



NATO Science for Peace and Security Series - B:
Physics and Biophysics

Nuclear Threats and Security Challenges

Edited by
Samuel Apikyan
David Diamond




Springer



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Nuclear Threats and Security Challenges

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This Series presents the results of scientific meetings supported under the NATO Programme: Science for Peace and Security (SPS).

The NATO SPS Programme supports meetings in the following Key Priority areas: (1) Defence Against Terrorism; (2) Countering other Threats to Security and (3) NATO, Partner and Mediterranean Dialogue Country Priorities. The types of meeting supported are generally "Advanced Study Institutes" and "Advanced Research Workshops". The NATO SPS Series collects together the results of these meetings. The meetings are co-organized by scientists from NATO countries and scientists from NATO's "Partner" or "Mediterranean Dialogue" countries. The observations and recommendations made at the meetings, as well as the contents of the volumes in the Series, reflect those of participants and contributors only; they should not necessarily be regarded as reflecting NATO views or policy.

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Following a transformation of the programme in 2006 the Series has been re-named and re-organised. Recent volumes on topics not related to security, which result from meetings supported under the programme earlier, may be found in the NATO Science Series.

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Series B: Physics and Biophysics

Preface

The world faces no greater or more urgent danger than a terrorist attack with the intent of killing, maiming, and traumatizing a large population. International peace and security is threatened in particular by the proliferation of nuclear materials and technologies that could lead to a nuclear or radiological attack. More nations are trying to acquire nuclear weapons, and black markets trade in nuclear secrets and materials. Terrorists are determined to buy, build, or steal a nuclear weapon or use a radioactive source in a conventional bomb.

Organizations like al Qaeda and the so-called Islamic State have said that obtaining these weapons and perpetrating another “Hiroshima” are their “religious duty.” Organizations such as these have the will, the technical know-how, and the financial resources to make these threats a reality.

Our strategy to combat these threats is multilayered, and events in recent years have shown the necessity to continually reevaluate national preparedness programs. Throughout the world there are people working on the key issues related to this subject such as:

- Preventing, avoiding, or stopping threats
- Protecting our citizens and assets against the greatest threats and hazards
- Mitigating the loss of life and property by lessening the impact of future disasters
- Responding quickly to save lives, protect property and the environment, and meet basic human needs in the aftermath of a catastrophic incident
- Recovering through timely restoration and strengthening of infrastructure and the economy, as well as the social fabric of communities affected by a catastrophic incident

The NATO Advanced Research Workshop on “Preparedness for Nuclear and Radiological Threats” was held in Los Angeles, on 18–20 November 2014 with support from the NATO Science for Peace and Security Programme. The purpose of the workshop was to contribute to the critical assessment of existing knowledge on this subject, to identify directions for future research and policies, and to promote close working relationships between scientists, engineers, and policy makers from different countries and with different professional experience. More

than 100 representatives of 18 countries participated. The program was built upon the accomplishments of The Hague 2014 Nuclear Security Summit and previous NATO workshops such as “Countering Nuclear/Radiological Terrorism” (2005); “Prevention, Detection and Response to Nuclear and Radiological Threat” (2007); and “Threat Detection, Response and Consequence Management Associated with Nuclear and Radiological Terrorism” (2008).

This book contains approximately half of the papers presented at the workshop. The other half of the papers are found in the book *Nuclear Terrorism and National Preparedness*. We hope it will be useful not only for the multinational scientific and technical communities engaged in combating nuclear and radiological terrorism but also for decision makers and for those working at governmental and policy levels whose actions affect the directions the science takes and how the technology is incorporated into country-specific national systems for combating nuclear and radiological threats.

Los Angeles
Upton

Samuel Apikyan
David Diamond

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Part I
Nuclear Security and Nonproliferation

Chapter 1

GAO: Two Decades Evaluating the Impact and Effectiveness of U.S. Nuclear and Radiological Material Security Programs

David Trimble

Abstract Since the early 1990s, the Government Accountability Office (GAO), the investigative arm of the U.S. Congress, has been reporting on the impact and efficiency of numerous federal programs—that have collectively cost U.S. taxpayers billions of dollars—to reduce the risks posed by vulnerable nuclear and radiological materials worldwide. GAO's assessments have focused on, among other things, the Department of Energy's (DOE) Material Protection, Control and Accounting program in Russia and the Global Threat Reduction Initiative that has been implemented in more than 100 countries. More recently, GAO has assessed federal agencies' efforts and strategies to implement the President's initiative to secure all vulnerable material worldwide within a 4-year period. A significant and growing part of GAO's portfolio, particularly after September 11, focuses on radiological material security, including federal preparedness for and response to a terrorist attack involving either a radiological dispersal device or improvised nuclear device attack in the United States.

An independent, nonpartisan agency, GAO's mission is to support the Congress in meeting its constitutional responsibilities and to help improve the performance and ensure the accountability of the federal government for the benefit of the American people. GAO provides the Congress with timely information that is objective, fact-based, nonpartisan, nonideological, fair, and balanced. Within GAO, the U.S. and International Nuclear Security and Cleanup mission group covers a wide range of nuclear issues that include nuclear nonproliferation; nuclear and radiological smuggling and terrorism; and special nuclear material production, consolidation, and storage. This paper provides an overview of the recent nuclear nonproliferation work that GAO has undertaken on behalf of the Congress, focusing on highlights of key reports, major findings, recommendations, and impact on federal agencies' programs.

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1.1 Introduction

One of the most serious threats facing the United States and other countries is the possibility that other nations or terrorist organizations could steal a nuclear warhead or nuclear weapon-usable materials from poorly secured stockpiles around the world, or that nations could divert nuclear material intended for peaceful purposes to the development of nuclear weapons.¹ Of great concern is that terrorists could fashion a crude nuclear bomb made from either highly enriched uranium (HEU) or plutonium into an improvised nuclear device. Such a device would create an explosion producing extreme heat, powerful shockwaves and intense radiation that would be immediately lethal to individuals within miles of the explosion, as well as radioactive fallout over thousands of square miles. Nonproliferation experts estimate that a successful improvised nuclear device could devastate the heart of a medium-sized U.S. city and could cause hundreds of thousands of deaths and injuries, as well as pose long-term cancer risks to those exposed to the radioactive fallout.

Radiological material also poses a significant security threat to the United States and the international community. Radiological material—such as cobalt-60, cesium-137, and iridium-192—is encapsulated or sealed in metal to prevent its dispersal and is commonly called a sealed radiological source. Sealed radiological sources are used worldwide for many legitimate purposes, such as medical, industrial, and agricultural applications. The total number of these sources in use worldwide is unknown because many countries do not systematically account for them. If certain types of these sources were obtained by terrorists, they could be used to produce a simple and crude but potentially dangerous weapon—known as a radiological dispersion device, or dirty bomb. Although experts believe that a dirty bomb would result in a limited number of deaths, it could have severe economic consequences. Depending on the type, amount, and form, the dispersed radiological material could cause radiation sickness for people nearby and produce serious economic and psychological disruption associated with the evacuation and subsequent cleanup of the contaminated area.

1.2 The Post-Cold War Era

GAO has been reporting on these and related nonproliferation and nuclear security issues since the 1990s. In the years following the end of the Cold War, GAO's work in this area focused on, among other things, U.S. nuclear engagement with the former Soviet Union. For example, reports from that time addressed the status of U.S. efforts to improve nuclear material controls in the newly independent

¹Weapon-usable nuclear materials are highly enriched uranium, uranium-233, and any plutonium containing less than 80 % of the isotope plutonium-238. Such materials are also often referred to as fissile materials or strategic special nuclear materials.

states of the former Soviet Union, the status of transparency measures for the U.S. purchase of Russian highly enriched uranium, and DOE's efforts to mitigate the risk to nonproliferation goals of unemployed former Soviet Union weapons scientists.² GAO also published several reports during this time on the International Atomic Energy Agency's (IAEA) nonproliferation activities, including reviews of the uncertainties regarding IAEA's changing safeguards system and the agency's ability to monitor operations at North Korean nuclear facilities.³ Below are two examples of this work.

- *Status of U.S. Efforts to Improve Nuclear Material Controls in Newly Independent States:* In 1996, GAO reviewed U.S. efforts to strengthen controls over nuclear materials in the newly independent states of the former Soviet Union.⁴ The Soviet Union produced about 1,200 metric tons of highly enriched uranium and 200 metric tons of plutonium, with much of this material outside of nuclear weapons and highly attractive to theft. GAO found that, at the time, the newly independent states may not have had accurate and complete inventories of the material they inherited and that the breakdown of Soviet-era material protection, control, and accounting (MPC&A) systems may have left the newly independent states unable to counter the threat of theft. In addition, GAO found that nuclear facilities could not quickly detect and localize nuclear material losses or detect unauthorized attempts to remove nuclear material, and seizures of direct-use material in Russia and Europe had increased concerns about theft and diversion. GAO also found that U.S. agencies had begun efforts to help the newly independent states improve their MPC&A systems for direct-use material, as well as cooperation with Russia's nuclear regulatory agency to develop a national MPC&A regulatory infrastructure.
- *Uncertainties with Implementing IAEA's Strengthened Safeguards System:* In 1998, GAO reviewed changes IAEA was undertaking at the time to strengthen its safeguards program by introducing advanced safeguards techniques under its existing safeguards agreements.⁵ IAEA has a dual role of promoting the peaceful uses of nuclear energy through its nuclear safety and technical cooperation programs, and verifying, through its safeguards program, that nuclear

²For example, see *Nuclear Nonproliferation: Status of U.S. Efforts to Improve Nuclear Material Controls in Newly Independent States*, GAO/NSIAD/RCED-96-89 (Washington, D.C.: Mar. 8, 1996); *Nuclear Nonproliferation: Status of Transparency Measures for U.S. Purchase of Russian Highly Enriched Uranium*, GAO/RCED-99-194 (Washington, D.C.: Sep. 22, 1999); and *Nuclear Nonproliferation: Concerns with DOE's Efforts to Reduce the Risks Posed by Russia's Unemployed Weapons Scientists*, GAO/RCED-99-54 (Washington, D.C.: Feb. 19, 1999).

³For example, see *Nuclear Nonproliferation: Uncertainties with Implementing IAEA's Strengthened Safeguards System*, GAO/NSIAD/RCED-98-184 (Washington, D.C.: Feb. 10, 1999) and *Nuclear Nonproliferation: Difficulties in Accomplishing IAEA's Activities in North Korea*, GAO/RCED-98-210 (Washington, D.C.: Jul. 7, 1998).

⁴GAO/NSIAD/RCED-96-89.

⁵GAO/NSIAD/RCED-98-184.

materials subject to safeguards are not diverted to nuclear weapons or other proscribed purposes. In response to Iraq's secret nuclear weapons program, the international community, led by the United States, launched an intensive effort to create a new capability within the IAEA's safeguards system to detect secret or undeclared activities. IAEA also sought additional rights to conduct more intrusive inspections and collect information on nuclear activities through an Additional Protocol that supplemented the existing safeguards agreements. These changes to the agency's safeguards systems were intended to give its inspectors greater ability to detect clandestine nuclear activities in non-nuclear weapons states that are signatories to the Non-Proliferation of Nuclear Weapons or other regional nonproliferation treaties. GAO reported that, under existing safeguards agreements with states and regional organizations, IAEA had increased its access to information on all nuclear activities at declared facilities in non-nuclear weapons states. However, we recommended that IAEA develop and circulate a plan for implementing elements of the enhanced safeguards system. GAO most recently reported on the status of IAEA's safeguards program in 2013.⁶

1.3 The Post-September 11 Era

Following the terrorist attacks of September 11, 2001, U.S. and international experts raised concerns that unsecured radiological sources were vulnerable to theft and posed a significant security threat to the United States and the international community. In 2003, GAO issued a number of reports focusing on U.S. and international efforts to secure radiological sources and recover unwanted sources.⁷ In 2007, GAO issued a report showing that many of the highest-risk and most dangerous sources still remain unsecured, particularly in Russia.⁸

- *U.S. and International Assistance Efforts to Control Sealed Radiological Sources*: In 2003, GAO reviewed the number of sealed sources in use worldwide, as well as those that have been lost, stolen, or abandoned.⁹ GAO found that the

⁶*Nuclear Nonproliferation: IAEA Has Made Progress in Implementing Critical Programs but Continues to Face Challenges*, GAO-13-139 (Washington, D.C.: May 16, 2013).

⁷For example, see *Nuclear Nonproliferation: DOE Action Needed to Ensure Continued Recovery of Unwanted Sealed Radioactive Sources*, GAO-03-483 (Washington, D.C., April 15, 2003), *Nuclear Nonproliferation: U.S. and International Efforts to Control Sealed Radioactive Sources Need Strengthening*, GAO-03-638 (Washington, D.C., May 16, 2003), and *Nuclear Security: Federal and State Action Needed to Improve Security of Sealed Radioactive Sources*, GAO-03-804 (Washington, D.C., Aug. 6, 2003).

⁸For example, see *Nuclear Nonproliferation: DOE's International Radiological Threat Reduction Program Needs to Focus Future Efforts on Securing the Highest Priority Radiological Sources*, GAO-07-282 (Washington, D.C., Jan. 31, 2007).

⁹GAO-03-804.

precise number of sealed sources is unknown because many countries do not systematically account for them. However, at the time, nearly ten million sealed sources existed in the United States and the 49 countries responding to a GAO survey. There is also limited information about the number of sealed sources that have been lost, stolen, or abandoned, but it was estimated to be in the thousands worldwide. Furthermore, many of the most vulnerable sealed sources that could pose a security risk were located in the countries of the former Soviet Union. GAO recommended in the report, among other things, that the Secretary of Energy take the lead in developing a comprehensive plan to strengthen controls over other countries' sealed sources.

- *DOE's International Radiological Threat Reduction Program:* In 2007, GAO assessed the progress DOE had made in implementing its program to help other countries secure their sealed radiological sources, as well as described DOE's coordination with other U.S. agencies and international organizations to secure radiological sources in other countries.¹⁰ GAO found that, since 2002, DOE had upgraded the security of hundreds of sites in other countries that contained radiological sources and had achieved noteworthy accomplishments, including removing radioactive material in Chechnya. However, DOE had made limited progress in securing many of the most dangerous sources located in waste storage facilities and hundreds of sources across Russia contained in radioisotope thermoelectric generators (RTG). As a result, as of September 2006, almost 70 % of all sites secured were medical facilities, which generally contain one radiological source, and many of the highest-risk and most dangerous sources still remained unsecured, particularly in Russia. For example, GAO reported that 16 of 20 waste storage sites across Russia and Ukraine remained unsecured, while more than 700 RTGs remained operational or abandoned in Russia and were vulnerable to theft or potential misuse. In the report, GAO made several recommendations to DOE to better prioritize sites to be selected for security upgrades and strengthen program management practices.

1.4 Recent GAO Work

In recent years, GAO's nonproliferation work has continued to focus on the security of vulnerable nuclear materials worldwide. Recent reports have included a preliminary assessment of the President's 4-year global nuclear security initiative and U.S. agencies' ability to account for U.S. nuclear material overseas. GAO has also increased its focus on the security of radiological materials and has produced recent reports and testimonies on the security of radiological sources in hospitals and in industrial use in the United States. The following are summaries of some recent key reports.

¹⁰GAO-07-282.