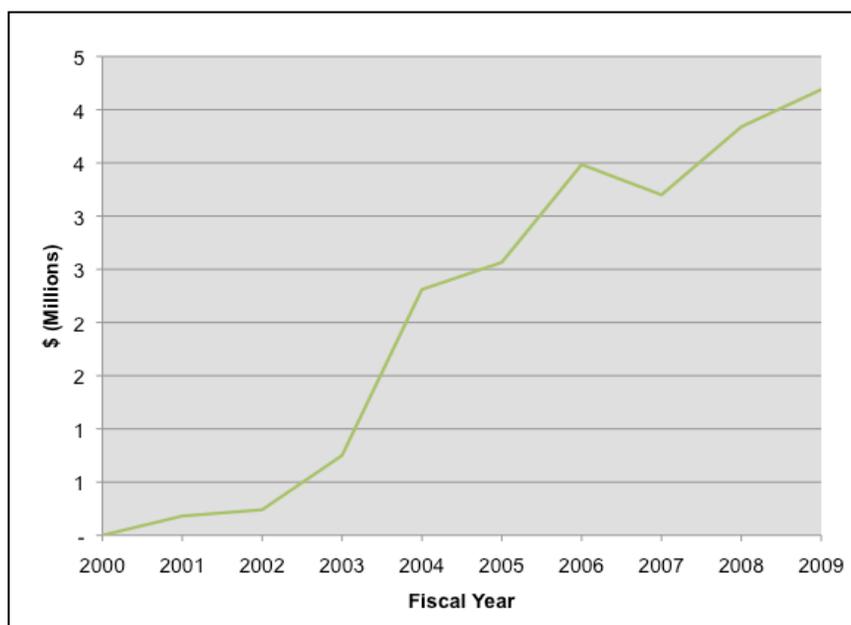


Figure 11: EXBS funding to East Asia, FY 2000-2009

data is not available for this initiative, the NNSA highlights the program’s installation of radiation detection equipment in countries including China, South Korea, and Thailand—all known destinations for Eastern route nuclear trafficking from Russia.⁶³

Impact of U.S. Funding on Nuclear Trafficking Incidents

U.S. programs to counter nuclear trafficking primarily divide into two categories: nuclear smuggling interdiction and nuclear materials security. Initiatives that fall within the first category provide radiation detection equipment for use at border crossings, ports, and airports; they often include training for customs and border patrol officials as well. Programs in the second category include efforts to enhance site security and MPC&A at

⁶³ NNSA, “Megaports Initiative Brochure,” September 2010, http://nnsa.energy.gov/sites/default/files/nnsa/inlinefiles/singlepages_9-15-2010.pdf. For details on interdicted nuclear traffic to China, South Korea, and Thailand, see NIS Nuclear Trafficking Database entries [20030400](#), [20000330](#), [20010040](#), [20010570](#), [20020160](#), and [20010210](#).

facilities housing nuclear and radiological materials. Combined, these initiatives are intended to raise the visibility of ongoing smuggling operations while preventing future trafficking by locking down materials at their sources.

As such, U.S. assistance should have a two-phase impact. In the near term, enhanced border security—particularly through the installation of radiation detectors—should provide a dramatic improvement in the ability to detect hidden nuclear and radioactive material at border crossings, leading to a spike in incidents. In the longer term, U.S. funding should shrink the nuclear smuggling business as material at nuclear sites is secured and nuclear traffickers are captured. These outcomes can reasonably be expected to materialize over a longer time period, as smugglers may possess stocks of nuclear or radioactive material stolen in the early 1990s that they are only now introducing into the market. Thus, the initial increase in incidents should be followed by a more gradual decrease in incidents over the next 5-10 years.

Hypothesis: Increased U.S. assistance to a region should lead to an initial spike in incidents, followed by a gradual decrease over time.

This hypothesis will be evaluated for the entirety of the selected region (the FSU and Eastern Europe), using overall funding levels as recorded in the Interactive Budget Database developed through the Securing the Bomb project at Harvard University.⁶⁴ It will specifically focus on funding for nonproliferation programs relating to two goals: 1) Securing nuclear warheads and materials, and 2) Interdicting nuclear smuggling. As

⁶⁴ Project on Managing the Atom. *Interactive Budget Database*. Belfer Center for Science and International Affairs / Nuclear Threat Initiative. Available online at http://www.nti.org/e_research/cnwm/charts/cnm_funding_interactive.asp

discussed above, these programs have the greatest relevance to nuclear trafficking. The Interactive Budget Database incorporates funding data from FY 1991-2011, allowing analysis across the full time period covered by this study (1997-2009).

However, due to the variance in funding levels for different countries within the FSU and Eastern Europe, a region-wide analysis has the potential to mask trends and correlations. Therefore, the hypothesis will also be tested for four individual sub-regions within this area: Europe, Turkey and the Caucasus, Central Asia, and Russia. The sub-regional analysis will rely on the same funding data from EXBS and CTR used in the previous section, with countries grouped by sub-region rather than by smuggling route. As noted in the previous section, country-specific funding data is not available prior to FY 1998; thus, the sub-regional analysis will cover fiscal years 1998-2009.

Region-wide Analysis

The data for U.S. funding and nuclear trafficking incidents across the FSU and Eastern Europe can be divided into two distinct periods: FY 1997-2003 and FY 2004-2009. With the exception of FY 1997, which appears to be an outlier in terms of the number of incidents, the first period shows a fairly direct positive correlation between increased funding and an increase in the number of incidents. Both funding and incidents spike noticeably in FY 2002, when funding for programs related to interdicting nuclear smuggling jumped from \$44.1 million to \$130.4 million. This correlation is largely consistent with the first part of the hypothesis, confirming that increased funding (particularly for interdiction capabilities) leads to an increase in recorded incidents, most

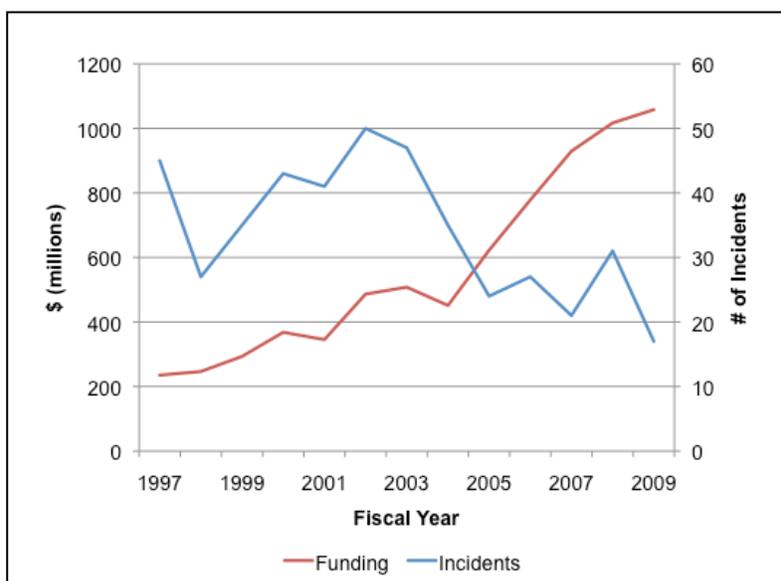


Figure 12: Total funding vs. incidents

likely due to the installation of radiation detection equipment. Interestingly, the spike in incidents occurred the same year as the increase in funding, rather than in the subsequent year as implied by the hypothesis.

Beginning in FY 2004, the data shows a distinct negative correlation between funding and incidents, as U.S. funding increases dramatically while the number of incidents drops by a third, from an average of 41 incidents/year to an average of 26 incidents/year. This shift from a positive correlation to a negative correlation could indicate that U.S. threat reduction efforts reached a turning point between 2003 and 2005, with site security and border security initiatives combining to meaningfully disrupt nuclear smuggling networks in the FSU and Eastern Europe. However, the drop in incidents is fairly abrupt, rather than the gradual decrease predicted by the hypothesis. Furthermore, as noted in Section V, the dramatic decrease in incidents recorded in the NIS Nuclear Trafficking Database beginning in 2004 is inconsistent with the trend

recorded by the ITDB and DSTO—though this discrepancy could be related to the exclusively regional focus of the NIS Nuclear Trafficking Database. Nonetheless, it remains unclear whether the correlation displayed between FY 2004-2009 accurately reflects the trafficking landscape, making it difficult to draw definitive conclusions.

Sub-Regional Analysis

Based on the data displayed in Figure 13, below, the negative correlation between funding and incidents from FY 2004-2009 is less distinct at the sub-regional level than it was for the region overall. All four sub-regions show a clear decrease in incidents in the mid-2000s, indicating that the drop in incidents recorded in the NIS Nuclear Trafficking Database was relatively evenly distributed across sub-regions. However, the dramatic upward trend in funding displayed in Figure 12 is not as apparent at the sub-regional level; in fact, only the Caucasus/Turkey demonstrates a marked negative correlation between funding and incidents after FY 2003. This discrepancy likely results from data limitations, given that the sub-regional analysis only includes funding figures from EXBS and CTR. If the drop in incidents post-2004 is assumed to be accurate, this inconsistency in funding trends implies that the negative correlation shown at the regional level is most directly linked to increased appropriations for other U.S. threat reduction programs, such as those managed by DOE.

The sub-regional data does provide further confirmation that increased funding produces a near-term increase in nuclear smuggling incidents. Each of the sub-regions examined shows notable, linked spikes in funding and incidents: Russia in FY 2000 and

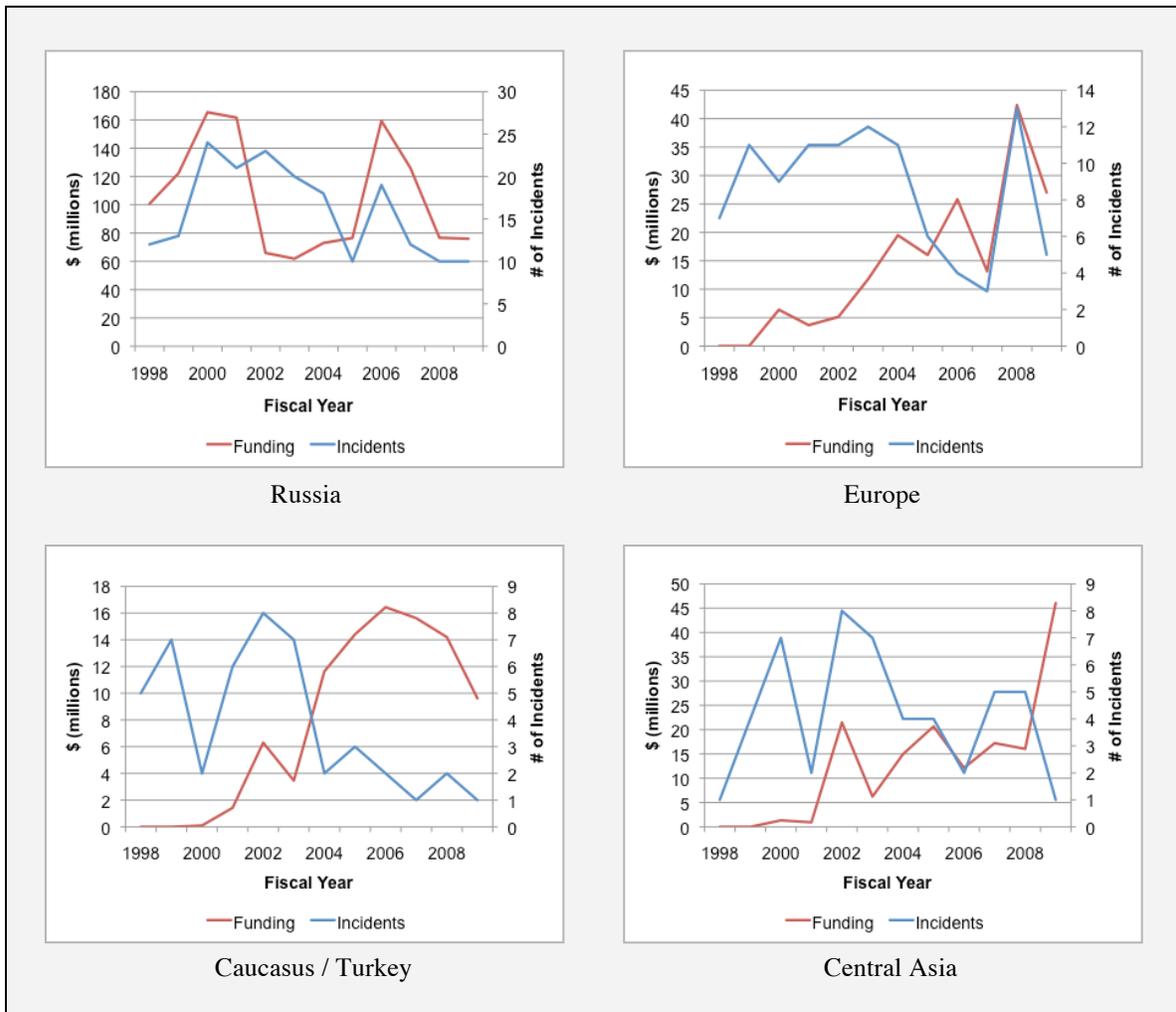


Figure 13: Funding vs. incidents by sub-region

FY 2006, Europe in FY 2008, the Caucasus/Turkey in FY 2002, and Central Asia in FY 2002. As with the regional data, these linked spikes occur simultaneously, rather than an increase in funding leading to an increase in incidents the following year. The correlation between funding and incidents is not 100% predictive, as the data also includes instances where funding peaks without a corresponding spike in incidents, such as Europe and the Caucasus/Turkey in FY 2006. Nonetheless, the overall prevalence and consistency of this trend presents strong evidence in support of the first part of the hypothesis.

The sub-regional data is weaker with regard to the second part of the hypothesis, which predicts a gradual decrease in incidents after the initial spike. The expected pattern does appear consistent with the figures from Russia, where a funding increase in FY 2000 corresponds to a spike in incidents, followed by a gradual decrease in incidents through FY 2005. A similar pattern is present in Central Asia between FY 2002 and FY 2006. However, the other instances in which incidents spike simultaneously with funding increases—such as Russia in FY 2006, the Caucasus/Turkey in FY 2002, and Europe in FY 2008—all show an abrupt rise in trafficking incidents that just as abruptly drops off a year or two later. Though these cases do show a spike in funding leading to a decrease in incidents in subsequent years, they are inconsistent with the expectation of a *gradual* decrease in incidents, as put forth in the hypothesis.

VI. Conclusions and Policy Implications

This study examined two interrelated issues in the ongoing effort to understand and combat the illicit trafficking of nuclear and radioactive materials: First, given the challenges to gathering accurate data on nuclear smuggling incidents, is there sufficient consistency between different databases—particularly between open vs. restricted-access databases—to indicate consensus on the general shape of the illicit nuclear trade? Second, using openly published data on trafficking incidents and U.S. funding for threat reduction initiatives, what conclusions can be drawn regarding the dynamic between U.S. assistance and trafficking trends? The answers to these questions, as explored through

this study, help to address major gaps in the nuclear trafficking literature and provide a solid foundation for future research in this area.

Nuclear Trafficking Trends

This study discussed in depth the many obstacles to compiling an accurate dataset of nuclear trafficking incidents, including over-reporting, underreporting, selection bias, and inconsistent and incomplete information. In spite of these challenges, the above analysis demonstrated that the same general trends hold true across open databases like the NIS Nuclear Trafficking Database and restricted-access databases like the ITDB and DSTO. The primary discrepancies between databases result from two key factors:

First, the media bias toward over-reporting the seizure of weapons-usable materials causes databases based on open-sources (like the NIS Nuclear Trafficking Database and DSTO) to contain artificially low rates of incidents involving natural and depleted uranium. Over-reporting incidents involving plutonium was particularly common in the NIS Nuclear Trafficking Database. Therefore, databases that rely in whole or in part on media reports should revise their information gathering methodology to include rigorous follow-up on any incident reported to involve nuclear material (particularly Pu or HEU). Although the media may not always publish follow-on stories to correct the misidentification of low-risk nuclear materials as HEU or Pu, the data indicates that many such reports may be missed in the existing databases. Any report of nuclear material— but especially those involving weapons-usable material— should be flagged for follow-up research in the subsequent weeks and months.

Second, the databases show divergent trends in the overall number of incidents reported beginning in 2003-2004. While the ITDB and DSTO recorded a significant rise in incidents beginning in the mid-2000s, the NIS Nuclear Trafficking Database shows a dramatic decrease in incidents during the same time period. This divergence may reflect a rise in incidents outside the FSU and Easter Europe, as the ITDB and DSTO both include global rather than regional data; it could also indicate changes to the NIS Nuclear Trafficking Database's methodology for data population. The final explanation for this discrepancy thus remains unclear, rendering this study unable to draw definitive conclusions regarding nuclear trafficking trends after 2004.

The Relationship Between U.S. Funding and Trafficking Incidents

The relationship between U.S. funding levels and the incidence of nuclear smuggling cases is remarkably complex, involving numerous actors and a myriad of potential causal mechanisms and feedback loops. This study examined two specific theories: First, that U.S. funding should shift to reflect changes in nuclear smuggling routes; and second, that increased U.S. funding should lead to an initial spike in incidents followed by a gradual decrease over time.

Based on country-specific funding data for CTR and EXBS, the U.S. has demonstrated a notable degree of awareness and agility in targeting funds to regions based on shifting trafficking trends and routes. In particular, the U.S. appears to have reprioritized funding in response to reports that traffickers had begun altering their smuggling routes to travel south to Turkey, the Caucasus, and Central Asia rather than west to Europe. As expected, this funding shift was delayed several years after these

reports arose, most likely due to the time needed to confirm the new trend and move re-focused budgets through the appropriations process. U.S. threat reduction program managers must continue to closely monitor trends in nuclear smuggling routes in order to ensure that funds remain appropriately targeted to the areas of greatest concern.

There is also significant evidence that U.S. efforts to increase awareness and interdiction of smuggled materials—especially through the installation of radiation detection equipment at border crossings, ports, and airports—have succeeded in enhancing countries’ abilities to identify nuclear and radioactive materials. At both the regional and sub-regional levels, the data showed a common pattern of funding and incidents spiking in the same year. This finding indicates that funding increases are rapidly translated into new capabilities for partner countries, with rapid deployment of radiation detection equipment resulting in near-term interdiction successes. This outcome was faster than anticipated, as the hypothesis assumed at least a one year delay between a funding increase and a resulting spike in incidents, due to the time needed to transport and install new radiation detectors in the field.

Similarly, following the spike in funding and initial increase in incidents, the rate at which incidents decreased proved faster than expected. Contrary to the hypothesis, the data rarely showed trafficking incidents gradually tapering off after a spike; instead, the number of incidents generally dropped rapidly after one or two years. This finding could indicate that the disruption of smuggling networks—either by securing materials at their source, identifying and arresting traffickers, or erecting sufficient barriers to prompt smugglers to change their route—occurs sooner than anticipated following a funding

spike. Alternately, this rapid drop-off in incidents could indicate implementation problems, such as officials becoming less meticulous in utilizing detection equipment one to two years after its initial installation. In order to ensure that the provided equipment is being used as intended, U.S. border and port security assistance programs should periodically conduct refresher trainings and review implementation procedures with the relevant agencies in partner countries.

The Eastern Smuggling Route

This study identified a probable Eastern smuggling route through Siberia to South and East Asia. The Eastern route appears to be more lightly traveled than the Western or Southern routes, with lower numbers of discrete incidents and fewer cases involving high-risk nuclear or radioactive materials. Based on available data, the U.S. is increasing the level of funding directed toward countries in East Asia; however, assistance to this region remains a degree of magnitude below that provided to countries along the Western and Southern routes. Due to this lower level of scrutiny, there remains the possibility that higher risk materials could be transported “under the radar” via the Eastern route to known transshipment hubs like Malaysia and Singapore. As the U.S. and its partners complete site and border security projects in Europe, the Caucasus, and Central Asia, traffickers may increasingly turn to the Eastern route as an avenue for smuggling materials out of the FSU. Therefore, U.S threat reduction programs should continue to allocate additional funds to the Eastern route. Furthermore, policymakers, program officers, and scholars should closely monitor the type and rate of nuclear trafficking

incidents along the Eastern route, in order to proactively identify any shift toward heavier traffic or higher risk materials.

Areas for Future Research

As noted in the introduction, this study was intended to set the stage for future research on the relationship between U.S. nonproliferation funding and known incidents of illicit nuclear trafficking. Based on the analysis conducted in this study, the following potential research paths would provide valuable additions to the literature. First, there are multiple ways in which it would be beneficial to repeat this research design with additional data, including: A) Obtaining country-specific funding data for more programs, particularly NNSA programs like Second Line of Defense and Megaports, B) Expanding the trafficking dataset through independent research or by utilizing a larger database like the DSTO or ITDB, C) Extending the timeframe back to 1992, or D) Expanding the scope to incorporate threat reduction programs sponsored by other governments or international organizations. Second, a future study could more closely examine the relationship between trafficking incidents and different categories of assistance, such as distinguishing between funding for border security and site security. Third, though this study primarily aimed to evaluate correlations between funding and trafficking data, additional research could utilize a case study approach to validate the underlying causality behind the identified correlations. Fourth, the datasets utilized in this research could be applied to examine other causal mechanisms in the relationship between U.S. assistance and nuclear trafficking incidents. Finally, this analysis opted to focus on two relatively narrow hypotheses when examining the relationship between

nuclear smuggling and U.S. funding. So long as the limitations of the existing nuclear trafficking databases are taken into account, a similar approach could be used by government analysts for broader program assessment and evaluation purposes.

VII. Appendix: Incidents Involving Weapons-Usable Nuclear Material

Incident Type	Date	Location	Material	Amount	Within Scope? (reason)	Present in Dataset?
Seizure	24 May 1993	Vilnius, Lithuania	HEU	150 g	No (date)	N/A
Seizure	Mar 1994	St. Petersburg, Russia	HEU	2.972 kg	No (date)	N/A
Seizure	10 May 1994	Tengen-Weichs, Germany	Pu	6.2 g	No (date)	N/A
Seizure	13 Jun 1994	Landshut, Germany	HEU	.795 g	No (date)	N/A
Seizure	25 Jul 1994	Munich, Germany	Pu	.24 g	No (date)	N/A
Seizure	8 Aug 1994	Munich, Germany	Pu	363.4 g	No (date)	N/A
Seizure	14 Dec 1994	Prague, Czech Republic	HEU	2.73 kg	No (date)	N/A
Seizure	Jun 1995	Moscow, Russia	HEU	1.7 kg	No (date)	N/A
Seizure	6 Jun 1995	Prague, Czech Republic	HEU	.415 g	No (date)	N/A
Seizure	8 Jun 1995	Ceske Budejovice, Czech Republic	HEU	16.9 g	No (date)	N/A
Seizure	29 May 1999	Rousee, Bulgaria	HEU	10 g	Yes	Yes
Theft	Dec 2000	Karlsruhe, Germany	Pu	.001 g	No (location)	N/A
Seizure	16 Jul 2001	Paris, France	HEU	.5 g	Yes	Yes
Seizure	26 Jun 2003	Sadahlo, Georgia	HEU	~170 g	Yes	Yes
Loss	Mar-Apr 2005	New Jersey, USA	HEU	3.3 g	No (location)	N/A
Loss	24 Jun 2005	Fukui, Japan	HEU	.0017 g	No (location)	N/A
Seizure	1 Feb 2006	Tbilisi, Georgia	HEU	79.5 g	Yes	Yes
Discovery	30 Mar 2006	Henninsdorf, Germany	HEU	47.5 g	No (location)	N/A

Table 1: Confirmed Incidents Involving HEU and Pu, ITDB⁶⁵

Incident Type	Date	Location	Material	Amount	Within Scope? (reason)	Present in Dataset?
Seizure	6 Oct 1992	Podolsk, Russia	HEU	1.5 kg	No (date)	N/A
Seizure	29 Jul 1993	Andreeva Guba, Russia	HEU	1.8 kg	No (date)	N/A
Seizure	28 Nov 1993	Sevmorpu, Russia	HEU	4.5 kg	No (date)	N/A
Loss	1996	Tomsk, Russia	HEU	145 g	No (date)	N/A
Loss	1992-1997	Abkhazia, Georgia	HEU	655 g	No (incident year unknown)	N/A
Diversion Attempt	1998	Chelyabinsk, Russia	HEU	18.5 kg	Yes	Yes
Seizure	2000	Elektrostal, Russia	HEU	3.7 kg	Yes	Yes

Table 2: Additional Highly Credible Cases Involving HEU, DSTO⁶⁶

⁶⁵ IAEA, "IAEA Illicit Trafficking Database (ITDB)." 26 September 2008.

http://www.iaea.org/newscenter/features/radsources/pdf/fact_figures2007.pdf.

⁶⁶ Zaitseva 2010, 7.

VIII. Bibliography

- Albright, David. *Peddling Peril: How the Secret Nuclear Trade Arms America's Enemies*. New York: Free Press, 2010.
- Allison, Graham. *Nuclear Terrorism: The Ultimate Preventable Catastrophe*. New York: Henry Holt, 2005.
- Bunn, Matthew. *Securing the Bomb 2007*. Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard University, September 2007.
- . *Securing the Bomb 2008*. Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard University, November 2008.
- . *Securing the Bomb 2010: Securing All Nuclear Materials in Four Years*. Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard University, April 2010.
- , and Anthony Weir. *Securing the Bomb: An Agenda for Action*. Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard University, May 2004.
- and Anthony Weir. *Securing the Bomb 2005: The New Global Imperatives*. Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard University, May 2005.
- and Anthony Weir. *Securing the Bomb 2006*. Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard University, July 2006.
- Butler, Kenley, and Akaki Dvali. "Nuclear Trafficking Hoaxes: A Short History of Scams Involving Red Mercury and Osmium-187." James Martin Center for Nonproliferation Studies. April 2004. http://www.nti.org/e_research/e3_42a.html.
- Caravelli, Jack. *Nuclear Insecurity: Understanding the Threat from Rogue Nations and Terrorists*. Westport, CT: Praeger Security International, 2008.
- Cook, Diane, Lawrence Holder, Sandy Thompson, Paul Whitney, and Lawrence Chilton. "Graph-Based Analysis of Nuclear Smuggling Data." *Journal of Applied Security Research* 4 (2009): 501-17.

- Ewell, Emily S. "NIS Nuclear Smuggling Since 1995: A Lull in Significant Cases?" *Nonproliferation Review* 5, no. 3 (Spring-Summer 1998): 119-25.
- Fitzpatrick, Mark, ed. *Nuclear Black Markets: Pakistan, A.Q Khan and the rise of proliferation networks*. London: International Institute for Strategic Studies, 2007.
- Frantz, Douglas . "Nuclear Booty: More Smugglers Use Asia Route." *New York Times*. 11 September 2001.
<http://www.nytimes.com/2001/09/11/international/asia/11NUKE.html>.
- Hibbs, Mark. "Crime Agencies in 1997 Detected No New HEU, Plutonium Smuggling." *Nucleonics Week* 39, no. 2 (8 January 1998): 11-13.
- . "IAEA, WCO, Interpol May Try to Harmonize Contraband Data." *Nucleonics Week* 39, no. 40 (1 October 1998).
- Illicit Nuclear Trafficking: Collective Experience and the Way Forward*, Conference Proceedings (Vienna: International Atomic Energy Agency, 2008)
- International Atomic Energy Agency. "IAEA Illicit Trafficking Database (ITDB)." Fact Sheet. 31 December 2004.
http://www.iaea.org/newscenter/features/radsources/pdf/itdb_31122004.pdf.
- . "IAEA Illicit Trafficking Database (ITDB)." Fact Sheet. 1 September 2010.
<http://www-ns.iaea.org/downloads/security/itdb-fact-sheet.pdf>.
- . "Illicit Trafficking Database Factsheet." September 2009. <http://www-ns.iaea.org/downloads/security/itdb-fact-sheet-2009.pdf>.
- . "New Report on Illicit Nuclear Trafficking." 26 September 2008.
<http://www.iaea.org/NewsCenter/News/2008/itdb.html>.
- . "Nuclear Trafficking Latest Statistics Released." 27 September 2005.
<http://www.iaea.org/NewsCenter/News/2005/traffickingstats.html>.
- James Martin Center for Nonproliferation Studies. *NIS Nuclear Trafficking Database*. Nuclear Threat Initiative. Available online at
<http://www.nti.org/db/nistraff/index.html>.

- Kellman, Barry, and David S. Gualtieri. "Barricading the Nuclear Window: A Legal Regime to Curtail Nuclear Smuggling." *University of Illinois Law Review* 1996, no. 3 (1996): 667-742.
- Lee, Rensselaer W. "Nuclear Smuggling: Patterns and Responses." *Parameters* 33, no. 1 (2003): 95-111.
- , "Recent Trends in Nuclear Smuggling." *Russian Organized Crime: The New Threat?* Ed. Phil Williams. London: Frank Cass & Co. Ltd., 1997, 109-21.
- , *Smuggling Armageddon: The Nuclear Black Market in the Former Soviet Union and Europe*. New York: St. Martin's Press, 1998.
- , "Why Nuclear Smuggling Matters." *ORBIS* 52, no. 3 (Summer 2008): 434-44.
- Morton, David P., Feng Pan, and Kevin J. Saeger. "Models for Nuclear Smuggling Interdiction." *IIE Transactions* 39, no. 1 (2007): 3-14. Available in September 2005 version from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.155.2752&rep=rep1&type=pdf>.
- National Nuclear Security Administration. "FY 2011 Congressional Budget Request." Department of Energy. February 2010. http://nnsa.energy.gov/sites/default/files/nnsa/inlinefiles/nnsa_fy2011_budget_request.pdf.
- , "Megaports Initiative Brochure." September 2010. http://nnsa.energy.gov/sites/default/files/nnsa/inlinefiles/singlepages_9-15-2010.pdf.
- Office of the Press Secretary. "Key Facts about the Nuclear Security Summit." The White House. 13 April 2010. <http://www.whitehouse.gov/the-press-office/key-facts-about-national-security-summit>.
- , "Remarks by President Obama." The White House. 5 April 2009. <http://www.whitehouse.gov/the-press-office/remarks-president-barack-obama-prague-delivered>.
- Parrish, Scott. "Issue Brief: Illicit Nuclear Trafficking in the NIS." James Martin Center for Nonproliferation Studies / Nuclear Threat Initiative. March 2002. http://www.nti.org/e_research/e3_8a.html.

- Potter, William C., and Elena Sokova. "Illicit Nuclear Trafficking in the NIS: What's New? What's True?" *Nonproliferation Review* 9, no. 2 (Summer 2002): 112-120.
- Project on Managing the Atom. *Interactive Budget Database*. Belfer Center for Science and International Affairs / Nuclear Threat Initiative. Available online at http://www.nti.org/e_research/cnwm/charts/cnm_funding_interactive.asp.
- Prosser, Andrew. "Nuclear Trafficking Routes: Dangerous Trends in Southern Asia." Center for Defense Information, 22 November 2004.
- Solaiman, G.M. "Illicit Nuclear Trafficking in Asia and How to Prevent It." In *Illicit Nuclear Trafficking: Collective Experience and the Way Forward*, 261-71. Conference Proceedings. Vienna: International Atomic Energy Agency, 2008.
- Zaitseva, Lyudmila. "Illicit Trafficking in the Southern Tier and Turkey Since 1999: A Shift from Europe?" *Nonproliferation Review* 9, no. 3 (Fall-Winter 2002): 168-82.
- , "Nuclear Trafficking: 20 Years in Review." Paper presented at the World Federation Of Scientists International Seminars on Planetary Emergencies, 43rd Session, Erice, Italy, 19-25 August 2010.
- , "Nuclear Trafficking in Ungoverned Spaces and Failed States." *Ungoverned Spaces*. Ed. Anne L. Clunan and Harold A. Trinkunas. Stanford, CA: Stanford University Press, 2010, 193-211.
- , "Organization Crime, Terrorism and Nuclear Trafficking." *Strategic Insights* 6, no. 5 (August 2007)
- , and Friedrich Steinhausler. "Illicit trafficking of nuclear and other radioactive material: the 'net' security threat." *International Journal of Nuclear Law* 1, no. 2 (2006): 168-81.
- , and Friedrich Steinhausler. "Illicit Trafficking of Weapons-Usable Nuclear Material: Facts and Uncertainties," *Physics & Society* 33, no. 1 (January 2004): 5-8.
- , and Kevin Hand. "Nuclear Smuggling Chains: Suppliers, Intermediaries, and End-Users." *American Behavioral Scientist* 46, no. 6 (February 2003): 822-44.