Project on Managing the Atom

Securing China's Nuclear Future

By Hui Zhang and Tuosheng Zhang

HARVARD Kennedy School

Belfer Center for Science and International Affairs

March 2014

Report by The Project on Managing the Atom

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Paper Number: 2014-03

Cover Photo: An entrance to a protected area at Daya Bay nuclear power plant. (Source: Photo provided by Daya Bay nuclear power plant official).

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Acknowledgments

Hui Zhang and Tuosheng Zhang are grateful to the many Chinese nuclear experts who participated in the workshops and interviews on nuclear security during the preparation of this report. They also wish to thank Matthew Bunn and Martin Malin for helpful discussions and comments on an earlier draft of this report. Tong Zhao and Tiffany Chan assisted with translation. Xiadon Liang provided expert editorial assistance. Dominic Contreras and Josh Anderson assisted with layout and production. The authors thank them all for their hard work. The Project on Managing the Atom thanks the Carnegie Corporation of New York and the John D. and Catherine T. MacArthur Foundation for financial support of this work.

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Preface

China's approach to the security of its nuclear facilities, materials, and weapons is of paramount concern not only to Chinese leaders and citizens, but to the whole world. China has the fastest growing nuclear energy sector in the world, and a stockpile of nuclear weapons and weapons-useable materials. Although China has strengthened its nuclear security in recent years, and nuclear security has become a concern at the highest level of government, we believe more work is still needed.

There are very few public sources that describe China's nuclear security efforts or suggest steps China could take to improve its current policies. This report is meant to fill that gap. It reviews the evolution of approaches to nuclear security in China, and describes the current status of Chinese nuclear security policies, rules, regulations, and practices. It also recommends steps China should consider to reduce the risk of an act of nuclear or radiological terrorism.

In addition to published sources, the report draws upon interviews and communications with Chinese nuclear experts and officials. The work also benefited significantly from several workshops held in China, organized by the Project on Managing the Atom (MTA) and Chinese partners, and supported by the Carnegie Cooperation of New York and the John D. and Catherine T. MacArthur Foundation. The following meetings were particularly significant in the preparation of this report:

- A workshop on nuclear energy and nuclear security, held on March 14–15, 2010, co-hosted by MTA and Institute of International Studies at Tsinghua University in Beijing.

- A workshop on nuclear security, held on October 13–14, 2011, co-hosted by MTA and the Institute for Nuclear Science and Technology at Peking University in Beijing.

- A workshop on the safety and security of China's nuclear fuel cycle facilities, January15-18, 2013, co-hosted by MTA, the China Arms Control and Disarmament Association, and the Institute for Nuclear Science and Technology at Peking University, in Shenzhen, China.

The workshop discussions covered a wide range of topics from perceptions of the threat of nuclear terrorism in China, to actions needed to reduce nuclear terrorism, to regulatory approaches to nuclear security, to China's role in the Nuclear Security Summits, to expanding US-Chinese cooperation on nuclear security, to safety and security practices at reprocessing facilities.

The Chinese participants were mainly from the China Atomic Energy Authority, the National Nuclear Safety Administration, the China National Nuclear Corporation, China's Institute of Atomic Energy, Ministry of Public Security, Ministry of Foreign Affairs, China Academy of Engineering Physics, China Arms Control and Disarmament Association, China Foundation for International and Strategic Studies, the Guangdong Nuclear Power Group, the Daya Bay Nuclear Power Plant, and Peking and Tsinghua Universities. Non-Chinese participants included experts from Harvard

University, Princeton University, the University of Texas, as well as former officials from the US Department of Energy, national laboratories, International Atomic Energy Agency, and others.

We divided the writing in this report as follows: Tuosheng Zhang was the lead author for chapter 1, with the exception of the section on the principle forms of nuclear terrorism in China. He also wrote the section in Chapter 2 on China's nuclear security policy. Hui Zhang was the lead author on other parts of the report, with contributions from Tuosheng Zhang. We share responsibility for the recommendations of this report.

Hui Zhang and Tuosheng Zhang, March 2014

Executive Summary

Since the terrorist attacks of September 11, 2001, the threat of nuclear terrorism has become one of the most significant challenges to international security. China has worked to meet this challenge, but a continuing effort is needed. The 2010 and 2012 Nuclear Security Summits raised the issues of nuclear security to a higher political level and enhanced international consensus on the danger of nuclear terrorism. China actively participated in the first two summits, and President Xi Jinping will participate in the Nuclear Security Summit in the Netherlands in March 2014. China's commitment to nuclear security is now well established. Former president Hu Jintao emphasized in 2012 that, "the threat of nuclear terrorism cannot be overlooked." Meeting that threat, as President Hu recognized, "is a long and arduous task."

Evolving Chinese Perspectives on the Threat of Nuclear Terrorism

Chinese perceptions of the threat of nuclear terrorism have evolved in three major phases over the past 20 years.

During the first phase, from the end of the Cold War to the events of 9/11, the international community began to pay attention to the problem of nuclear terrorism and the possible acquisition of nuclear weapons or materials by non-state actors. China, after joining the nuclear Non-Proliferation Treaty (NPT) in 1992, focused mainly on strengthening its nuclear non-proliferation measures at the national level and establishing its relevant domestic legislation. China did not pay significant attention to the problem of nuclear terrorism during this time.

The second phase, from 9/11 to 2008, was characterized by a heightened Chinese perception of the threat of nuclear terrorism within a limited sphere. While China supported a series of relevant UN resolutions in this period, it expressed less concern about nuclear terrorism than did the United States and other Western countries because China assessed the probability of a direct attack to be very low. Relevant Chinese government departments were concerned with nuclear security and limited academic research on the problem took place. But the issue of nuclear terrorism was not well known in local governments, the nuclear industry, international affairs think tanks, the media, or the general public.

In the third phase, from 2009 to the present, the relevant functional departments of the Chinese government began to pay much more attention to nuclear security and sped up their efforts on this issue in preparation for the 2010 Nuclear Security Summit. The public and the media have also begun to be more concerned about the issue of nuclear terrorism and security. The 2012 Nuclear Security Summit in Seoul helped to induce China's policy makers to pay more attention to nuclear security. At both summits, President Hu Jintao expounded upon China's nuclear security policy and China's views on the threat of nuclear terrorism.

Through these three stages of policy development, China has developed and established a more comprehensive, in-depth understanding of the threat of nuclear terrorism and its prevention.

Chinese Assessments of the Risk of Nuclear Terrorism

Because China's nuclear arsenal is very limited, tightly monitored, and guarded by heavily armed forces, many Chinese experts believe it is implausible for Chinese nuclear weapons to be stolen.

Chinese nuclear experts also tend to believe that the probability of terrorists obtaining fissile materials inside China and manufacturing a crude bomb is extremely low. They argue that the technologies necessary for manufacturing, delivering, and detonating a weapon are very difficult for Chinese terrorists to obtain. Furthermore, China has established a strict regime of security and accountability of its nuclear materials. Therefore, it is difficult for terrorists to get enough highly enriched uranium or plutonium for a crude nuclear weapon. However, Chinese officials cannot rule out the possibility of terrorists smuggling in a nuclear weapon or nuclear materials from outside China.

Chinese experts and officials believe the risk of sabotage of civilian nuclear facilities, in particular of nuclear power plants, is plausible. As the number of China's nuclear power plants is rapidly increasing, such a risk poses a challenge to China's nuclear security. Also, the Fukushima accident may increase the interest of terrorists in targeting the rapidly growing number of power reactors in China.

Further, Chinese nuclear experts believe that a terrorist attack using a radiological dispersal device or "dirty bomb" is a very real threat. It is easier to make a weapon using radioactive sources and nuclear waste because China has many radioactive sources distributed widely, and also many orphan and spare sources. Moreover, there is a weaker control and management system for radioactive sources than there is for weapons-useable HEU and plutonium.

Rethinking the Nuclear Terrorism Threat in China

The possibility of insider theft of nuclear materials in China cannot be ruled out, especially as China grows into a market-oriented society and contends increasingly with corruption. Terrorist attacks by outsiders may also pose a real threat to China's nuclear facilities—in particular, the terrorist forces of "East Turkestan," which the Chinese government believes have long been recipients of training, financial assistance, and support from international terrorist groups including Al Qaeda.

Another concern of Chinese officials is the increasing threat of smuggling fissile materials or weapons in China. China should be concerned about its borders with Central Asia and Pakistan, where there is a high level of international terrorist activity and the risk of nuclear smuggling and proliferation is believed to be higher. Most importantly, these regions are also the locations where the Eastern Turkestan Islamic Movement has a solid presence.

Finally, a security incident on the scale of Chernobyl, wherever it occurs, would be a global catastrophe. It would result in severe consequences that doom prospects for large-scale nuclear growth everywhere, foremost within China, which has the most rapidly growing nuclear power sector in the world.

National Regulators and Legal System in Chinese Nuclear Security

The major actors responsible for the security of nuclear materials and facilities include the China Atomic Energy Authority (CAEA), National Nuclear Safety Administration (NNSA), and the Ministry of Public Security (MPS). However, regulatory responsibilities and functions in some areas are not clearly defined or coordinated, thus operators and licensees sometimes face unnecessarily complicated requirements, some of which are duplicated for different regulatory bodies.

After the 9/11 attacks, China improved and built up its legal system in some areas related to nuclear security, including nuclear export control and nuclear emergency response. However, with the exception of physical protection guidelines issued in 2008, there have not been many updates of regulations and rules on the security of nuclear materials and facilities. All related regulations and rules were issued before the 9/11 attacks, and do not mention the threat of nuclear terrorism.

Practices of China's Nuclear Security

Since the 9/11 attacks, China has made significant progress on its nuclear security system, with a focus on switching from the traditional "guns, gates, guards" approach to an effective mixed approach; combining personnel with up to date techniques and technology. However, more work is needed. China lacks any national standard of protection against plausible nuclear security threats, and is still in the process of bringing the security of its facilities into line with international norms and recommendations. Continual improvements in nuclear security culture are also needed.

Physical protection system. The major changes to, and challenges confronting, China's physical protection measures include:

- The 2008 Nuclear Facility Physical Protection Guidelines require all civilian nuclear facilities to apply a security approach based on a "design basis threat" (DBT) including outsiders, insiders, and a collusion of both. Facility operators typically design their own DBTs on a case-by-case basis according to a number of factors, including the socioeconomic situation in the surrounding area. However, the published guidelines lack clearly defined national standards for each nuclear facility.
- The operators of Category I nuclear facilities are required to have hardened central alarm stations, armed forces on duty 24 hours a day, and a "two man and double-lock" rule for the vital area. Also, the licensee is required to set up a group and prepare detailed contingency plans to prevent nuclear terrorist acts and nuclear accidents. However, the extent to which China has implemented procedures that meet or exceed the latest International Atomic Energy Agency (IAEA) guidelines for physical protection remains unclear.
- China's nuclear facilities, particularly the nuclear power plants, have widely applied advanced equipment and technology for the physical protection system. For example, detection systems for radioactive material and prohibited items have been installed at access points to the protected and vital areas at nuclear power plants. To control access to facilities, the plants use mobile barrier gates, metal detecting gates, and electric retractable gates; floor-to-ceiling turnstile doors with barcode reading systems; biometric identification systems; and alarm and video monitoring systems at all access points. Like other countries, however, China remains vulnerable to a variety of sabotage measures, particularly those involving insiders.
- Currently, the operator is required to do in-depth vulnerability assessments and

performance tests of their security systems. However, they do not include realistic "force-on-force" exercises. No Chinese regulations require such tests.

The material control and accounting (MC&A) system. Based on China's 1990 rules and related IAEA recommendations, China has established and revised its nuclear materials control and accounting system. However, China may lack the human resources and experience necessary to operate an effective MC&A system for bulk processing facilities, particularly large-scale reprocessing facilities. Further, unlike operators of nuclear power plants whose budgets benefit through market sales of electricity, fuel cycle facilities are currently heavily dependent on government financial support. This may leave operators with insufficient funding to hire enough highly-qualified staff and to purchase more and better sensors and equipment needed for an effective MC&A system.

International cooperation. Since the 9/11 attacks, China has greatly improved its nuclear security and control system, and has benefited significantly from CAEA cooperation with external organizations, in particular the US Department of Energy (DOE) and the IAEA. While the current cooperation focuses mainly on the Chinese civilian sector, it can be expected that current and relevant MPC&A "best practices" learned from cooperative efforts are being applied to fissile materials and facilities in the military sector. However, without knowing what real problems exist in the military sector, it is difficult to assess the impact of civilian cooperation on the military sector. Moreover, cooperation on security and control of China's nuclear weapons has yet to be initiated.

Recommendations for Improving China's Nuclear Security

At the 2012 Nuclear Security Summit in Seoul, Chinese President Hu Jintao spoke of the importance of improving nuclear security in China and around the world. In the spirit of President Hu's statement, China should take further steps to install a complete, reliable, and effective security system to ensure that all its nuclear weapons, weapon-usable nuclear materials, nuclear facilities, and transports, are secured with adequate standards to defeat the threats it could plausibly face. The report recommends the following steps to strengthen nuclear security in China (see details in Table ES-1):

- Updating and clarifying the requirements for a national level DBT
- Strengthening measures to address insider threats
- Improving material control and accounting methods
- Updating and enforcing existing regulations
- Consolidating further nuclear material stocks
- Conducting realistic force-on-force performance tests
- Strengthening nuclear security culture
- Offering stronger international assurance of the effectiveness of China's nuclear security system
- Providing adequate resources for the continual improvement of nuclear security, with special attention to fuel cycle facilities

- Strengthening international cooperation on nuclear security, particularly with the US Department of Energy and the IAEA.

In sum, China has made significant progress in strengthening nuclear security. Its concepts and strategies for addressing security threats have evolved since 9/11, and its focus on the problem has grown stronger in the last four years. But significant gaps remain in China's efforts to prevent nuclear and radiological terrorism. China's work in this area should continue and be intensified to ensure a safe, secure, and prosperous future for all.

Table ES-1: Highlights of Recommendations

Updating and clarifying the requirements for design base threat (DBT)	• Review and upgrade requirements for DBT to include the full spectrum of plausible adversaries and tactics. • Have a minimum national DBT standard -- protection against a modest group of well-armed and well-trained outsiders; a well-placed insider; and both outsiders and an insider working together, using a broad range of possible tactics. • Enhance R&D investments in DBT studies to learn best practices from other nations through bilateral and international cooperation.
Reducing risk of insider threats	• Subject personnel with access to vital areas to background checks, drug testing, and psychological or mental fitness tests. • Vet personnel at specified intervals. • Require personnel to report suspicious behavior to an official authority. • Provide constant surveillance of inner areas when occupied using a two-person surveillance system.
Improving material control and accounting	• Have an accounting system that will detect if any significant quantity is removed, be able to localize the removal in time and space, and identify which insiders had access. • Use reliable and accurate measurement methods and equipment for material accounting.
Updating and enforcing regulations	• Update the 1987 regulations and 1990 rules and issue new, strict, and clear regulations and rules based on a minimum DBT standard. • Integrate effectively international frameworks into domestic regulations and rules to strengthen nuclear security on the ground. • Have a strong system of enforcement to ensure the new regulations and rules are effectively implemented, and continually improved, with weak points identified and corrected. • Have a nuclear security regulatory body that has adequate legal authority, technical and managerial competence, and financial and human resources to ensure it can carry out its responsibilities and functions effectively, efficiently, and independently.
Further consolidation	• Assess the security of every military and civilian location that houses sensitive nuclear materials and nuclear weapons; consider whether the location could contribute to the consolidation of nuclear stockpiles to reduce the number of locations where nuclear material must be protected. • Speed up conversion of China's HEU-fueled reactors and help to convert reactors China has exported. • Take a leading role in negotiating an international agreement for phasing out and ultimately banning the civilian use of HEU. • Reconsider plans for commercial reprocessing.
Conducting realistic performance tests	• Conduct realistic vulnerability assessments at all facilities, envisioning all the various means to get in and get material, and how security measures might be overcome. • Use realistic "force-on-force" exercises to test the performance of its nuclear security systems' ability to detect and defeat intelligent adversaries using asymmetric attacks.

Table ES-1: Highlights of Recommendations (cont.)

Strengthening nuclear security culture	• Confront complacency among senior nuclear experts and within the nuclear industry by convincing relevant personnel that the threat of nuclear terrorism is real. • Conduct regular training programs to impress upon relevant personnel that nuclear security is important and should be taken seriously. • Encourage each staff member to actively and continuously find further ways to improve security systems. • Establish a targeted program to assess and improve security culture.
Increasing international assurance	• Release detailed accounts of nuclear security regulations. • Issue general reports on implementation of and compliance with those regulations. • Share information with others confidentially or publicly about approaches, procedures, regulations, best practices, and lessons learned from incidents. • Allow experts organized by the IAEA to conduct reviews of the country's nuclear security arrangements, e.g. by hosting an IAEA International Physical Protection Advisory Service (IPPAS) mission. • Undertake peer reviews under a bilateral-type agreement or program, e.g., expanding China-US cooperation to include security reviews of some facilities including HEU-fueled reactors and the pilot reprocessing plant.
Providing adequate resources for nuclear security	• Balance the costs of security against the threats the security system must protect against. • Clarify responsibilities and shares of security costs between the government and operators. • Ensure all operators have sufficient resources to provide effective security for their facilities. • Require operators to implement effectively all security regulations and rules issued by the government.
Strengthening international cooperation	• Strengthen cooperation with the IAEA, e.g. continuing and increasing China's contribution to the IAEA Nuclear Security Fund. • Contribute to nuclear security in other countries, e.g., through the 1540 Implementation Fund, and actively support the Global Initiative to Combat Nuclear Terrorism. • Participate in sharing and implementing nuclear security best practices and exchanges, e.g., through the participation of relevant Chinese professionals in the activities of the World Institute for Nuclear Security. • Expand cooperation with the US in the civilian sector, e.g. through in-depth discussions and best practice exchanges on applying the latest material control and accounting systems and best practices to China's pilot reprocessing plant and pilot MOX facility. • Consult on steps China can adopt to improve realistic performance tests, including "force-on-force" exercises. • Restart China and US lab-to-lab program by launching in-depth discussions of a number of areas, including safety and security measures for protecting weapon-usable nuclear materials and nuclear weapons.

Introduction

China is a nuclear weapon state and rising power entering an era of particularly rapid nuclear energy growth. China's approach to strengthening the security of its nuclear weapons, materials, and facilities plays an important role in facilitating strong global action on nuclear security. Since the terrorist attacks of September 11, 2001, the threat of nuclear terrorism has become one of the most significant challenges to international security. China has worked to meet this challenge, but a continuing effort is needed. The 2010 and 2012 Nuclear Security Summits raised the issues of nuclear security to a higher political level and enhanced international consensus on the danger of nuclear terrorism. China actively participated in the first two summits, and President Xi Jinping will participate in the Nuclear Security Summit in the Netherlands in March 2014. China's commitment to nuclear security is now well established. Former president Hu Jintao emphasized in 2012 that, "the threat of nuclear terrorism cannot be overlooked." Meeting that threat, as President Hu recognized, "is a long and arduous task."[1]

The purpose of this report is to provide a better understanding of Chinese perceptions of the threat of nuclear terrorism and attitudes toward the nuclear security challenge; to describe the current status of nuclear security practices in China and of planned improvements in rules and organization, management, and technologies; and to recommend steps for making further improvements. We hope our recommendations for strengthening China's nuclear security will help China's policy makers as they consider their options for the future.

The Structure of the Report

The report begins with a review of Chinese perspectives on the nuclear terrorism threat and how they have evolved since the attacks of September 11, 2001. Chapter 1 examines current Chinese nuclear security concepts and approaches, considers the various forms that nuclear and radiological terrorism might take, and identifies possible gaps in China's strategies for securing its nuclear weapons, facilities, and materials against both external and insider threats.

In Chapter 2, we briefly discuss China's stated policies on nuclear security, describe the responsibilities of major regulators associated with China's nuclear security, and discuss the relevant laws and regulations on nuclear security. Chapter 3 examines in detail China's current nuclear security practices and challenges, including China's approach to physical protection, its material control and accounting system, its security during nuclear materials transport, and the role of international cooperation in informing these practices.

Finally, in Chapter 4, we recommend measures for strengthening China's nuclear security, including updating and clarifying design basis threat requirements, reducing internal risks, improving material control and accounting, updating and enforcing regulations, undertaking further consolidation of nuclear materials, conducting realistic performance tests, strengthening nuclear security culture, increasing international assurance, balancing the costs of nuclear security, and strengthening international cooperation.

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[1] Hu Jintao, "Towards Greater Nuclear Security through Cooperation: Statement at the Seoul Nuclear Security Summit," (Beijing: Ministry of Foreign Affairs, China, March 27, 2012), http://www.fmprc.gov.cn/eng/topics/hjtatnsnss/t920822.htm (accessed March 3, 2014).

Chapter I: Chinese Perspectives on the Threat of Nuclear Terrorism

There are several ways nuclear theft and terrorism could affect China. First, terrorists might carry out a nuclear or radiological attack—detonating a nuclear bomb, sabotaging a nuclear facility, or detonating a so-called "dirty bomb" to spread radioactive nuclear material. Most Chinese analysts think it is extremely unlikely that China would be the target of a terrorist nuclear bomb, though sabotage or attack with dirty bombs may be more plausible. However, we argue below that those analysts should rethink their assumptions.

Second, even if China is not likely to be the target of a terrorist nuclear bomb, a nuclear or radiological attack by terrorists in another country might still have effects on China. If terrorists succeeded in detonating a nuclear bomb in any of the world's major cities, the political and economic consequences would reverberate with potentially dramatic effect on China's national interests. Kofi Annan, while he was Secretary-General of the United Nations, warned that the global economic consequences of an act of nuclear terrorism would push millions into poverty, creating a "second death toll in the developing world."[2] The 9/11 attacks led to the US-led invasions of Afghanistan and Iraq and, later, the controversial expansion of unmanned drone warfare in many countries; a terrorist nuclear attack would provoke a much more far-reaching reaction. In particular, if the United States is attacked with a nuclear weapon or material brought in from elsewhere, it might very well close its borders until it is confident that no further weapons could be brought in—an extraordinarily difficult, possibly infeasible standard, but one for which there would be strong public demand—and this would have a huge impact on global trade and China's economy. [3]

Third, nuclear weapons or weapons-usable nuclear materials might be stolen within the country and used on a target elsewhere. For example, if terrorists detonated a nuclear bomb in the United States and the material were traced to China, there would be huge political ramifications; the American public might demand action against the country that was the source of the nuclear material, even if it never intended this material to fall into terrorist hands. Even if the stolen items were eventually recovered and never used, this could affect the source country's reputation for effective management of its nuclear assets.

Finally, a terrorist attack elsewhere would also doom China's ambitious plan for nuclear power development. A Chernobyl-scale security incident, wherever it occurs, would be a global catastrophe and would very likely doom the prospects for large-scale nuclear growth.[4] This is especially true for China, which currently has the most ambitious plans for nuclear energy growth of any country on the planet.

[2] Kofi Annan, "A Global Strategy for Fighting Terrorism," (Keynote address to the Closing Plenary of the International Summit on Democracy, Terrorism and Security, March 10, 2005, Madrid, Spain), http://english.safe-democracy.org/keynotes/a-global-strategy-for-fighting-terrorism.html (accessed March 6, 2014).

[3] Matthew Bunn, "The Threat of Nuclear Terrorism and Next Steps to Reduce the Danger," (presentation at Harvard-Peking University Workshop on Nuclear Security, October 13-14, 2011, Beijing, China).

[4] Bunn, "The Threat of Nuclear Terrorism and Next Steps to Reduce the Danger."

Hence, even if China is unlikely to be attacked with nuclear explosives, it is in China's national interest to put strong security measures in place – particularly as it is difficult to convince less powerful developing countries to do the same unless leading nuclear states like the United States, Russia, and China are already taking action.

Evolving Official Perspectives on Nuclear Terrorism in China

Chinese policy maker perceptions of the threat of nuclear terrorism have been gradually evolving. The 2010 Nuclear Security Summit marked a particular watershed in China's perception of the problem. Chinese perceptions have evolved through three major phases before and after the 2010 Nuclear Security Summit.

From the End of the Cold War to September 11, 2001

During this period, the international community paid increasing attention to the problem of nuclear proliferation and nuclear terrorism. The increased concern arose because after the disintegration of the Soviet Union, with its huge nuclear arsenal, nuclear material and nuclear technology were distributed across some of the newly independent countries and Russia, while much of the Soviet system of nuclear security, based on a closed society with closed borders, collapsed when the Soviet Union collapsed, leaving gaping holes in fences and a variety of other security weaknesses. Therefore the newly independent states of the former Soviet Union became potentially vulnerable targets for non-state actors or terrorists seeking to acquire nuclear weapons or the materials needed to make them.[5] As one solution, the United States established the Cooperative Threat Reduction Program and other initiatives. Meanwhile, the United Nations and other international organizations passed a number of agreements and resolutions to curb the threat of terrorism and the proliferation of weapons of mass destruction.

China joined the NPT in 1992, and in this early period mainly focused on strengthening its nuclear non-proliferation controls at the national level (instead of focusing on the issue of non-state actors) and establishing relevant domestic legislation. China did not pay much attention to the problem of proliferation to non-state actors and nuclear terrorism in this phase.

From 2001 to 2008: A Growing Concern

In the wake of the 9/11 attacks, and the following disclosure of A.Q. Khan's international underground network marketing technologies to produce nuclear materials, the urgency of the international community's efforts to prevent proliferation to non-state actors increased immensely. Since 2002, the United Nations, International Atomic Energy Agency (IAEA), and other international organizations have passed a number of important resolutions and formulated new regulations to patch loopholes in the existing international legal system and establish a new code of conduct for preventing nuclear terrorism. United Nations Security Council Resolution 1540, approved in 2004, identified the threat of nuclear terrorism as a serious concern of the international community, and imposed binding legal obligations on all states to provide "appropriate effective"

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[5] See Matthew Bunn, *The Next Wave: Urgently Needed New Steps to Control Warheads and Fissile Material* (Washington, D.C.: Carnegie Endowment for International Peace, April 2000), http://belfercenter.ksg.harvard.edu/files/fullnextwave.pdf (accessed March 6, 2014).

physical protection and accounting for any nuclear weapons or weapons-usable nuclear materials they might have, to keep them from falling into terrorist hands.

In the meantime, Chinese awareness of the threat of terrorism increased rapidly. Uighur separatists and others have carried out a number of terrorist attacks within China. China has supported a series of relevant UN resolutions, and has reported annually to the United Nations on the implementation of the 1540 resolution. But, in general, Chinese concern about nuclear terrorism in particular was still lower in this period than that of the United States and other Western countries. Because China thought the direct threat of nuclear terrorism to itself was a lower probability, it was less concerned about nuclear terrorism than the United States and other Western countries. Under such circumstances, concerns about nuclear security were mainly limited to relevant departments of the Chinese government, including the China Atomic Energy Authority (CAEA), National Nuclear Safety Administration (NNSA), and the Ministry of Public Security (MPS).

Despite being less concerned about nuclear terrorism than the West, Chinese experts began to analyze the risks of nuclear and radiological terrorism and to discuss the management of the threat of nuclear terrorism. In 2005, China published an authoritative book, "Management of Nuclear and Radiological Terrorism Incidents," based on a research project of the China Academy of Engineering. The project, initiated around 2003, involved a number of experts from distinguished Chinese nuclear agencies including NNSA, China Institute of Atomic Energy (CIAE), the China National Nuclear Corporation (CNNC), and the China Academy of Engineering Physics (CAEP).[6] However, academic research was still limited. In fact, until the 2010 Nuclear Security Summit, except for the relevant functional departments of the government, the issue of nuclear terrorism was not well known by other sectors, including local governments, think tanks, industries, researchers in international affairs, the media, and the general public. Also, there was a lack of a sense of urgency in China to respond to the threat of nuclear terrorism.

It should be noted that while the majority of Chinese nuclear experts did not believe the threat of nuclear terrorism was urgent in China, some relevant departments including CAEA and NNSA took significant steps to develop and apply approaches to nuclear security and nuclear accounting in the aftermath of 9/11. Several reasons could explain these developments. First, as a rising power, China may one day become the target of nuclear terrorism, thus improving its nuclear security is one important step to prevent nuclear terrorism. Second, as a responsible country, China's participation in international legal instruments relevant to nuclear security and fulfillment of its obligations would improve its international image. Third, given the fact that the nuclear terrorist threat is a top priority in Washington, Beijing's cooperation on the issue would be beneficial to the Sino-US relationship. In fact, since 9/11, Chinese experts have had extensive discussions with US experts on security and accounting, designing improved security and accounting systems, and putting new regulations or guidance in place based in part on those discussions.

From 2009 to the Present: High-level Statements of Support

In contrast with the earlier unilateralism of the Bush administration, the Obama administration came to office emphasizing international cooperation and focusing on a comprehensive nuclear

[6] Pan Ziqiang, et al, Eds., *Management of Nuclear and Radiological Terrorism Incidents* (in Chinese) (Beijing: Science Press, 2005).

agenda, promoting nuclear arms control, nuclear disarmament, non-proliferation, and nuclear security. In April 2010, United States hosted the first Nuclear Security Summit in Washington. This meeting played a huge role in elevating the world's concerns about the threat of nuclear terrorism, and promoting research on, and responses to, the problem.

In preparation for the first Nuclear Security Summit, the relevant functional departments of the Chinese government sped up the study of responsive measures. Chinese president Hu Jintao emphasized at the 2010 Nuclear Security Summit that "the potential threat of nuclear terrorism cannot be neglected and the risk of nuclear material diversion and illicit trafficking is on the rise." He further proposed that "all countries need to honor their commitments and responsibilities by adopting effective measures to secure nuclear materials and facilities."[7] President Hu also recognized the economic interest reducing the risk of nuclear terrorism: "Finding appropriate ways to tackle nuclear security challenges so as to ensure healthy and continuous development of nuclear energy and preserve international security and stability has become an important task that all countries share."[8]

The April 2012 Nuclear Security Summit in Seoul further promoted China's attention to nuclear security. At the Seoul summit, Hu recognized what had been accomplished, noting that "significant achievements have been attained in the domain of nuclear security, with a general increase in the acknowledgement of the importance of nuclear security, gradual perfection of relevant international legal frameworks, deepening of international cooperation, major improvements in the security of nuclear materials and nuclear facilities, and a significant rise in nuclear terrorism response capability." But he also cautioned that "the nuclear security situation that we are currently facing remains grim. Factors of uncertainty and instability on the international scene are growing, while the risk of loss and proliferation of nuclear materials has not diminished, the threat of nuclear terrorism can [not] yet be safely neglected, and the effective supervision and control of the development and use of nuclear energy continues to be a heavy burden."[9]

Moreover, the Chinese government's recognition of the threat posed by nuclear terrorism is reflected in many international documents, resolutions, and initiatives that the government has signed to strengthen nuclear security and remonstrate against nuclear terrorism. The basic conclusions and judgments contained in these documents are essentially shared by the Chinese government.

Through the above three stages of development, China has developed a more comprehensive, in-depth understanding of the threat of nuclear terrorism. These perceptions are mainly reflected in the statements of the Chinese leaders, government published documents, regulations, and the products of the research community. China's perspectives on nuclear terrorism have been informed by the many important areas of consensus in the international community. But Chinese officials and experts also have their own unique views on both the current and future potential threats of nuclear terrorism posed to China and the world.

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[7] "Quotable quotes from Chinese president's speech at nuclear security summit," *CCTV*, April 14, 2010, http://english.cctv.com/20100414/105069.shtml (accessed March 6, 2014).
[8] "Quotable quotes from Chinese president's speech", *CCTV.*
[9] Hu, "Towards Greater Nuclear Security through Cooperation: Statement at the Seoul Nuclear Security Summit."

The Threat of Nuclear Terrorism in China: Concepts and Approaches

The academic community, public, and media have also begun to be more concerned about the nuclear security issue. In 2012, China published another authoritative book, "Combating Nuclear Terrorism—Non-state actors' nuclear proliferation and nuclear security,"[10] based on a research project of China Foundation for International and Strategic Studies. The project, sponsored by China Social Science Fund since 2007 involved a range of participants, from nuclear weapon experts to social scientists. The book discusses the threats of nuclear terrorism and provides measures in response to control such threats from the national, social, and international levels.[11]

Based on published sources and our discussions with Chinese experts on nuclear security both inside and outside of government, we offer the following summary of Chinese thinking about the problem of nuclear terrorism.

The problem of nuclear terrorism should be defined broadly. Nuclear proliferation by non-state actors is a behavior of individuals, multinational networks and terrorist organizations. This problem mainly includes the illegal acquisition, production, and sale of nuclear materials, equipment, and technology needed for making nuclear weapons. Stealing or manufacturing nuclear weapons would be an important goal of some terrorist organizations, though most terrorist organizations are unlikely to be interested in the nuclear level of violence.

The problem is multi-faceted. Compared to state-directed nuclear proliferation, proliferation by non-state actors is more complex, decentralized, and diversified. It may be motivated by political goals or economic benefits or both. The proliferation activities may be undertaken by independent individuals or groups or associated with state actors. State sponsors of terrorism or terrorist organizations may use other non-state actors such as nuclear thieves, nuclear smugglers, middlemen, etc. Alternatively, proliferation activities can be the direct action of terrorists or terrorist organizations.

Preventing nuclear terrorism requires new, comprehensive strategies. Traditional government strategies like diplomacy, sanctions, and deterrence would not work to prevent the use and spread of nuclear weapons among non-state actors, especially nuclear terrorists. Disastrous consequences would befall international security if terrorists succeed in obtaining nuclear weapons. The immense harm and the sensational effects created by nuclear attacks would be instrumental to achieving the terrorists' objectives of globalizing their cause, and threatening and coercing their opponents. Yet it is unlikely if not impossible for a state to respond to nuclear terrorists with retaliatory nuclear strikes since terrorist organizations do not have citizens, territory, or a political regime to hold hostage. Preventing and controlling nuclear proliferation among non-state actors is an important part of improving and reinforcing the non-proliferation regime. For this reason, the existing foundation of non-proliferation mechanisms and tactics should be supplemented

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[10] China Foundation for International & Strategy Studies (CFISS), *Combating Nuclear Terrorism—Non-state actors' nuclear proliferation and nuclear security* (Beijing: Social Science Academic Press, 2012).

[11] Expert opinion in China on the issue of nuclear terrorism is summarized in CFISS, *Combating Nuclear Terrorism—Non-state actors' nuclear proliferation and nuclear security*. Also see Tuosheng Zhang, "Nuclear proliferation of non-state actors and nuclear security," *Foreign Affairs Review*, Vol. 27, No. 3 (2010), pp. 26-34, (in Chinese).

with new measures that, in due time, will garner general support among states and exert binding power internationally. In addition, it should be fully recognized that the prevention of nuclear proliferation must be comprehensive—that proliferation can only be effectively prevented and nuclear terrorism defeated if efforts to stop non-state and state actors are consistently and closely integrated.

Weapon-usable nuclear material is widespread around the globe and theft is a real concern. Nuclear theft is possible in: a) nuclear-weapon states under the NPT; b) nuclear-weapon states outside the NPT; and c) states that do not possess nuclear weapons but do possess a significant amount of nuclear material and civilian nuclear facilities. Owing to their weak nuclear security conditions, countries that are immersed in political and civil disorder and that have unsound supervisory and control systems are particularly susceptible to the opportunism of non-state nuclear proliferation.

Nuclear terrorists could strike in developing or developed countries. Many states are facing real threats posed by nuclear proliferation among non-state actors. Among these actors, terrorist groups constitute the most dangerous force. States that are currently facing particularly significant and frequent threats of terrorism may also confront similarly significant and frequent threats of nuclear terrorism in the future. These include not only developing countries beset by unstable governance and embroiled in serious internal strife and social conflict, but also developed Western countries that are frequently heavily involved in regional conflicts. Beginning with the George W. Bush administration, the United States has explicitly regarded the "the union of terrorism and weapons of mass destruction" as the country's primary security threat.[12] The threat posed by nuclear terrorism will not remain unchanged; rather, it will reflect the national security interests and internal and external security situations of nation-states. Also, the capabilities of terrorist groups could change.

The effects of an act of nuclear terrorism would be global. Although the extent of the direct threat to national security varies widely between states, the adverse effects of a nuclear terrorist attack in any country would spread rapidly across the world due to globalization; if the victim were a major country, then the consequences on world politics, economics, and security would be even greater. The adjustment of US national security policies following the September 11 attacks is an excellent forewarning. If terrorists come to possess nuclear weapons, the nuclear taboo would become a thing of the past, regional and global security conditions would undergo immense changes, and all countries may be confronted with tremendous threats.

Unless efforts to strengthen security are sustained, the threat will grow. While the international community has enhanced efforts to prevent nuclear terrorism and has made important progress, nuclear technology continues to entice, interest in nuclear energy has been revived, and more nuclear weapon states are emerging. Coupled with deficiencies in existing systems for preventing nuclear terrorism[13] and uneven stringency in nuclear security requirements from state

[12] There are some Chinese researchers who believe that the United States, particularly under the George W. Bush administration, has tended to exaggerate the threat of nuclear terrorism, causing two erroneous wars and harming international security. See, e.g. Pan Yaling, "The United States and the Security Issues of Nuclear Terrorism," *Contemporary International Relations*, No. 6, 2008.

[13] Some Chinese analysts argue that the existing patchwork of nuclear security and nuclear terrorism agreements and initiatives

to state, the risk of non-state actors, especially terrorists, obtaining nuclear materials and nuclear weapons still exists. Although the likelihood of nuclear terrorism is much lower in the foreseeable future than the likelihood of conventional terrorist attack, the former will grow unless further preventive action is taken.

The Principal Forms of Nuclear Terrorism

Chinese experts, scholars and officials widely accept the IAEA definition of nuclear security: "The prevention and detection of and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances, or their associated facilities."[14] They agree with counterparts in other countries that there are four main categories of potential threats related to nuclear terrorism: 1) theft, seizure and explosion of nuclear weapons; 2) acquisition of nuclear materials through theft, smuggling, purchase and other means, followed by manufacture and explosion of a nuclear device; 3) sabotage of nuclear facilities; and 4) detonation of a radiological dispersal device or "dirty bomb."[15] We will discuss each of these possibilities in turn.

Theft, Seizure, and the Explosion of Nuclear Weapons

While Chinese experts are aware of the international community's concerns about the theft or loss of nuclear weapons in other countries, particularly the former Soviet Union/Russia and Pakistan, many believe the likelihood of such an event is very low because states with nuclear weapons take measures to maintain very tight control of their strategic assets. Chinese experts further argue that, even if terrorists acquire a nuclear weapon, it is likely to be difficult to detonate because many of these weapons are equipped with electronic locks or other measures designed to prevent them from being detonated without authorization or without passing through their normal flight sequence (e.g. permissive action links).[16]

In the case of China's own arsenal, most Chinese experts believe it is implausible (if not impossible) for Chinese nuclear weapons to be stolen. This is because China's arsenal is very limited in size, tightly monitored, and guarded by substantial and well-armed forces.[17] Moreover, most Chinese warheads are stored in remote, mountainous locations that are kept highly secret and are very difficult for outsiders to access.

In fact, even before the events of 9/11, the Chinese government emphasized in its national defense white paper, that: "China's nuclear force is under the direct command of the Central Military Commission (CMC). China is extremely cautious and responsible in the management of

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is insufficient to ensure that all nuclear weapons, materials, and facilities worldwide are effectively protected against theft and sabotage. See Gao Ning, "Strategic Analysis of International Laws on the Prevention of Nuclear Terrorism," *Journal of Chinese People's Public Security University*, No. 3, 2007, pp. 128-132; Wang Zhongchun, "Nuclear Security Summit: The Search for Common Actions on Dealing with the Nuclear Terrorism Threat," *Contemporary World*, No. 5, 2010, p. 33.

[14] Zhu Zhixuan, "China's nuclear security and international cooperation," (presentation at Harvard –Tsinghua Workshop on Nuclear Policies: Nuclear Energy and Nuclear Security, March 14-15, 2010, Beijing, China). See also CFISS, *Combating Nuclear Terrorism—Non-state actors' nuclear proliferation and nuclear security.*

[15] The most important and current public source on Chinese expert views on nuclear terrorism and nuclear security is Pan, *Management of Nuclear and Radiological Terrorism Incidents*. We rely on it extensively in the following section.

[16] Pan, *Management of Nuclear and Radiological Terrorism Incidents.*

[17] Pan, *Management of Nuclear and Radiological Terrorism Incidents.*

Box 1-1: China's Production of Fissile Materials for Military Use

Beginning in the 1960s, China established a complete military nuclear fuel cycle for plutonium and HEU production. The facilities for producing military HEU and separated plutonium, however, have all been closed or are being converted to civilian use. Some are being decommissioned.

China produced HEU for weapons at two facilities: Lanzhou gaseous diffusion plant (GDP), which began operating in January 1964; and Heping GDP, which began operating in1975. The Lanzhou and Heping GDPs stopped production of HEU in 1979 and 1987, respectively.

China has produced plutonium for weapons at two nuclear complexes. The first is the Jiuquan Atomic Energy Complex, site of China's first plutonium reactor and associated reprocessing facilities; the reactor began operations in 1966. The second is the Guangyuan plutonium production complex which houses a reactor that began operations in 1973. The Jiuquan and Guangyuan reactors stopped plutonium production in 1984 and 1989 respectively.

For more information on the history of China's production of fissile materials for military use, see Hui Zhang, "China's HEU and Plutonium Production and Stocks," *Science & Global Security*, Vol. 19, No. 1, (January–April 2011), pp. 68–89.

its nuclear weapons, and has established strict rules and regulations and taken effective measures to ensure the safety and security of its nuclear weapons."[18]

Published estimates of the size of China's arsenal vary, though credible sources agree it is relatively small. Some estimates suggest China has roughly 170 total nuclear weapons,[19] while others suggest the figure may be 40-50% higher.[20] It has been reported that China has a highly centralized warhead storage and handling system managed by the 22 Base, a Second Artillery Corps facility.[21] The Second Artillery Corps is directly under the command of the Chinese Communist Party's Central Military Commission (CMC).

Most of China's warheads are stored at the 22 Base, while a very limited number are stored at six missile bases. The central warhead storage complex is a secure facility nestled deep in Taibai Mountain.[22] The 22 Base's physical protection system reportedly incorporates not only "guns, gates, and guards," but also real-time video monitoring, an infrared security system, a computerized warhead accounting system, temperature and humidity controls, fingerprint recognition and advanced communication controls.[23]

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[18] Information Office of the State Council of the People's Republic of China, "China's National Defense in 2000," October 2000, http://www.china.org.cn/e-white/2000/ (accessed March 6, 2014).

[19] Hui Zhang, "Nuclear Modernization in China," in *Assuring destruction forever: nuclear weapon modernization around the world,* ed. Ray Acheson, (New York, N.Y.: Reaching Critical Will, a project of the Women's International League for Peace and Freedom, March 2012), http://reachingcriticalwill.org/images/documents/Publications/modernization/assuring-destruction-forever (accessed March 6, 2014).

[20] SIPRI recently estimated that China has a total of 250 nuclear warheads, ten more than estimated in January 2012. See *SIPRI Yearbook 2013: Armaments, Disarmament and International Security: Summary,* (Stockholm: Stockholm International Peace Research Institute, 2013), http://www.sipri.org/yearbook/2013/files/SIPRIYB13Summary.pdf (accessed March 6, 2014).

[21] Mark Stokes, *China's Nuclear Warhead Storage and Handling System* (Arlington, VA: Project 2049 Institute, March 12, 2010), http://project2049.net/documents/chinas_nuclear_warhead_storage_and_handling_system.pdf (accessed March 6, 2014).

[22] Stokes, *China's Nuclear Warhead Storage and Handling System.*

[23] Stokes, *China's Nuclear Warhead Storage and Handling System.*

Theft and Smuggling of Nuclear Materials

Chinese nuclear weapons experts believe that terrorists do not have the capabilities to produce highly enriched uranium and separated plutonium by themselves – a view shared in most international writing on the topic. However, once terrorists acquire enough fissile materials through theft, smuggling, purchase, or other means, they would be able to manufacture a crude nuclear weapon and explode it, although such a weapon would not be as easily deliverable, complicated or high-yield as those of nuclear-weapon states. In particular, a gun-type bomb made of HEU is quite possibly within the capabilities of a sophisticated terrorist group. While HEU would therefore be the material most coveted by terrorists, a terrorist bomb made from plutonium is also plausible. Chinese experts agree that any grade of plutonium, including reactor-grade plutonium, could be used to build an implosion bomb.[24]

However, Chinese nuclear experts believe the probability of terrorists obtaining fissile materials inside China and manufacturing a crude bomb is very low. The experts argue that the technologies necessary for manufacturing, delivering, and detonating a weapon are very difficult for Chinese terrorists to master. Further, China has established a strict regime of security and accountability for nuclear materials. Therefore, it would be difficult for terrorists to get enough materials for a crude nuclear weapon. However, the experts cannot rule out the possibility of terrorists smuggling a nuclear weapon or nuclear materials into China from outside.[25]

Material under military control. According to unclassified estimates, the Chinese military's inventory of fissile material includes approximately 16 metric tons of weapons-grade HEU and 1.8 tons of weapons-grade plutonium.[26] China stopped producing HEU for all purposes in 1987 and halted plutonium production for military purposes in 1991. China has the smallest military stocks of fissile materials among the P5 nuclear-weapon states. Most of China's weapon-usable fissile materials are tightly controlled within the military. Less than half of China's military stocks of fissile materials are believed to be contained in its nuclear warheads.[27] Sites at which the remaining stocks may be stored include: the Jiuquan and Guangyuan plutonium production complexes, which conduct HEU and plutonium processing, warhead component production and weapon assembly; the China Academy of Engineering Physics, which conducts research, development and design of nuclear weapons; and dedicated fissile material storage facilities (see Table 1-1). Use in China of HEU and plutonium for non-weapon purposes are discussed below. China's nuclear-powered submarines are fueled with LEU.

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[24] Pan, *Management of Nuclear and Radiological Terrorism Incidents.*

[25] Pan, *Management of Nuclear and Radiological Terrorism Incidents.*

[26] See Hui Zhang, "Chapter 7: China," *Global Fissile Material Report 2010: Balancing the Books: Production and Stocks* (Princeton, N.J.: Princeton University, 2011), http://belfercenter.ksg.harvard.edu/files/Hui-Zhang-China-Chapter-Global-Fissile-Materials-Report.pdf (accessed March 6, 2014), or Hui Zhang, "China's HEU and Plutonium Production and Stocks," *Science & Global Security, Vol.* 19, No. 1, (January–April 2011), pp. 68–89.

[27] Zhang, "Nuclear Modernization in China," in *Assuring Destruction Forever: Nuclear Weapon Modernization Around the World,* ed. Ray Acheson.

Table 1-1: China's Institutions and Facilities for Fissile Material Production

Nuclear Weapon Design and Manufacture Facilities	
China Academy of Engineering Physics (CAEP), Mianyang, Sichuan	Research, development and design of nuclear weapons.
Jiuquan Atomic Energy Complex, Yumen, Gansu (Plant 404)	Previously produced plutonium and conducted reprocessing; conducts HEU and plutonium processing; warhead component production; and weapon assembly.
Guangyuan plutonium production complex, Guangyuan, Sichuan (Plant 821)	Previously produced plutonium and conducted reprocessing; not clear if it conducts plutonium processing or warhead production as the Jiuquan complex does.
Plutonium Production Reactors	
Jiuquan reactor at Plant 404	Previously military; shutdown; operated 1966-1984.
Guanyuan reactor at Plant 821	Previously military; shutdown; operated 1973-1989; being decommissioned.
Reprocessing Plants	
Jiuquan intermediate reprocessing plant (Small Plant) at Plant 404	Previously military; shutdown; operated 1968-early 1970s.
Jiuquan military reprocessing plant (Large Plant) at Plant 404	Previously military; shutdown; operated 1970-1984.
Guangyuan reprocessing plant at Plant 821	Previously military; shutdown; operated 1976-1991.
Pilot reprocessing plant at Plant 404	For commercial purposes; operational since Dec. 2010.
Enrichment Plants	
Lanzhou GDP (Plant 504), Lanzhou, Gansu	Previously military; shutdown; began operations in 1964 and ended HEU production in 1979.
Heping GDP (Plant 814), Heping, Sichuan	Previously military; began operations in 1975 and ended HEU production in 1987. Possibly producing LEU for naval reactors.
Lanzhou CEP (Plant 504), Lanzhou, Gansu	Operational since 2001; producing LEU for civilian use.
Hanzhong CEP, Shaanxi	Operational since 1996; producing LEU for civilian use; under IAEA safeguards.

Source: Hui Zhang, "China's HEU and Plutonium Production and Stocks," *Science & Global Security* Vol. 19. No. 1 (January-April 2011): pp. 68-89."

Weapons-usable nuclear materials under civilian control. Civil use of HEU in China is very limited. China's Experimental Fast Reactor (CEFR), which reached criticality in July 2010, has an initial loading of almost 240 kg of HEU (64.4% U-235), provided by Russia. Under current plans, the CEFR would use mixed-oxide fuel (MOX) in later loadings, as would China's planned future fast reactors. China has 17 HEU-fueled research reactors (see Table 1-3). Since 2007, several of them have been shut down or converted to use LEU. The remaining major operational facilities include two Miniature Neutron Source Reactors (MNSR) (approximately 1 kg of 90% U-235 in each), one Zero-Power Fast Critical Reactor (90% U-235 0.05 kWt), and one PPR Pulsing Reactor (20% U-235 1MWt).[28]

China has decided to shut down its MNSRs and build the new ones using LEU. In September 2010, the relevant research institutions in China and the US signed an agreement to convert a miniature research reactor in China to enable it to use LEU fuel rather than HEU. This project has now entered into its implementation phase. China is willing to assist other countries in converting their research reactors by applying the expertise and experience gained from cooperation with the United States. China currently operates two centrifuge enrichment plants at Hanzhong and Lanzhou that produce LEU for civilian use. China's future use of HEU in research reactors is likely to be modest.

Chinese nuclear experts are aware of the risks posed by loose HEU or spent HEU fuel at the research reactors. Because those reactors are located at institutes, they are not as well-controlled and guarded as military facilities and stocks, and are hampered by a scarcity of funding. They suggest the government should address this problem and take measures to prevent those materials from falling into the hands of terrorists.[29]

China had no civilian plutonium program until 2010. China briefly tested a pilot civilian reprocessing plant at Jiuquan nuclear complex in 2010. This plant has a production capacity of 50 tHM/year. After starting up the pilot reprocessing plant on December 21, 2010, China declared on December 31 in its annual INFCIRC/549 report of civilian plutonium holdings a stock of 13.8 kg of separated plutonium "in product stores at reprocessing plants."[30] In September 2013, China reported that as of December 2012 its total civilian stock of separated plutonium was 13.8 kg, indicating that there was no additional plutonium produced between 2010 and 2012.[31] In fact, the reprocessing operation had not resumed as of February 2014; and the plant's reprocessing operations lasted for only 10 days and, even then, were below capacity.[32]

In recent years, the China National Nuclear Corporation (CNNC) has been negotiating with France's AREVA on the construction of a commercial reprocessing plant (800 tHM/year).

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[28] NNSA, et al., Comprehensive Safety Inspection Report on Civilian Nuclear Facilities, 2012, http://www.mep.gov.cn/zjyj/201206/W020120615619308262677.pdf; NTI, Civilian HEU: China, http://www.nti.org/analysis/articles/civilian-heu-china/; IAEA Research Reactor Data at http://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx.

[29] Pan, *Management of Nuclear and Radiological Terrorism Incidents*.

[30] International Atomic Energy Agency, *Communication received from China Concerning Its Policies Regarding the Management of Plutonium,* INFCIRC/549/Add.7/10, (Vienna: IAEA, July 8, 2011), www.iaea.org/Publications/Documents/Infcircs/2011/infcirc549a7-10.pdf (accessed March 6, 2014).

[31] International Atomic Energy Agency, *Communication received from China Concerning Its Policies Regarding the Management of Plutonium,* INFCIRC/549/Add.7/12, (Vienna: IAEA, September 26, 2013), www.iaea.org/Publications/Documents/Infcircs/2013/infcirc549a7-12.pdf (accessed March 6, 2014).

[32] Communications with Chinese nuclear safety and security experts, February 2014.

Overview of Jiuquan Nuclear Complex: Box A shows the complex's reactor area; Box B shows the intermediate pilot reprocessing plant; Box C shows the military reprocessing plant; Box D shows the civilian pilot reprocessing plant. (Source: DigitalGlobe and Google Earth, Aug. 31, 2007.)

In addition, the CNNC has discussed independent plans to build a medium-scale commercial reprocessing plant (200 tHM/year) by 2020 and a larger one (800 tHM/year) between 2025 and 2030.[33]

A pilot MOX fuel fabrication plant (with a capacity of 0.5 MT/year) is now under construction near the pilot reprocessing plant, with plans to supply MOX fuel to the CEFR, in operation since July 2010. The CEFR is currently fueled by Russia-supplied HEU. Since July 2010, the experimental breeder has been online for only 26 hours and produced the equivalent of one full power-hour during 2011.[34] The plutonium for the MOX fuel will come from the pilot reprocessing plant. Moreover, the CNNC signed an agreement in 2009 with Russia expressing a general intention to purchase two Russian 800 MWe BN-800 fast breeder reactors, though no agreement on price and other details has yet been reached. The CNNC also has stated it plans to build a series of commercial FBRs by 2032.[35]

One major concern about the pilot reprocessing plant is that plutonium could be stolen by an insider. Since the plant is co-located with a military reprocessing plant that stopped reprocessing spent fuel but likely still processes aging plutonium from warheads, the area should be both heavily guarded and very difficult for outsiders to access.

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[33] Zhao Zhixiang, "Closed Nuclear Fuel Cycle and Sustainable Development of Nuclear Power in China," (presentation at Harvard-Peking University Workshop on Economics of Nuclear Reprocessing, October 15, 2011, Beijing, China). However, recent discussions with CNNC and CIAE nuclear experts suggest China may not build either of these plants on schedule. If China enters into a deal with AREVA, the country might decide it does not need the 200tHM/year plant.

[34] Communication with Chinese nuclear expert, July 2013.

[35] Xu Mi, "Fast Reactor Development for a Sustainable Nuclear Energy Supply in China," (presentation at Harvard-Tsinghua University Workshop on Nuclear Energy and Nuclear Security, March 14-15, 2010, Beijing, China).

The pilot reprocessing plant at the Jiuquan nuclear complex (Source: CNNC Press Briefing Center.)

However, because construction of this pilot plant began in 1995, it does not incorporate security-by-design. Also, the plant shares some facilities with its older neighbor, including high level waste tanks not designed in compliance with modern MC&A standards. Consequently, the plant's accounting system might not operate satisfactorily. Indeed, one recognized problem is that the plant's MUF is higher than permitted.[36] Chinese nuclear experts are therefore concerned the pilot plant's plutonium could become a target for nuclear terrorists.

To prevent the theft of nuclear materials for economic benefit or the furtherance of terrorist objectives, it is necessary to deny outsider access, insider theft, and collusion between insiders and outsiders.[37]

Sabotage of Nuclear Facilities

While Chinese nuclear experts widely believe the probability of terrorists or non-state actors acquiring nuclear weapons and fissile materials inside China is extremely low, the risk of sabotage at civilian nuclear facilities, in particular a nuclear power plant, is considered plausible.[38]

As the number of nuclear power plants in China is rapidly increasing (see Table 1-2), such a risk poses a challenge to China's nuclear security. The Fukushima accident may also increase terrorists' interest in targeting China's power reactors.

In a comprehensive assessment of the risk of sabotage of nuclear facilities, the China Academy of Engineering's 2005 book, "Management of Nuclear and Radiological Terrorism Incidents" concluded that, "one possible route nuclear terrorists would take is to sabotage [a] nuclear facility. Once [it] happen[s], it could seriously affect the environment and public. China has a number of nuclear facilities that have a variety of vulnerabilities if attacked."[39]

Based on the design features of China's power reactors and the likely characteristics of a terrorist attack, the book's authors identified five potential modes of attack against a nuclear power

[36] Interview with a Chinese nuclear regulator, January 2013.
[37] Pan, *Management of Nuclear and Radiological Terrorism Incidents*.
[38] Pan, *Management of Nuclear and Radiological Terrorism Incidents*. pp. 191.
[39] Pan, *Management of Nuclear and Radiological Terrorism Incidents*. pp. 191.

Table 1-2: Operating Power Reactors in China in 2013

Reactors	Capacity (Mwe)	Type	Design	Operation
Qinshan I #1	320	PWR	China	1991
Daya Bay #1	984	PWR	Franatom	1994
Daya Bay #2	984	PWR	Franatom	1994
Qinshan II #1	650	PWR	China	2002
Qinshan II #2	650	PWR	China	2004
Lingao #1	990	PWR	Franatom	2002
Lingao #2	990	PWR	Franatom	2003
Qinshan III #1	728	Candu	Candu	2002
Qinshan III #2	728	Candu	Candu	2003
Tianwan #1	1060	VVER	Russia	2007
Tianwan #1	1060	VVER	Russia	2007
Lingao #3	1080	PWR	China	2010
Qinshan II #3	650	PWR	China	2010
Qinshan II #4	650	PWR	China	2011
Lingao #4	1080	PWR	China	2011
Hongyanhe I #1	1080	PWR	China	2013
Ningde I #1	1080	PWR	China	2013

plant.[40] These are: 1) attacks against the reactor building with the goal of causing a large-scale release of radioactive materials, which would lead to serious consequences including social and psychological disruption; 2) thefts of nuclear materials for future terrorist acts, including passive, explosive (i.e. dirty bomb) or atmospheric dispersal of the materials to incite public panic; 3) attacks against secondary facilities that would disrupt reactor operations, causing a shutdown with economic and psychological effects; 4) attacks against conventional facilities at nuclear power plants that would result in economic and psychological effects; and 5) attacks against plant workers, leading to a collapse in reactor operations and/or plant command structures, and inflicting a psychological setback.

Among these five modes of attack, the experts concluded that the first, an attack against a reactor building, is the only mode that could result in the severe consequence of a radioactive release. The impact of the others would be limited to social and psychological disruption.[41] However, it should be noted that the above conclusions are incomplete. As the Fukushima accident demonstrated, the destruction of off-site power supplies and on-site diesel generators could also lead to a major radioactive release even while the reactor building remained intact. Destroying the reactor's connection to the ultimate heat sink would be another possible out-of-building strategy. So might be causing a fire in the spent fuel pool if it is outside the building. Post-Fukushima reviews have concluded that assets outside the protected area of the reactor also need to be protected to avoid major releases.

Chinese experts have also discussed sabotage scenarios against the reactor and spent fuel pool buildings. Sabotage attempts by an outsider against a reactor could involve the use of portable

[40] Pan, *Management of Nuclear and Radiological Terrorism Incidents.* pp. 29-30.
[41] Pan, *Management of Nuclear and Radiological Terrorism Incidents*. pp. 31-34.

weapons and limited amounts of explosives outside the reactor building. Experts believe that the safety measures incorporated in the existing DBA (design base accident), combined with security measures already in place, would prevent terrorists causing a radioactive release with those tools. However, they neglect to consider that terrorists would probably be able to take out off-site power and diesel generators from outside buildings. Chinese experts have also suggested that the current DBA also prescribes protection for the containment of damage to a reactor caused by the impact of a small airplane. However, it does not protect against a commercial plane impact or heavy weapons including missiles, which would damage the containment and cooling system of the reactor, resulting in reactor core meltdown and a radioactive release.[42] In addition, if explosives are used inside the reactor building, the explosion could also lead to release of some radioactive material. Commercial planes and missiles could damage the spent fuel pool and create a loss of cooling water. This could overheat the spent fuel or damage it directly, leading to a radioactive release.[43] However, many experts argue that the risk of an attack involving commercial planes and heavy weapons is extremely low in China.

Bearing in mind China's current security situation, those experts concluded that the worst manifestation of an insider threat would involve the sabotage of the main control room of the reactor or the reactor building itself, leading to unpredictable consequences. They further concluded that the consequences in all other scenarios involving insider threats, including reactor shutdown, breaking of the primary coolant loop, or a cutoff of the power supply system, would be limited or mitigated by DBAs for the reactors and other current safety and security measures. However, these conclusions do not take all factors into consideration. For instance, if terrorists were determined enough to take out the primary coolant loop, they would probably plan to disable any backup cooling system as well—in which case a release would likely occur. It is not clear if China has taken security measures to prevent insiders from accessing both of these systems in rapid succession. Moreover, consideration of the insider threat in publicly available discussion is limited to individual acts, when an entire well-organized group could be involved.[44] Critically, collusion between insiders and outsiders, which would pose a great threat to nuclear facilities as emphasized by other countries, should not be ignored in China.

Chinese experts have also examined sabotage scenarios against research reactors. Points of concern include: 1) research reactors might not be able to prevent or counter some threats associated with nuclear terrorism, even though their DBAs take into consideration some malicious acts; 2) the security and control systems at some older facilities are of a lower standard than those at new facilities; 3) possible threats to a research reactor include car bombs and malicious actions launched internally; 4) many research reactors are at research institutes located in or near large cities—about ten research reactors (roughly half of China's research reactors) are in or near Beijing. While a radioactive release and corresponding consequences caused by a serious event at a research reactor would typically be thousands of times smaller than a release from a nuclear power plant, social effects could still be relatively large.[45]

[42] This is also true for power reactors in the United States and most other places in the world.
[43] Pan, *Management of Nuclear and Radiological Terrorism Incidents,* pp. 31-32.
[44] Pan, *Management of Nuclear and Radiological Terrorism Incidents,* pp. 32-33.
[45] Pan, *Management of Nuclear and Radiological Terrorism Incidents*. pp. 35-36.

Table 1-3: China's Research Reactors

Reactor	Operator	Characteristics	Status
China Experimental Fast Reactor (CEFR)	China Institute of Atomic Energy (CIAE), Beijing	FBR, 64.4% HEU, 65 MWt/25 MWe	Operational since July 2011
CEFR	Nuclear Power Institute of China (NPIC), Chengdu, Sichuan	Critical fast, 90% HEU, 0.05 kWt	Operational
Zero Power Fast Critical Reactor	Nuclear Power Institute of China (NPIC), Chengdu, Sichuan	Critical fast, 90% HEU, 0.05 kWt	Operational
PPR Pulsing Reactor	NPIC, Chengdu	Pool, 20% HEU, 1 MWt	Operational
MNSR-SZ	Shenzhen University, Guangdong	Tank in pool, LW, formerly 90% HEU, 30 kWt	Operational (to be converted)
MNSR-IAE	CIAE, Beijng	Tank in pool, LW, formerly 90% HEU, 27 kWt	Operational (to be converted under US-China cooperation)
HFETR	NPIC, Chengdu	Tank, LW, formerly 90% HEU, 125 MWt	Converted in 2007; Operational
MJTR	NPIC, Chengdu	Pool, LW, formerly 90% HEU, 5 MWt	Converted in 2007; Operational
MNSR-SD	Research Institute of Geological Science, Jinan, Shandong	Tank in pool, LW, 90% HEU, 33 kWt	Shutdown (reported Dec. 2010)
MNSR-SH	Shanghai Institute for Measurement and Testing Technology, Shanghai	Tank in pool, LW, 90% HEU, 30 kWt	Shutdown in 2007
HFETR Critical Assembly	NPIC, Chengdu	Critical assembly, LW, formerly 90% HEU, 0 kWt	Converted in 2007 (reported shutdown later)
Fast Neutron Critical Assembly	CIAE, Beijing	0 kWt	Operational
HWRR	CIAE, Beijing	LEU, 15 MWt	Operational
SPR	CIAE, Beijing	Pool, LEU, 3.5 MW	Operational
China Advanced Research Reactor (CARR)	CIAE, Beijing	Tank in pool, LW, 19.75% LEU, 60 MWt	First critical in May 2010
NHR-5	Tsinghua University, Beijing	Heating supply reactor, LEU, 5 MWt	Operational
HTR-10	Tsinghua University, Beijing	High Temperature Gas-Cooled Reactor, coated particle fuels, LEU, 10 MWt	Operational
ESR-901	Tsinghua University, Beijing	Pool, 2-cores, 19.75% LEU, 1 MWt	Critical in 1964; Operational

Source: NNSA, et al., Comprehensive Safety Inspection Report on Civilian Nuclear Facilities, 2012, http://www.mep.gov.cn/zjyj/201206/W020120615619308262677.pdf; NTI, Civilian HEU: China, http://www.nti.org/analysis/articles/civilian-heu-china/; IAEA Research Reactor Data at http://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx.

Chinese nuclear experts have also estimated sabotage risks at other nuclear facilities. One of the major sabotage concerns at the pilot reprocessing plant is an attack against the storage facility for separated plutonium, which could result in a critical event. A successful attack on a spent fuel pool or high level waste tanks could also lead to a radioactive release. Sabotage of enrichment facilities would likely have limited environmental repercussions.[46]

Radiological Dispersal Devices or "Dirty Bombs"

Overall, Chinese nuclear experts believe the most likely form of nuclear or radiological terrorism in China would be the detonation of a radiological dispersal device or "dirty bomb," which is relatively easy to make using radioactive sources such as nuclear waste. Such sources are distributed widely across China. There also exist many orphan and spare radioactive sources. Moreover, the control and management systems for radioactive sources are weaker than those for nuclear materials.[47] As one nuclear expert emphasizes, "the most realistic nuclear terrorist threat is from a dispersion device containing radioactive material," and thus, "the basic approach for preventing acts of nuclear terrorism is to ensure the safe control of radioactive materials."[48]

If such a bomb were to explode in a densely populated area, while physical damage would be much more limited than in a nuclear explosion, it could still cause serious social disorder, and long-term damage to the health of persons. Commercial and other social activities could also be seriously disrupted.[49]

Based on a 2002 survey conducted by the State Bureau of Environmental Protection, the Ministry of Public Health, and the Ministry of Public Security, China had a total of 63,721 radioactive sources and 8,312 users, including hospitals, industrial concerns, agricultural bodies, research institutes and education departments. Approximately 13,000 spent radioactive sources were awaiting disposal.[50] According to estimates by one nuclear expert, approximately 2,000 radioactive sources were completely lacking in controls due to problems with management systems.[51] Between 1988 and 1998, 966 individuals were exposed to unsafe levels of radiation in 332 radiation accidents, and 8 people died. While the government makes efforts to find orphan sources, about 1,000 radioactive sources have still not been found.[52]

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[46] Pan, *Management of Nuclear and Radiological Terrorism Incidents*. pp. 36-40.

[47] Pan Ziqiang, "Discussion of several issues in safety management of radioactive sources," *Radiation Protection,* Vol. 22, No. 5, (September 2002).

[48] Liu Senling, "Status of research on nuclear security technology in CIAE" (presentation at Harvard-Peking University Workshop on Nuclear Security, October 13-14, 2011, Beijing, China).

[49] Pan, *Management of Nuclear and Radiological Terrorism Incidents*. It is perhaps true that the probability of an attack using a radiological dispersion device is higher than one involving a full nuclear detonation. However, since the consequences of a nuclear attack are much higher, the overall risk should be judged as greater.

[50] Zou Yunhua, "Preventing Nuclear Terrorism: A View from China," *Nonproliferation Review,* Vol. 13, No. 2, (July 2006), pp. 253–273.

[51] Zou, "Preventing Nuclear Terrorism: A View from China."

[52] Liu, "Status of research on nuclear security technology in CIAE."

Rethinking the Nuclear Terrorism Threat in China

As described above, many Chinese nuclear experts do not consider the risk of terrorists acquiring nuclear weapons and fissile materials in China to be as serious or urgent as US and other international experts have emphasized. They believe that the "dirty bomb" threat is most realistic. However, while the probability of a nuclear bomb detonation is lower than that of a dirty bomb, the consequences of a nuclear blast are much larger than those of a radiological dispersal device. Therefore, the overall risk posed by a nuclear blast may be higher. This is why the nuclear security summit process has focused first on the security of HEU and plutonium. In fact, no country, in particular those that have nuclear weapons or weapon-usable fissile materials, can ignore the real and urgent threat of nuclear terrorism. China cannot and should not exclude the possibility of outsider and insider threats as discussed below. We strongly suggest that Chinese nuclear experts and analysts rethink the threat nuclear terrorism poses to China.

As international nuclear security experts have emphasized, a number of facts suggest that the nuclear terrorism threat is real and urgent.[53] Some terrorist groups are seeking nuclear weapons and have repeatedly attempted to acquire the materials and expertise needed to make them. Many governments and nuclear experts believe a terrorist group could plausibly make a crude nuclear weapon if it got enough of the needed nuclear materials. By 2010, there have been over 18 documented cases of theft or loss through smuggling of HEU or plutonium. It is very difficult to stop nuclear smuggling given the immense length and porous nature of national borders. Even if the probability of loose nukes and materials reaching terrorist hands is not high, given the incredibly catastrophic consequences of a nuclear explosion, urgent actions to reduce risks are justified.

Since 9/11, many leaders have emphasized the threat of nuclear terrorism. Then-UN Secretary-General Kofi Annan stated in 2005 that, "Nuclear terrorism is still often treated as science fiction. I wish it were. But unfortunately we live in a world of excess hazardous materials and abundant technological know-how, in which some terrorists clearly state their intention to inflict catastrophic casualties. Were such an attack to occur, it would not only cause widespread death and destruction, but would stagger the world economy... [creating] a second death toll throughout the developing world."[54] In 2007, UN Secretary-General Ban-Ki Moon warned that, "Nuclear terrorism is one of the most serious threats of our time. Even one such attack could inflict mass casualties and create immense suffering and unwanted change in the world forever. This prospect should compel all of us to act to prevent such a catastrophe."[55]

China must consider and plan for threats that originate from both inside its nuclear facilities and from groups operating outside.

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[53] Bunn, "The Threat of Nuclear Terrorism and Next Steps to Reduce the Danger"; Matthew Bunn, *Securing the Bomb 2010* (Cambridge, M.A., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, April 2010), www.nti.org/securingythebomb (accessed March 6, 2014).
[54] Annan, "A Global Strategy for Fighting Terrorism."
[55] UN Department of Public Information, "Secretary-General welcomes swift entry into force of nuclear terrorism convention, calls on all states to ratify without delay," SG/SM/11040, L/T/4404, June 13, 2007, http://www.un.org/News/Press/docs/2007/sgsm11040.doc.htm (accessed March 5, 2013).

Insider Threats

The possibility of an insider theft of nuclear materials cannot be ruled out, particularly as China continues to transform into a market-oriented society and becomes increasingly corrupt. Certain Chinese experts argue that the significant changes in Chinese society over the last decades could increase crime rates, perhaps raising the probability of theft and smuggling.[56] Many experts believe that the more severe the corruption in a country is, the higher the potential for insider theft of materials and the greater the need for rigorous nuclear materials security measures.[57] The risk of an insider threat is perhaps the most difficult to deal with, because insiders are those authorized to access areas containing nuclear materials.[58] They are knowledgeable about operations, rules, policies, and regulations concerning nuclear materials. Insiders are highly trained on handling nuclear materials. They have the opportunity to understand how to defeat, test, or circumvent safety and security systems and distract other insiders and guards. One or more of these individuals could take advantage of access to perform acts of theft or sabotage, and potentially aid terrorists. Insiders could work with outsiders, other employees, on-site personnel, or off-site personnel.

An insider might be motivated by a number of factors, including: desperation; greed and the temptation of bribery; political or religious ideology; social or cultural motivations; blackmail; and ego.[59] Based on the documented history of thefts of valuable items from guarded facilities, the involvement of insiders, including guards, is widespread. Insiders are capable of utilizing tactics including but not limited to: deception, breach or avoidance of physical barriers, and conspiracy with other insiders or outsiders.[60]

Outsider Threats

Outsider terrorist attacks may someday pose a real threat to China's nuclear facilities. As the Chinese government has emphasized, the terrorist forces of the East Turkestan movement have long been recipients of training, financial assistance and support from international terrorist groups, including core al-Qaeda.[61] Indeed, concern in Beijing about the threat of terrorism has

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[56] Tang Dan, et al., "Physical Protection System and Vulnerability Analysis Program in China," (presentation at the 8th ISODARCO Conference on Arms Control, Beijing, China, October 2002).

[57] The linkage between corruption and nuclear security is suggested, for example, by the Nuclear Threat Initiative, in the *NTI Nuclear Materials Security Index: Building a Framework for Assurance, Accountability, and Action,* Second Edition (Washington, D.C.: Nuclear Threat Initiative, January 2012), http://ntiindex.org/wp-content/uploads/2014/01/2014-NTI-Index-Report.pdf (accessed March 6, 2014).

[58] Lonnie Moore, "Dealing with the Insider Threat," (presentation at the workshop on the safety and security of China's nuclear facilities, hosted by the Managing the Atom Project of Harvard University, the China Arms Control and Disarmament Association, and the Institute for Nuclear Science and Technology at Peking University, January 15–18, 2013, Shenzhen, China); Also see International Atomic Energy Agency, *Preventive and Protective Measures Against Insider Threats: Implementing Guide* (Vienna: IAEA, 2008), http://www-pub.iaea.org/MTCD/publications/PDF/pub1359_web.pdf (accessed March 6, 2014); World Institute for Nuclear Security, *Managing Internal Threats: A WINS International Best Practice Guide for Your Organization* (Vienna: WINS, 2010); Matthew Bunn and Kathryn M. Glynn, "Preventing Insider Theft: Lessons from the Casino and Pharmaceutical Industries," *Journal of Nuclear Materials Management,* Vol. 41, No. 3, (Spring, 2013), pp. 4–16.

[59] See, e.g., Moore, "Dealing with the Insider Threat."

[60] Matthew Bunn, "Nuclear 101: Technology and Policy of Nuclear Security," (seminar at Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, May 8, 2013), http://belfercenter.ksg.harvard.edu/files/technologies-bunn-may-8-2013.pdf (accessed March 6, 2014).

[61] Ministry of Public Security of the People's Republic of China, "The first determined lists of 'East Turkestan' terror

Box 1-2: China's Nuclear Power Development and the Fukushima Nuclear Accident

By January 2014, China had 17 reactors in operation with an aggregate installed capacity of about 15 GWe, which accounts for less than 2% of China's total electricity generation. In addition, 31 reactors, capable of producing a total of 34 GWe, are under construction–making the Chinese nuclear industry by far the fastest growing in the world.[1] The Fukushima nuclear accident in March 2011 slowed China's nuclear power construction momentarily, but China is now on pace to meet or exceed its pre-Fukushima development plans.

In October 2012, after comprehensive post-Fukushima safety inspections on all plants in operation and under construction, the State Council issued a new "Medium- and Long-Term Nuclear Power Development Plan (2011-2020)," which reconsiders nuclear safety and the pace of development.[2] The new plan includes: (1) return to normal construction; (2) a "scientific" layout for new reactor sites, with a limited number of coastal facilities based on proven designs (inland nuclear power projects would be rejected because the government fears a shortage of cooling water in the case of a nuclear accident); and (3) a requirement that all future nuclear power projects meet the world's highest safety standards, which means, in essence, that they must meet the safety standards for third-generation (or Gen III) reactors.

Based on this new nuclear development plan, although only a few new reactor construction projects would be approved before 2016, China now plans to grow its total nuclear capacity to 40 GWe by 2015[3] and 58 GWe by 2020 –representing a pace faster than envisioned in official plans before Fukushima, which called for a total installed nuclear capacity of 40 GWe by 2020/

Since the Fukushima nuclear accident, China has officially approved a number of plans to e hance its nuclear safety standards. All emphasize that the pace of nuclear power development

[1] Shan Sun, "Challenges during Construction of New NPPS", Presentation at the 8th annual Technical Meeting on Topical Issues in the Development of a Nuclear Power Infrastructure, Feb. 2-7, 2014, IAEA Headquarters,Vienna, Austria. http://www.iaea.org/NuclearPower/Downloadable/Meetings/2014/2014-02-04-02-07-TM-INIG/Presentations/37_S7_China_Sun.pdf.

[2] "Wen Jiabao chairs executive meeting of the State Council," website of the Central People's Government of the People's Republic of China, October 24, 2012, http://www.gov.cn/ldhd/2012-10/24/content_2250357.htm (accessed March 4, 2013).

[3] "The Information Office of the State Council", China's Energy Policy 2012, Oct. 24, 2012, http://news.xinhuanet.com/english/china/2012-10/24/c_131927649.htm.

been rising. China has been the victim of terrorism and faces various terrorist threats.[62] Its recent national defense White Paper states, "China still faces multiple and complicated security threats and challenges. The threats posed by 'three forces,' namely, terrorism, separatism, and extremism, are on the rise."[63]

China faces a growing threat from extremists in the predominantly Muslim Uighur community who want to form a separate state called East Turkestan. In 2003, China's Ministry of Public

organizations and terrorists," December 15, 2003, http://www.mps.gov.cn/n16/n983040/n1988498/1988553.html (in Chinese) (accessed March 6, 2014).

[62] Permanent Mission of the People's Republic of China to the U.N., "Statement by Ambassador Li Baodong at the UN Security Council High-level Briefing on Counter-terrorism," May 5, 2005, http://www.china-un.org/eng/hyyfy/t930746.htm (accessed March 6, 2014).

[63] Information Office of the State Council of the People's Republic of China, "The Diversified Employment of China's Armed Forces,"April 2013, http://news.xinhuanet.com/english/china/2013-04/16/c_132312681.htm (accessed March 6, 2014).

Box 1-2: China's Nuclear Power Development and the Fukushima Nuclear Accident (cont.)

should be controlled by safety considerations. The State Council approved in May 2012 the "Comprehensive Safety Inspection Report on Civilian Nuclear Facilities" and "the 12th Five-Year Plan and the 2020 Vision of Nuclear Safety and Radioactive Pollution Prevention," both submitted by the National Nuclear Safety Administration. The inspection report indicated that most of China's nuclear power plants satisfy existing domestic nuclear safety regulations and meet the standards of the International Atomic Energy Agency.[4] However, the inspections also revealed several major nuclear safety issues at some plants, including: a lack of adequate guidelines for prevention and mitigation of severe accidents; failure to satisfy new requirements on flood prevention; and vulnerability to tsunami damage. The inspection report required plants to resolve these issues and make improvements by 2015 in a phased manner, including urgent changes by the end of 2012. One such urgent change is an increase of mobile backup emergency power systems and mobile pumps at power plants to ensure the operation of cooling systems under any condition.

In October 2012, a State Council executive meeting also approved the "Nuclear Power Safety Plan (2011-2020)" which was submitted by the National Energy Administration. The State Council emphasized several points at that meeting: planning, construction, operation, decommissioning and other related nuclear power activities should follow a principle of prioritizing safety; safety upgrades to nuclear power units in operation and under construction should be continuously carried out; the development of China's nuclear power safety standards and regulatory system should be accelerated and nuclear accident emergency management and response capabilities should be enhanced; and public oversight and efforts to cultivate public opinion on nuclear power should be strengthened.[5] A new nuclear safety law has been included in the five-year legislative plan of the National People's Congress, which means that it is highly likely that China will promulgate a nuclear safety law within the coming four years.

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[4] NNSA, et al., *Comprehensive Safety Inspection Report on Civilian Nuclear Facilities* (2012), http://www.mep.gov.cn/zjyj/201206/W020120615619308262677.pdf (accessed March 5, 2013).

[5] "State Council adopts nuclear safety and medium-to-long-term nuclear energy development plans," China.com (online), October 24, 2013, http://news.china.com/domestic/945/20121024/17491799.html (accessed March 4, 2013).

Security identified several associated terrorist organizations, including the Eastern Turkestan Islamic Movement (ETIM), the East Turkestan Liberation Organization (ETLO), the World Uyghur Congress, and the East Turkistan Information Center.[64] ETIM has claimed responsibility for over 200 acts of terrorism between 1990 and 2001.[65] The group has a close relationship with al-Qaeda, which has provided training in Afghanistan and funding. Several of the terrorist groups have been involved in the recent crisis in Syria. "Their aim is not only troop training, but also acceptance and support from other terrorist groups, so as to be able to solicit help in the future."[66]

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[64] Ministry of Public Security of the People's Republic of China "The first determined lists of 'East Turkestan' terror organizations and terrorists".

[65] NBC News, "Al-Qaida: Dead or captured," last updated June 22, 2005, http://www.nbcnews.com/id/4686228 (accessed on March 6, 2014).

[66] See SINA.com.cn, "Al-Qaeda asks East Turkestan terrorists to covertly enter Syrian War," October 29, 2012, http://news.sina.com.cn/w/2012-10-29/092225461490.shtml (in Chinese) (accessed March 6, 2014).

Over the last six years, Eastern Turkestan terrorists have carried out a dozen attacks, most involving explosives and grenades, resulting in numerous deaths. On April 23, 2013, clashes between police and a group of terrorists in Xinjiang killed 21 people including 15 police officers and community workers and six terrorists.[67] Eight terrorists were captured. In addition, 11 suspected of involvement in the attack were captured in the following days. Officials reported that police had seized a batch of homemade explosives, lethal weapons, and flags associated with East Turkestan terrorists. The suspects had been watching extremist recordings and attending outlawed religious events. The group had tested explosives and were planning to "do something big" in a densely populated parts of Kashgar later in 2013. Preliminary investigations have established that this group was plotting to carry out violent, religiously inspired terrorist activities. Over the years to come, it is plausible that similar terrorists groups might be able to put together an attack on a nuclear facility involving a significant number of participants, automatic weapons, and explosives; Chinese nuclear facilities should therefore have security systems capable of providing an effective defense against such threats.

The April incident began when three community workers called on a house in Bachu county, near Kashgar. A clash began after the suspects attacked officials who spotted them making explosives. When the community workers called their superiors to report "suspicious people," they were taken hostage by the terrorists. Armed with guns, axes, and large knives, the gang attacked police and officials who rushed to the scene. The gang later killed the hostages and set the house on fire, killing the other people inside.

Another concern of Chinese experts and scholars is the growing possibility of fissile material and nuclear weapons smuggling.[68] China borders the Central Asian states and Pakistan, in which there is a high level of international terrorist activity, considerable risk of nuclear smuggling and proliferation activities, and most importantly, safe havens for the Eastern Turkestan terrorists outside China.

Evolving Threats Require Adaptive Responses

Due to differences in national security conditions, the threat of nuclear proliferation by non-state actors that each country faces—in particular the threat of nuclear terrorism—is different. For some countries, nuclear terrorism has become a severe, indeed primary, manifest threat; for others, it remains a relatively small or latent threat. For China, the nature of the threat needs to be continually reevaluated to yield up-to-date and accurate assessments that reflect the latest developments. Of course, even if another country, not China, were to be the target of a nuclear terrorist attack, the effects on China would still be considerable.

In the short- and medium-term future, nuclear security concerns within China will remain focused on the protection of nuclear power stations, the supervision and control of nuclear materials and radioactive sources, the prevention of nuclear proliferation (including illicit transport and smuggling of nuclear materials), and the prevention of nuclear terrorist acts conducted by terrorist, separatist, and extremist groups within and outside the country. At the same time, China will continue to express appropriate concerns about the threats to nuclear security around the world.

[67] Yang Jingjie, "Xinjiang terror spree kills 21," Global Times (online), April 25, 2013, http://www.globaltimes.cn/content/777361.shtml (accessed March 6, 2014).
[68] CFISS, *Combating Nuclear Terrorism—Non-state actors' nuclear proliferation and nuclear security,* pp. 134-134.

Over the long term, given global nuclear proliferation trends and the increasingly wide-spread use of nuclear power, it can be foreseen that China—as a nuclear-weapon state and a rising, major power, with extensive plans for nuclear energy development and facing a growing terrorist threat—will likely shoulder an increasingly heavy and difficult responsibility to strengthen its nuclear security. The maintenance of a high level of concern for nuclear security and resolute opposition to nuclear proliferation and nuclear terrorism would become inevitable policy for China.

Chapter II: China's Nuclear Security: Policy, Administrative System, Law, and Regulations

After years of efforts reflecting unique domestic circumstances and informed by international experiences and a deepening awareness of the threat of nuclear terrorism, China has formed a relatively complete set of nuclear security policies, promulgated and implemented a series of laws and regulations that meet international standards, and established a fairly complete nuclear security management, monitoring, and emergency response system. Nevertheless, as China has less experience in managing nuclear security—especially in the civilian sector—than countries such as the United States and Russia, there remain areas for improvement and learning from best practices.

China's Nuclear Security Policy

At the 2012 Nuclear Security Summit in Seoul, President Hu Jintao proposed adoption of four points to strengthen nuclear security, which jointly reflect Beijing's policy on nuclear security:[69]

- First, follow a scientific and sensible approach to nuclear security and boost confidence in the development of nuclear energy.
- Second, strengthen nuclear security capacity-building and fulfill national responsibilities for ensuring nuclear security.
- Third, deepen international exchanges and cooperation and improve nuclear security around the world.
- Fourth, take a comprehensive approach and address both the symptoms and root causes of nuclear proliferation and nuclear terrorism.

China stresses that preventing nuclear proliferation and combating nuclear terrorism should not rely solely on military means. Instead, efforts should be comprehensive—both the root causes and symptoms should be dealt with. At the same time, the right of every country to the peaceful use of nuclear power should be protected.

The second and third points listed above are completely in sync with the approach adopted by the international community. Through learning from the experiences of nuclear-weapon states like the United States and organizations such as the IAEA, accepting their principles and policies, and ratifying the primary relevant international legal documents and supporting and abiding by a series of United Nations resolutions, China has achieved rapid progress in establishing laws and regulations and in building capacity for implementing nuclear security measures. The country has launched policies of active multilateral and bilateral cooperation with the goal of ensuring the security of large-scale international public events that have taken place in China (e.g. the Olympics Games in 2008 and the Shanghai World Expo in 2010). It has also assisted developing countries in building and improving the foundational framework of their nuclear security capabilities and has contributed to raising technical standards for nuclear security.

[69] Hu, "Towards Greater Nuclear Security through Cooperation: Statement at the Seoul Nuclear Security Summit."

Box 2-1: China's International Nuclear Security Commitments

- China has joined nearly all international legal instruments relevant to nuclear security. In practice, the obligation to fulfill those international pledges is one major driver of the development of China's nuclear security capabilities.
- In 1989, China acceded to the 1980 Convention on the Physical Protection of Nuclear Material (CPPNM). In October 2008, China ratified the 2005 Amendment to the Convention on the Physical Protection of Nuclear Material.
- China signed the Protocol Additional to the Agreement between China and IAEA for the Application of Safeguards in China in 1998, and in early 2002 formally completed the domestic legal procedures necessary for the entry into force of the Additional Protocol, thus becoming the first nuclear-weapon state to complete the relevant procedures.
- In 2007, China began contributing to the Incident and Trafficking Database (ITDB), the IAEA's information system on incidents of illicit trafficking and other unauthorized activities and events involving nuclear and other radioactive material outside of regulatory control.
- In August 2010, China ratified the International Convention for the Suppression of Acts of Nuclear Terrorism.
- Since 1999, China has implemented obligations under relevant UNSC resolutions, including Resolution 1267 of 1999, Resolution 1373 of 2001, Resolution 1540 of 2004, and Resolution 1887 of 2009.
- China contributed US $200,000 to the IAEA Nuclear Security Fund in 2011. Chinese officials have expressed willingness to continue such donations.
- China is establishing an International Center of Excellence on Nuclear Security to strengthen capacity inside of China for preventing nuclear terrorism and to provide a regional hub for the promotion of best practices in the field.

Compared to the policies that China openly declared at the 2010 Nuclear Security Summit, at the 2012 Summit China declared policies that emphasized: a) capacity building for nuclear security (in particular, China proposed the establishment of nuclear emergency response teams and highlighted the problem of providing technical and manpower support for nuclear security);[70] b) promoting comprehensive governance and nuclear security standards and norms; and c) eradicating nuclear proliferation and the sources of nuclear terrorism. China hopes that the rest of the world community will follow suit in adopting these policies.

It appears that the latest nuclear security policies declared by China are directly descended from similar policies formulated in the past—for instance, those declared in reports provided to the United Nations on implementing Security Council Resolution 1540. Aside from deeper, more comprehensive, and more specific substance, and a firmer and more proactive stance towards maintaining nuclear security and opposing nuclear terrorism, there is a strong measure of continuity between the latest policies and those that preceded them. However, while in the past China

[70] In 2011, China expanded human resources for nuclear security, formulated a plan for comprehensive training, and established a versatile mode of training the more than five hundred nuclear security personnel in China. The country has also enhanced its capabilities to safely manage radioactive sources and radioactive waste, and pushed the creation of a national database of radioactive sources. See the speech that Hu Jintao delivered at the 2012 Nuclear Security Summit, "Towards Greater Nuclear Security Through Cooperation."

often proposed what should not be done, it now proposes positive policies. For instance, in the past China insisted that efforts to enhance nuclear security and prevent nuclear proliferation not rely on new measures, new international laws, or the use of military means.[71]

Needless to say, China's nuclear security policies are not yet perfect. Confronted with new security challenges—like nuclear proliferation among non-state actors and nuclear terrorism—that are pertinent to the peace and security of China and the rest of the world, Chinese nuclear security policies need to remain flexible and should change according to circumstances and developments.

National Regulators in Chinese Nuclear Security

China's arsenal of nuclear weapons is under the tight control of the PLA, which is responsible for their safety and security. Major actors responsible for the security of nuclear materials and facilities include the China Atomic Energy Authority (CAEA), National Nuclear Safety Administration (NNSA), and the Ministry of Public Security (MPS).

The CAEA, housed under the Ministry of Industry and Information Technology (MIIT), is responsible for managing all nuclear defense facilities other than nuclear weapons and naval nuclear materials sites, including all HEU, plutonium, and tritium production facilities and sites that manage waste released from those facilities. The safety and security of these facilities is also entrusted to the CAEA. In addition, the CAEA is responsible for the control of nuclear materials in both the military and civilian sectors nationwide. It is the principal authority that presides over all civilian nuclear fuel cycle facilities except for nuclear power plants, which are subject to control by the National Energy Administration (NEA), a part of the National Development and Reform Commission (NDRC). However, the CAEA is responsible for nuclear security functions at civilian nuclear facilities including nuclear power plants.

The CAEA is the leading agency for formulating policy and development plans for the nuclear industry. Its responsibilities include the development of nuclear security laws, regulations, and standards, the review and approval of licenses to operators of nuclear facilities based on the requirements of the MPC&A system and the designation of design-basis threats (DBT), and oversight and inspection of implementation of the MPC&A system. In partnership with the Ministry of Public Security (MPS), it is also responsible for the secure shipment of nuclear materials and spent fuel.

The CAEA, jointly with the Commerce Department and at times the Ministry of Foreign Affairs, holds responsibility for managing nuclear exports. It is also responsible for maintaining adherence to IAEA safeguards and international nuclear cooperation agreements, as well as security training and the development of a nuclear security culture.

The CAEA is also a lead organization in the State Committee for Nuclear Emergency Coordination, which is composed of 18 entities from the State Council and PLA; the committee's office is located at the CAEA. After the Fukushima accident, the CAEA increased the staff-size of its Nuclear Emergency Response Technical Support Center, and in 2012 established a new Department of Nuclear Emergency Response and Supervision of Military Nuclear Facilities Safety. As

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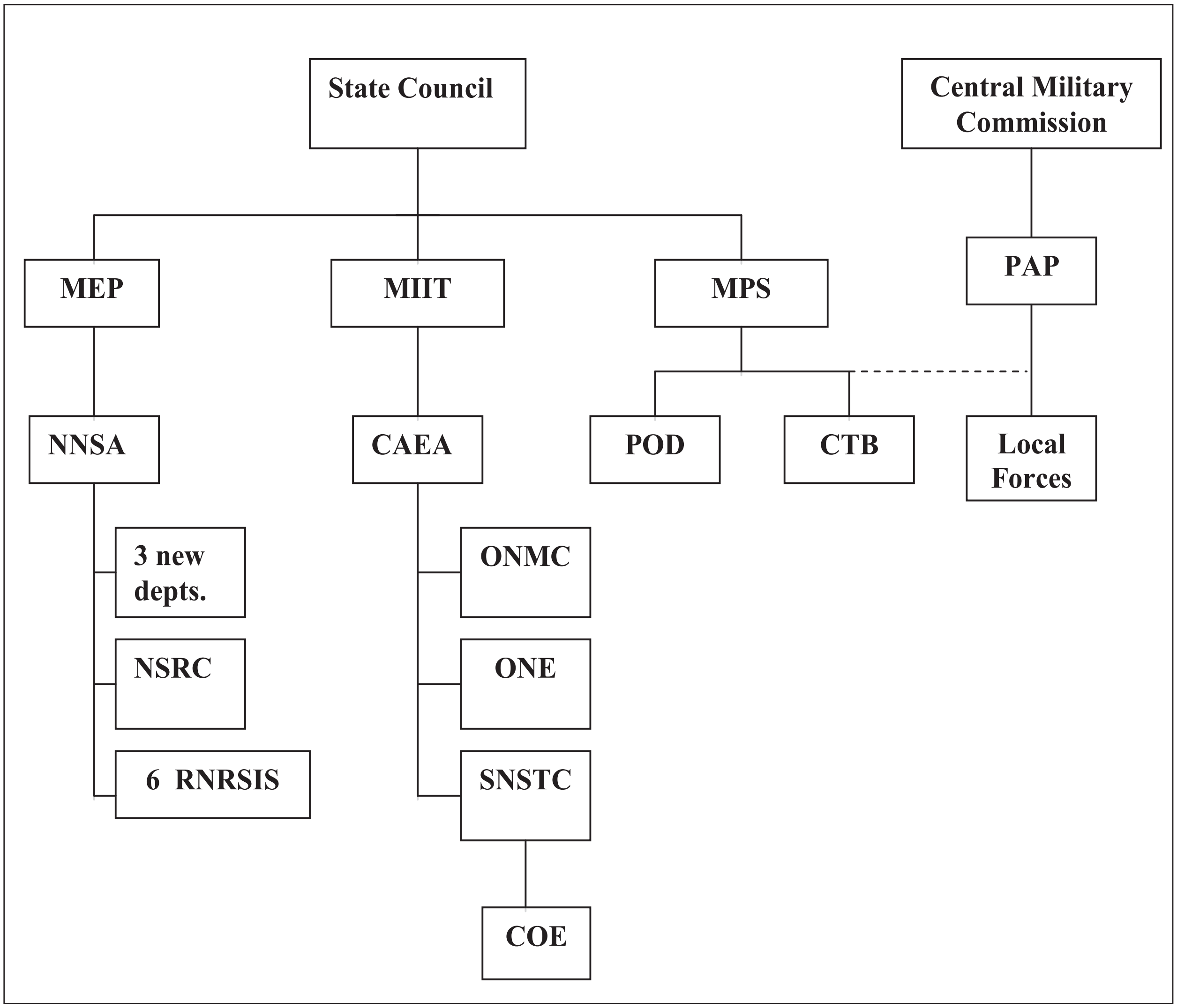
[71] See e.g. UN Security Council, S/AC.44/2004/(02), "Report of China on implementation of United Nations Security Council resolution 1540," October 14, 2004, http://www.un.org/Docs/journal/asp/ws.asp?m=S/AC.44/2004/(02)/4 (accessed March 6, 2014); speech delivered by Wang Jun, deputy head of the Department of Arms Control of the Ministry of Foreign Affairs, at a seminar hosted by the Asian-Pacific Disarmament Center, December 7, 2004.

Figure 2-1: Administrative System of China's Major Regulators



Legend

CAEA	China Atomic Energy Agency	**ONE**	Office of Nuclear Emergency
COE	Center of Excellence on Nuclear Security	**ONMC**	Office of Nuclear Materials Control
CTB	Countering Terrorist Bureau	**PAP**	People's Armed Police
MEP	Ministry of Environmental Protection	**POD**	Public Order Department
MIIT	Ministry of Industry and Information Technology	**RNRSIS**	Regional Nuclear and Radiation Safety Inspection Stations
MPS	Ministry of Public Security	**SNSTC**	State Nuclear Technology Center
NNSA	National Nuclear Safety Administration	**3 New Departments**	(1) Department of Nuclear Facilities Safety Supervision; (2) Department of Nuclear Power Safety Supervision; and (3) Department of Radiation Safety Supervision

the principle authority for nuclear power plants, the NEA is also responsible for nuclear power plant emergency management.

In November 2011, the CAEA established the State Nuclear Security Technology Center (SNSTC) to provide technical support for nuclear security, nuclear materials control, management of nuclear exports, and international cooperation.[72] The SNSTC is also responsible for establishing and managing the Center of Excellence on Nuclear Security (CoE), created in cooperation with the United States. The China Institute of Atomic Energy (CIAE) provides technical support on nuclear security issues to the CAEA as well.

The NNSA is an independent safety regulator for all civilian nuclear materials and facilities. Its responsibilities include the evaluation of the safety and design of civilian nuclear facilities and the issuance of safety licenses. It is also the principal authority for the control and safety of radioactive sources. The NNSA is responsible for the control and physical protection of nuclear materials in the civilian sector, the treatment and disposal of radioactive waste, and the supervision of the safety of radioactive materials in transport.

Since its nuclear safety responsibilities include physical protection and material accountancy, the NNSA overlaps significantly with the CAEA. For management of civilian nuclear materials, the NNSA is responsible for reviewing applications while the CAEA issues licenses based on the NNSA's recommendation. For civilian nuclear materials and facilities, both the CAEA and NNSA have responsibilities for inspections and imposing fines in the case of a serious violation. However, for the military sector only the CAEA is relevant.

The NNSA is also responsible for monitoring environmental radiation and the disposal of radioactive waste. The NNSA also plays a major role in nuclear and radiation emergency response and investigation, shipment of nuclear materials, spent fuel, and other radioactive materials, and compliance with international conventions related to nuclear and radiation safety. As the principle authority for nuclear power plants, the NEA is also responsible for drafting regulations about nuclear power plant safety.

In the wake of the Fukushima accident, the NNSA expanded its original Department of Nuclear Safety Management into three new departments—the Department of Nuclear Facilities Safety Supervision, the Department of Nuclear Power Safety Supervision, and the Department of Radiation Safety Supervision—and increased total staff from 38 to 85. These three departments are in charge of administrative management. The NNSA receives technical support from the Nuclear Safety and Radiation Center (NSRC) and six regional offices. The NSRC is mainly responsible for technical reviews and has a staff of 600, expanded from an original 162; the six regional offices are nuclear and radiation safety inspection stations and are primarily responsible for on-site monitoring of facilities. Total staff at these stations has increased from 100 to 331. Thus, total personnel employed in nuclear safety have increased from 300 to over 1000 within only a few years.[73] However, in terms of staff per facility regulated, the Chinese regulator still lags behind the US Nuclear Regulatory Commission (NRC).

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[72] Deng Ge, director of the SNSTC, "Untitled presentation," (presentation at workshop on the safety and security of China's nuclear facilities, January 15-18, 2013, Shenzhen, China).
[73] Interview with a Chinese nuclear regulator, July 2013.

While the CAEA develops laws and regulations on nuclear security, the NNSA issues specific technical guidance and codes for physical protection and materials accounting systems. In 2008, the NNSA issued its Nuclear Facility Physical Protection Guidelines,[74] which are treated in practice as mandatory.[75] The 2008 guidelines require all nuclear facilities to meet certain standards; if an operator deviates from the guidance, it must prove that its approach results in equivalent outcomes. The guidelines are the benchmark for the review, inspection, and licensing of all nuclear facilities.

The inspectors of the six regional offices, who live on-site at facilities, are responsible for monitoring and verifying the implementation of the MPC&A system at sites as well as reporting problems to headquarters. Operators are then required to address these problems. Inspectors, working with headquarters, also have the authority to suspend or revoke licenses or impose fines in the case of violations.

The MPS is primarily responsible for the security of nuclear materials transport, countering nuclear terrorism and smuggling of nuclear materials, detection of and response to radiological crimes, and the recovery of missing nuclear or radioactive material with the help of the CAEA or the NNSA. In cooperation with the CAEA, it reviews and approves the DBT of nuclear facilities and security systems.

In 1991, the MPS set up an office of protection of nuclear materials to comply with the CPPNM. In 1998, this office was incorporated into the Public Order Department (POD) responsible for the public security of explosives, highly toxic chemicals, and radioactive materials. Since 1995, fifteen local public security bureaus have set up liaison offices for the protection of nuclear materials. At present, the MPS and the CAEA are responsible for fulfilling China's commitments under the CPPNM. In 1994, the MPS and CAEA issued regulations for the physical protection of nuclear material during international transport. The transportation of spent fuel from nuclear reactors also requires approval by the MPS. In 1997, the two organizations issued implementing rules for nuclear power plant security.[76]

After the 9/11 attacks, the MPS established in 2002 the Countering Terrorists Bureau (CTB), which is responsible for dealing with all terrorist activities, including nuclear terrorism. The CTB also hosts the office of the National Group for Countering Terrorist Coordination, established in 2001. The office is responsible for the development, planning, guidance, coordination, and promotion of national efforts to counter terrorists. Prevention of nuclear terrorism is one of its major tasks. In 2008, the MPS issued a "Handbook on Citizen Prevention of Terrorist Attacks," which includes guidelines for managing nuclear radiation.

While the People's Armed Police (PAP) is responsible for providing on-site armed guards for nuclear materials and facilities, the MPS is responsible for their management. Local public security bureaus also play a major role in nuclear security.

Finally, regulatory responsibilities and functions in some functional areas are neither clearly defined nor coordinated, thus causing unnecessary duplication and creating complicated

[74] NNSA, "Nuclear Facility Physical Protection Guidelines," 2008, HAD 501/502.

[75] Interview with a Chinese nuclear regulator, July 2013.

[76] Li Jungang, "The Current Status and Plan of China Nuclear Security," (presentation at workshop on the safety and security of China's nuclear facilities, January 15–18, 2013, Shenzhen, China).

requirements for the operator or licensee. For example, both the CAEA and the NNSA have responsibilities for the security of nuclear materials and facilities in the civilian sector. For some military production facilities later converted to solely civilian use (e.g. the Lanzhou enrichment plant), safety and security are likewise overseen by both the CAEA and the NNSA. The NNSA and the NEA have overlapping responsibilities for the development of regulations for nuclear power plant safety. The CAEA and the NEA both have oversight over nuclear power development plans and international cooperation on nuclear energy. These overlapping remits decrease the effectiveness of the regulatory functions.

Furthermore, the CAEA is not only responsible for setting security rules for civilian nuclear materials and facilities, but also responsible for promoting nuclear energy development in China. This is contrary to the principle that nuclear regulators should be independent of any promotional responsibilities, enshrined in the Nuclear Safety Convention. The convention states that "[e]ach Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organization concerned with the promotion or utilization of nuclear energy."[77]

In addition, a major challenge to the independence and authority of the NNSA is that it lacks enough technical staff for sufficient capability to identify potential safety issues. This affects its review and assessment, licensing, inspection, enforcement, and decision-making functions.[78] Therefore, China needs to enhance the independence, authority, and effectiveness of its nuclear security agencies and safety regulators.

China's Nuclear Security Regulations

Since the mid-1980s, China has issued a number of regulations, rules, and technical guidelines regarding the security of nuclear and radioactive materials and nuclear facilities (see Table 2-1). In China, legal documents are classified into four tiers: statutory law requiring approval by the National People's Congress; State Council law and regulations; departmental rules; and regulator's guidance or publications.[79] While officials work on the drafting of an Atomic Energy Law, the Chinese nuclear industry continues to operate without any direct, overarching statutory law for nuclear development, safety, and security.[80]

Currently, the only major regulations on fissile material controls are found in the "Regulations for Control of Nuclear Materials," issued in 1987.[81] Based on these regulations, China issued "Rules for Implementation of the Regulations on Nuclear Materials Control" in 1990,[82] which

[77] International Atomic Energy Agency, *Convention on Nuclear Safety, INFCIRC/449*, (Vienna: IAEA, July 5, 1994), http://www.iaea.org/Publications/Documents/Infcircs/Others/inf449.shtml (accessed March 7, 2014).

[78] Communications with Chinese nuclear experts on nuclear safety and security, October 2012.

[79] Liu Tianshu, "Regulation on Physical Protection for Civilian Nuclear Installations in China," (presentation at workshop on the safety and security of China's nuclear facilities, January 15–18, 2013, Shenzhen, China); Tang Yingmao, "China's Nuclear Law: Recent Development," (presentation at the same workshop in Shenzhen).

[80] Tang, "China's Nuclear Law: Recent Development."

[81] State Council of the People's Republic of China "Regulations for Control of Nuclear Materials of the People's Republic of China," June 1, 1987, http://www.caea.gov.cn/n16/n1130/77219.html (in Chinese) (acccessed March 7, 2014).

[82] NNSA, the Ministry of Energy, and the Commission of Science, Technology, and Industry for National Defense, "Rules for Implementation of the Regulations on Nuclear Materials Control of the People's Republic of China," September 25,` 1990, www: http://www.caea.gov.cn/n16/n1130/77224.html (in Chinese) (accessed March 7, 2014).

Table 2-1: China's Major Regulators and Responsibilities for Nuclear Security

Regulator	Responsibilites
CAEA	• Authority over all defense nuclear facilities and civilian nuclear fuel cycle facilities (except nuclear power plants which are regulated by the NEA) • Control of nuclear materials (military and civilian), licenses, and inspections • Security of all nuclear facilities (military and civilian), nuclear materials (military and civilian), and spent fuel shipments • Nuclear emergency response • Safety of all defense nuclear facilities and their waste products • Development of the legal framework for nuclear security • Formulation of policy and development plans for the nuclear industry
NNSA	• Safety of all civilian nuclear material and facilities (safety measures include security aspects and MPC&A) • Treatment and disposal of radioactive waste • Technical evaluation of nuclear facilities' safety and design • Review and issuance of safety licenses; technical review and recommendation to CAEA of security license approval • Safety and control of radioactive sources • Supervision of the safe transport of nuclear materials, spent fuel, and radioactive sources • Radiation emergency response and investigation • Issuance of specific technical guidance and codes for physical protection and materials accounting systems • On-site monitoring and inspections
MPS	• Security of nuclear materials and spent fuel transportation • Countering nuclear terrorism and smuggling of nuclear materials • Detection of and response to radiological crimes; recovery of missing nuclear or radioactive material • Review and oversight of DBT for nuclear facilities and security systems in cooperation with CAEA • Implementation of CPPNM in China, in partnership with the CAEA • Management of PAP personnel guarding nuclear facilities

are also the only existing rules on the subject. When both the 1987 regulations and 1990 rules were issued, all of China's weapons-usable fissile materials were produced by its military production facilities and were used almost solely for weapons purposes (a very tiny portion went to HEU-fueled reactors), so we expect this 1987 regulation and the 1990 Rules are perhaps still the main restrictions applied to China's military nuclear materials and nuclear facilities.

In 1997, China issued its "Rules on Security of Nuclear Power Plants," and in 2008 updated its guidelines on physical protection measures for all civilian nuclear facilities. However, it is not clear whether measures for military nuclear facilities were updated.

Based on the 1987 regulations, China issued in 1997 its "Rules on Inspection of Nuclear Materials Control." To obtain recognition from the CAEA that a facility has adequate nuclear materials security measures in place, an operator should establish an effective MPC&A system that satisfies these rules. Under the 1997 text, inspection activities should include verification of the integrity of accounting records, changes in physical inventory, measurement and quality control systems, material balance areas, and effectiveness and reliability of physical protection measures.

If a facility is found to be in violation of regulations, it can be punished through a warning, penalty, or revocation of its license, depending on the severity of the violation.

Since the 9/11 attacks, China has improved and filled gaps in its legal system in other areas related to nuclear security. Compliance with international obligations and accession to international mechanisms have propelled the development of relevant legal ordinances in China. After China joined the Nuclear Suppliers Group in 2004, it updated its "Regulations on the Control of Nuclear Export" in 2006 and "Regulations on the Control of Nuclear Dual-Use Items and Related Technologies Export" in 2007. The overhauled regulations concerning nuclear exports include content on the prevention of nuclear terrorism. China has also issued and updated regulations and rules to enforce strict control of radioactive materials and sources. The focus of this activity may reflect the assessment by Chinese experts that the threat of radioactive material dispersal is the most likely to be realized.

In recent years, China has paid more attention to nuclear emergency response. Informed by the 2010 and 2012 Nuclear Security Summits processes, and startled into action by the Fukushima nuclear accident, China issued in August 2012 a revision to its Nuclear Emergency Response and Preparedness document of 2006. Concurrently, the government issued its "National Nuclear Emergency Response Work Plan (2011–2015)," which aims to create an effective system for nuclear emergency response through improvements to regulations and standards, a build-up of infrastructure, promotion of scientific and technological research and development, and augmentation of training exercises.

However, there have not been many updates to regulations and rules on the security of nuclear materials and facilities since 9/11. This may be a reflection of the conclusion reached by many experts that the risk of illegal acquisition of nuclear materials in China is extremely low. In fact, all relevant regulations and rules were issued before the attacks of 9/11, and in no place mention the threat of nuclear terrorism.

Finally, China has not issued a law to provide an overall legal framework to govern the use of nuclear energy and related safety and security issues. The only indirectly relevant statute is the Radiation Pollution Prevention Act of 2003. While some relevant regulations and rules have been issued since the 1980s, most were promulgated in the 1980s or 1990s when nuclear energy was being developed at a relatively slow pace. There is thus a need for a harmonization and updating of the industry's legal basis to meet new requirements. Between 1984, when China first considered an atomic energy law, and the Fukushima accident, the government has drafted and rejected four versions of the proposed law. All four versions were held up by frequent institutional changes to relevant agencies.[83] After the Fukushima accident, a fifth draft was completed in late 2011.

In the fall of 2012, another revised draft was circulated within the relevant working team. Since the release of a nuclear safety plan in the summer of 2012, relevant agencies have worked on the law; however, there has been no significant progress due to inter-departmental arguments. Any final law should further ensure that regulatory responsibilities and functions are clearly defined and coordinated, as well as enhance the independence, authority, and effectiveness of nuclear safety and security regulators.

[83] Tang, "China's Nuclear Law: Recent Development."

Table 2-2: Legal Framework for China's Nuclear Safety and Security

Legal Tiers	Current Status	Notes
Statutory Law	• None yet. Atomic Energy Law currently in drafting stage. • NNSA advocating an alternative Nuclear Safety Law (Statutory laws with indirect relevance) • Law on the Prevention and Control of Radioactive Pollution (June 28, 2003) • Emergency Response Law (August 30, 2007)	Requires approval by National People's Congress Approval process more difficult than for administrative regulations
Regulations	• Regulations on Nuclear Materials Control (1987) • Regulations on the Control of Nuclear Export (1997/2006) • Regulations on the Control of Nuclear Dual-Use Items and Related Technologies Export (1998/2007) • Regulations on Nuclear Power Plant Nuclear Emergency Response (1993), Order No. 124 (August 4, 1993) • Regulations on Safety and Protection from Radiological Isotopes and Radiation Devices (2005) • Regulations on Supervision and Administration of Safe Transportation of Radioactive Materials (2009) • Regulations on Supervision and Administration of the Safety of Radioactive Wastes (2011)	Administrative laws and regulations issued by the nuclear regulatory bodies, including the CAEA and NNSA State Council documents are more authoritative than Rules
Rules	• Rules for the Implementation of Regulations on Nuclear Materials Controls (1990) • Rules on Power Plant Radioactive Waste Management Safety Rules (1991) • Rules on Physical Protection for Nuclear Materials International Transport (1994) • Rules on Inspection of Nuclear Materials Control (1997) • Rules on Security of Nuclear Power Plants (1997) • Rules on Radioactive Items Import and Export License Application and Cooperation Safeguards (2002) • Rules on Supervision and Management of Nuclear Import and Export and Foreign Nuclear Cooperation (2002) • Interim Rules on Road Transport of Spent Nuclear Fuel (2003)	While laws and regulations are seldom changed, departmental rules are more frequently updated and reflect new information and improvements
Guidelines, Technical Standards and Manuals	• Physical protection for nuclear facilities (HAD 501-02, 2008) • Material accounting for LEU conversion and fuel fabrication plants (HAD 501-01, 2008) • Material accounting for nuclear power plants (HAD 501-07) • Physical protection for nuclear material transportation (HAD 501-05) • Material accounting for reprocessing plant of spent fuels from nuclear power reactors (HAF-J0018, 1990) • Intrusion alarm system of the nuclear facilities perimeter • Access Control of Nuclear Facilities • The standard format and content of nuclear facilities safety analysis report on the physical protection and the balances of nuclear materials	Updated more regularly than regulations and rules

Chapter III: China's Nuclear Security Practices

Since the 9/11 attacks, China has strengthened its system of physical protection for nuclear facilities and has significantly improved its MPC&A system. Major factors that influenced these alterations to the Chinese MPC&A system include the 9/11 attacks, cooperation with the United States, implementation of international legal obligations such as the 1980 CPPNM and its 2005 amendment as well as UNSCR 1540, and recommendations from the IAEA including the most recent revision of INFCIRC/225.[84]

After the Fukushima nuclear accident, China completed a comprehensive inspection of the safety of its civilian nuclear facilities. As emphasized by Liu Daming, an expert on Chinese nuclear security who was heavily involved in the CAEA's cooperation with the IAEA and US Department of Energy (DOE), China also completed a comprehensive security assessment of its nuclear power plants and nuclear facilities.[85] Some safety improvements introduced at nuclear facilities since the Fukushima accident, such as an increase in mobile backup emergency power systems and mobile pumps—aimed at preventing a loss of cooling functions at a nuclear reactor and its spent fuel pools—also have relevance for addressing the threat of nuclear sabotage.

This chapter examines China's current nuclear security practices and challenges, including China's approach to physical protection, its material control and accounting system, its security during nuclear materials transport, and the role of international cooperation in informing these practices.

China's Approach to Physical Protection

In recent years, China has revised its approach to physical protection. The principal changes include:

- A security approach based on a design basis threat (DBT).
- Application of modern concepts of physical protection, based on systems-engineering approaches to analyzing vulnerabilities and designing defenses to address them.
- The use of modern physical protection, material control, and material accounting technologies.
- Requirements for in-depth vulnerability assessments of security systems.
- Improvements to the organization of nuclear security and guard force training and equipment on the part of facility operators.
- Strict requirements for personnel screening.

The Design Basis Threat

Before the 9/11 attacks, China's nuclear facilities were mainly designed to withstand natural disasters and accidents. Since the 9/11 attacks, China has adopted the concept of protecting

[84] Communications with Chinese nuclear safety and security experts, November 2012 and January 2013.
[85] China Nuclear Security: " no[t] one gram missed and no[t] one item disappeared" over last fifty years, Liaowang Xinwen Zhoukan (in Chinese) (Outlook Weeks), March 26, 2012. http://www.zhige.net/html/2012/0326/43604.html.

nuclear facilities against a Design Basis Threat (DBT) that might involve both outsider and insider adversaries.

The 2008 "Nuclear Facility Physical Protection Guidelines" call on all civilian nuclear facilities to apply a security approach based on a DBT.[86] Each operator should develop a site-specific DBT, which is then approved by regulators before it is used in the design of a physical protection system. In developing a site-specific DBT, the 2008 guidelines recommend an evaluation of potential threats the nuclear facility could face. Major elements of the evaluation should include the attributes and characteristics of potential criminals, their motivations and intentions, and the scale of their activity and capabilities, as well as possible means and tactics they could adopt. Potential adversaries could include outsiders, insiders, and a collusion of both.

While the new 2008 guidelines require a DBT, they contain no clearly defined standards for how each nuclear facility should design one for its local conditions. Operators typically design their site-specific DBTs on a case-by-case basis taking into account a number of factors, including the socioeconomic situation in the area surrounding the facility.[87] Based on the general requirements for DBTs in the 2008 Guidelines, the operators of a nuclear facility study, discuss, and evaluate their proposed DBT based on current threat levels with the CAEA, the MPS, the Chinese Armed Police Force, the local security department, and other relevant organizations. Eventually, the DBT is submitted to the CAEA for approval. The details of the DBT are kept secret from the public.

As discussed in Chapter I, Chinese experts have analyzed possible sabotage scenarios against China's nuclear facilities, including scenarios involving nuclear power plants. The experts concluded that China's nuclear power plants would not be able to withstand impact with commercial planes and heavy weapons, including missiles. Moreover, collusion between insiders and outsiders would pose a great threat to nuclear facilities. As Li Ganjie, the director of the NNSA, noted, the existing DBT for nuclear power plants could have produced designs that are unable to resist attacks from larger-scale and well-organized terrorist groups with powerful weapons.[88]

There are debates in China about whether the country should have official, comprehensive, and unified DBT standards for all of its nuclear power plants. Some experts argue that it is very difficult and possibly unnecessary to have unified DBT standards, because of differences in local situations.[89] However, others disagree. Li even suggests China should develop and propose international unified DBT standards for nuclear power plants; each country would design its security systems for new reactors based on the international standards as well as update existing security systems for operational reactors by evaluating compliance with the international standard.[90]

The licensee of a nuclear facility is required to provide for its security through cooperation with relevant government agencies. Some Chinese nuclear experts argue that operators are unlikely to be able to afford the cost of dealing with extreme potential security threats, such as the

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[86] NNSA, "Nuclear Facility Physical Protection Guidelines."
[87] Communications with Chinese nuclear experts, October 2011 and November 2012.
[88] Li Ganjie, "Nuclear Security: The New Challenges for Security of Nuclear Power Plants," (presentation at 2008 IAEA meeting), http://www-pub.iaea.org/mtcd/meetings/PDFplus/2008/cn168/Presentations/Session3_Li.pdf (in Chinese) (accessed March 7, 2014).
[89] Communications with Chinese nuclear security experts, Beijing, October 2011 and November 2012.
[90] Li, "Nuclear Security: The New Challenges for Security of Nuclear Power Plants."

possibility of terrorists crashing large commercial planes into facilities or using heavy weapons.[91] Certainly, operators cannot be expected to cope with war-time threats, such as strikes by long-range missiles or bombing by military aircraft. Hence, some officials and experts in China argue that the central government should be responsible for addressing these threats. Many other countries, including the United States, take a similar approach, under which operators of nuclear facilities are required to be able to protect up to a certain level of threat, beyond which the government assumes responsibility. If such a division is adopted, it is imperative that legislation, regulation, or rules clarify the responsibilities that would be shouldered by the government and those that would rest with the operators of facilities.[92]

Physical Protection of Nuclear Materials

Management of nuclear materials security and physical protection in China is primarily based on the 1990 "Rules" and recommendations by the IAEA (INFCIRC/225 Rev.4).[93] All operators are required to establish facility-level organizations in charge of the security of facilities and nuclear materials. Like IAEA recommendations on physical protection of nuclear materials, China divides its protection requirements for nuclear materials into three categories based on type, quantity, and harmfulness (see Table 3-1).[94] For example, the physical protection measures for Category I nuclear materials facilities should include: at least two complete, reliable physical barriers; a vault or special security container for storing nuclear material; a technical protection system with alarm and monitoring installations; 24-hour armed forces on guard; special passes for all people entering the site; strict control of non-site-personnel access, including a registration procedure and full-time escort by site-personnel after entry; and a "two-person and double lock" system.

Physical Protection of Nuclear Facilities

The most up-to-date and detailed documents on physical protection of China's nuclear facilities are the 2008 NNSA guidelines for "Nuclear Facility Physical Protection."[95] These 2008 guidelines are for civilian nuclear facilities; measures for military nuclear facilities are assumed to be more restrictive.

The 2008 NNSA guidelines require the operators of nuclear facilities to establish a comprehensive, reliable, and effective physical protection system.[96] As noted above, operators should put in place security measures capable of defending against a DBT. The guidelines state that the system should assure coordination among the three elements of detection, delay and response. The system is also expected to integrate the functionality of physical protection equipment with personnel-level preventive measures to provide effective security.

[91] Pan, *Management of Nuclear and Radiological Terrorism Incidents*.
[92] Li, "Nuclear Security: The New Challenges for Security of Nuclear Power Plants."
[93] China is working on moving to Rev. 5 implementation. Interview July 2013.
[94] "Rules for Implementation of the Regulations on Nuclear Materials Control of the People's Republic of China."
[95] NNSA, "Nuclear Facility Physical Protection Guidelines."
[96] NNSA, "Nuclear Facility Physical Protection Guidelines."

Table 3-1: Physical Protection of Fissile Materials by Category at Fixed Sites

Categorization of Fissile Materials in China		
Category I	**Category II**	**Category III**
• 2 kg or more of unirradiated Pu • 5 kg or more of U-235	• Less than 2 kg but more than 10 g unirradiated of Pu • Less than 5kg but more than 1 kg of U-235 • 20 kg or more of unirradiated U-235 (enriched to more than 10% but less than 20%) • 300 kg or more of unirradiated U-235 (enriched to less than 10%; not including natural and depleted uranium)	• 10 g or less of unirradiated Pu • 1 kg or less but more than 10 g of U-235 • 1 kg or more but less than 20 kg of unirradiated U-235 (enriched to more than 10% but less than 20%) • 10 kg or more but less than 300 kg of unirradiated U-235 (enriched to less than 10%; not including natural and depleted uranium)
Physical Protection Measures for Fissile Materials at Fixed Sites		
Category I	**Category II**	**Category III**
• At least two complete, reliable physical barriers • Vault or special security container for storing Category I nuclear material • Technical protection system with alarm and monitoring installations • 24-hour armed guard • Special passes for all people entering the site; strict control of non-site-personnel access with a registration procedure and full-time escort by site-personnel after entry • Vault secured with "two-person and double lock" system	• Two physical barriers, one of which must be complete and reliable; a "strong room" or "solid container" storage area • Alarms or surveillance equipment in vital areas • Armed guards or specially assigned persons on guard day and night • Special passes for all people entering the site	• One complete and reliable physical barrier • Specially assigned persons for observing or permitting storage of nuclear materials in security containers

Source: National Nuclear Safety Administration, Ministry of Energy, and the Commission of Science, Technology, and Industry for National Defense, "Rules for Implementation of the Regulations on Nuclear Materials Control of the People's Republic of China," September 25, 1990. (in Chinese)

The guidelines require all new nuclear facilities to comply with all current physical protection standards, and old facilities, where technology and standards provide a lower overall level of protection, to upgrade their systems. The operator should establish a professional organization to oversee the plant's physical protection. The organization should be staffed with an appropriate number of personnel and the operator should designate a high-level plant official to be fully in charge of physical protection work. Security personnel should also pass stringent and regular exams, and receive rigorous training and assessment.[97]

[97]NNSA, "Nuclear Facility Physical Protection Guidelines."

Through Chinese-US cooperation in the late 1990s, such as lab-to-lab activities, China began to study modern physical protection system (PPS) theory.[98] Since the early 2000s, China has been developing and installing security systems based on modern PPS theory in cooperation with the United States. For instance, the Qinshan plant, China's first indigenous nuclear power plant, became operational in 1991 and began to update its security system in 2002 based in part on insights gained from discussions with US experts. That system has been tested since 2007.[99]

According to the relevant Chinese implementation rules and IAEA guidelines, the design of a PPS should include several major components:[100]

- Threat evaluation as the basis for design;
- Application of the concepts of defense in depth and detection balance;
- Graded approach;
- Vulnerability analyses;
- Contingency plans;
- Security in design;
- Measures to protect confidential information.

To increase the probability of threat detection and accelerating assessment in the event of an intrusion, China has adopted a wide array of modern technologies and techniques.[101] These measures include enhanced perimeter detection, access control, video feed assessment, and personnel identification.

In particular, China has mandated widespread adoption of intrusion detection systems at its nuclear facilities. Licensees are required to install intrusion detection systems at the physical barrier surrounding the protected and vital areas. Regulations require detectors within the free zone between the double fences for the protected area, and also at the inner fence of the double fences if needed, and these should consist of a variety of technologies that cover all required detection areas. Intrusion detectors should also be installed at entrances and exits, tunnels, and ditches that cross the boundaries of protected and vital areas where there are no guards on duty. The intrusion detection system for perimeter control should incorporate high-tech sensors including microwave detectors, active infrared sensors, electric field sensors, ported coaxial cable systems, taut wire sensors, vibration or tensile detectors, fiber optical sensors, and video motion detectors.[102] The system should be tested on a regular basis. Moreover, a video monitoring system should also be set up where required for intrusion detection. Furthermore, Category I nuclear facilities, including nuclear power reactors and reprocessing plants, are required to have a permanently staffed

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[98] A physical protection system (PPS) is an integrated set of physical protection measures intended to prevent the completion of a malicious act. The primary PPS functions include three major elements: detection, delay, and response. See Mary Lynn Garcia, *Design and Evaluation of Physical Protection Systems* (Burlington, MA: Butterworth- Heinemann, 2007).

[99] Yun Zhou, "The Security Implications of China's Nuclear Energy Expansion," *Nonproliferation Review,* Vol. 17, No. 2, (July 2010), pp. 347-363.

[100] NNSA, "Nuclear Facility Physical Protection Guidelines."

[101] Liu Daming, "Practice of the Physical Protection of Nuclear materials and Nuclear Facilities in China," *Journal of Nuclear Materials Management,* Summer 2010, No. 4.

[102] NNSA, "Perimeter Intrusion Detection System," 2005, HAD 501-03.

and fortified central alarm station located in the vital area. These stations should be protected by armed forces on duty 24 hours a day, with access strictly controlled and minimized.

Additionally, China has improved a number of technical measures relevant to the delay function of its physical protection systems at nuclear facilities.[103] The purpose of the delay function is to increase the time needed for an adversary to enter or exit a nuclear facility, providing enough time for guard forces to respond. Physical barriers installed at nuclear power plants to delay an adversary include double fences with intrusion detectors and clear zones between them. Moreover, the facility operator is required to have an emergency plan for response to an unauthorized removal of nuclear materials or sabotage of nuclear facilities, and to conduct an annual exercise of this plan.[104] Category I nuclear facilities, including nuclear power plants and the pilot reprocessing plant, are protected by armed forces and security guards who are on duty 24 hours a day. The armed force is mainly responsible for the security of the grounds within the facility and the prevention of intrusion by outside adversaries. The security guards are responsible for the security of specific locations inside the facility and the management of the physical protection system.

Furthermore, the operator of a nuclear facility is required to improve and update its physical protection system to reflect evolving conditions and to maintain the system's effectiveness. Before 1998, vulnerability analyses did not receive adequate attention and there was no systematic evaluation of physical protection systems.[105] As late as the mid-2000s, most Chinese facilities had not conducted an in-depth assessment of their ability to protect against particular types of threats.[106] They are now required to conduct in-depth vulnerability assessments and to address identified vulnerabilities in a timely manner. Operators are also required to use technical approaches to strengthen the reliability of their security systems, including performance tests of detection and assessment capabilities and their ability to deploy reliable techniques.[107] China does not, however, conduct realistic "force-on-force" exercises to test the performance of its nuclear security systems.[108]

A Graded Approach for China's Nuclear Facilities

The 2008 guidelines require the operator of a nuclear facility to design its security system based on certain principles for protection of Category I, II, and III nuclear materials and facilities. These principles include protection measures graded according to the types of material held and the potential consequences if the facility were to be sabotaged. Table 3-2 shows the three categories of civilian nuclear facilities in China and the corresponding physical protection measures required.[109]

The operator is required to divide the grounds of a Category I nuclear facility into three security zones: the controlled area, the protected area, and the vital area. The vital area should be located

[103] Liu, "Practice of the Physical Protection of Nuclear Materials and Nuclear Facilities in China."
[104] NNSA, "Nuclear Facility Physical Protection Guidelines."
[105] Tang, et al., "Physical Protection System and Vulnerability Analysis Program in China."
[106] Personal communication with CAEA expert, October 2006.
[107] Liu Daming, "China National Nuclear Material Control System," (presentation at Harvard-Peking University Workshop on Nuclear Security, October 13-14, 2011, Beijing, China).
[108] Communications with Chinese nuclear experts on China's MPC&A, October 2011.
[109] NNSA, "Nuclear Facility Physical Protection Guidelines."

The Daya Bay Nuclear Power Plant. The double fences for the protected area can be seen in the photo. (Source: Hui Zhang photo, 2013)

within a protected area, which should be located within a controlled area. The operator should adopt management and physical protection measures based on these divisions. For a nuclear power plant, the vital area would contain the reactor's main control room, the reactor itself and auxiliary buildings, spent fuel storage buildings, the generator room, main coolant pump, and other facilities and equipment.

The 2008 guidelines also provide specific requirements for physical barriers in each area. The controlled area should have at least one layer of physical barriers, either barbed wire fences or a wall. The height of the barriers should be greater than 2.5 m. If a facility uses a wall to satisfy the requirement, the thickness of the wall should be greater than 24 cm. The protected area should have "two layers" of physical barriers. The height of the outer layer should be greater than 1.5m, and the inner one should be taller than 2.5 m. The distance between the two layers should be greater than 6 m. The physical barriers for a vital area can include buildings or connections with fences and walls. If buildings are used as physical barriers, they should be sturdy in all respects. To allow for the walls, floors and ceilings to play a role in delaying adversaries, they should include at least a layer of reinforced concrete with a thickness of more than 20 cm.[110]

Access Control Measures

Since the 9/11 attacks, China has enhanced the physical protection of its nuclear facilities through adoption of a combination of improved personnel management and technical measures, including access controls, intrusion detection systems, and video monitoring. Operators of nuclear facilities are required to take effective personnel and vehicle access control measures for the physical protection areas.[111] For example, according to the regulations, only a minimal

[110] NNSA, "Nuclear Facility Physical Protection Guidelines."
[111] NNSA, "Nuclear Facility Physical Protection Guidelines."

Table 3-2: Physical Protection of Civilian Nuclear Facilities

Categories of Civilian Nuclear Facilities in China		
Category I	**Category II**	**Category III**
• Facilities containing Category I nuclear materials • 100 MW(th) reactors or larger • Spent fuel pools with newly discharged fuel and a total radioactivity greater than 1017 Bq Cs-137 • Spent fuel reprocessing facilities • High-level liquid nuclear waste storage and processing facilities • Others facilities	• Facilities containing Category II nuclear materials • 2-100 MW(th) reactors • Middle-level liquid and high-level solid nuclear waste storage and processing facilities • Spent fuel pools requiring active cooling systems and not covered by Category I • Facilities where any on-site criticality accidents without control measures could have an impact beyond 0.5 km away from the facility perimeter • Others facilities	• Facilities containing Category III nuclear materials • 2 MW(th) and smaller reactors • Low-level liquid and middle-level solid nuclear waste storage and processing facilities • Facilities where direct exposure dosage rates without shielding measures would be larger than 100 mGy/h at 1 meter away • Facilities where any on-site criticality accidents without control measures could have an impact within 0.5 km from the facility perimeter • Others facilities
Physical Protection Measures for Civilian Nuclear Facilities by Category		
Category I	**Category II**	**Category III**
• 24-hour armed policemen at access points in the vital, controlled and protection areas • Alarm and monitoring systems at all access entrances • System of passes or badges to be displayed by authorized personnel and vehicles entering the three areas • Strict control of access for non-site-personnel and vehicles; full-time escort by site-personnel after entering the protected and vital areas • A "two-person and double lock" rule for the vital area • Radioactive material detection systems installed at access points to the protected and vital areas • Emergency power backup systems • A control center for management of the physical protection system	• 24-hour armed policemen at access points in controlled and protected areas • Alarm and monitoring systems at all access entrances • System of passes or badges to be displayed by authorized personnel and vehicles entering each area • Strict control of access for non-site-personnel and vehicles; full-time escort by site-personnel after entering the protected areas • Radioactive material detection systems installed at access points to the protected area • Emergency power backup systems • A control center for management of the physical protection system	• Facilities located in controlled area • Communication and monitoring system at all access points • System of passes or badges to be displayed by authorized personnel and vehicles entering the area • Emergency power backup systems • An office with security personnel on duty

Source: National Nuclear Safety Administration, "Nuclear Facility Physical Protection Guidelines," 2008, HAD 501/502.

number of persons and vehicles should be authorized to access the three zones. Authorized persons and vehicles are allowed to enter the areas only after their identification is verified, and should display a pass or badge after entering the secured areas. Access authorizations for non-site-personnel and vehicles should be strictly limited. After entering the protected and vital areas, authorized visitors should be escorted at all times by site-personnel with unescorted access rights. A "two person and double lock" rule for vital areas should be applied. Barriers to reduce vehicle speed should be set up outside access points to the controlled area. Structures to protect from vehicle collisions should be established outside the access points of the protected area, and the entry of vehicles into the protected area should be limited to designated parking areas.

In addition, China's nuclear power plants have adopted on a wide scale advanced equipment and technology for access control. For example, detection systems for radioactive materials and prohibited items have been installed at access points to protected and vital areas. To control access to facilities, plants use mobile barrier gates, metal-detecting gates, electric retractable gates, floor-to-ceiling turnstile doors with barcode reading systems, biometric identification systems, and alarm and video monitoring systems at all access points.[112]

China's Material Accounting and Control System

China established and revised its nuclear materials control and accounting system based on the 1990 "rules" and in accordance with international standards. In 2008, the NNSA issued new guidelines for what it called "the standard format and content of nuclear facilities safety analysis reports on MC&A."[113] A plant's MC&A system should include clear definitions for material balance areas and key measurement points, control of measurement quality, physical inventory of materials, materials unaccounted for (MUF) assessments, and a recording and reporting system. The licensee should establish physical inventory procedures for nuclear materials and conduct a complete inventory at least once a year. An inventory of Pu-239, U-233, HEU, and other sensitive materials should be completed at least twice a year. The licensee is required to ensure its records of nuclear materials accounting are clear, accurate, systematic, and complete. Records should be maintained for at least five years. If MUF of more than twice the standard deviation for the measurement is detected, an investigation into the discrepancy should be initiated.

The most significant challenge to China's efforts to establish an effective nationwide MC&A system is posed by its bulk processing facilities. Because MC&A for fresh and spent fuel at a nuclear power plant is relatively straightforward for identifiable items, their MUF is expected to be exactly zero. Moreover, because fresh fuel is made with LEU, it does not pose significant security concerns. China also makes very limited use of HEU in its research reactors. Thus, the nuclear materials in the country's reactors are relatively easy to account for. On the other hand, accurate material accounting in bulk processing facilities is much more difficult.

The operations of China's pilot reprocessing plant demonstrate the challenge. Although reprocessing operations stopped after only ten days, beginning in December 2010, many problems, including safety and security issues, were encountered or identified. These included both a very high amount of waste produced and a very high measure of MUF.[114]

[112] Interview with expert on nuclear security aspects of the Daya Bay nuclear power plant, January 2013. Also, see Zhou, "The Security Implications of China's Nuclear Energy Expansion."
[113] NNSA, "The standard format and content of nuclear facilities safety analysis report on MC&A," 2008, HAD 501/06.
[114] Communications with Chinese nuclear experts, Spring 2013.

China currently has stated plans to build larger reprocessing plants with capacities of 200tHM/year and 800tHM/year; it would be even more difficult to establish an effective MC&A system at these facilities than at the much smaller pilot facility. Even with an advanced, modern MC&A system, measurement uncertainties at a reprocessing plant are typically in the range of 1% of plutonium throughout, amounting to 20 kg of plutonium per year at a 200 tHM/year facility (since 200 tons of spent fuel contain about two tons of plutonium). Thus, the construction of the planned reprocessing facilities will require a substantial investment in improved MC&A measures. Given the inevitable uncertainties in accounting, it is likely that China will ultimately have to rely primarily on other measures to prevent insider theft.

To make matters worse, unlike operators of nuclear power plants, which derive revenue from market sale of electricity, other fuel cycle facilities such as the pilot reprocessing plant are currently heavily dependent on the government for financial support. They therefore often lack enough money to hire enough qualified people and to purchase the number and type of appropriate sensors and equipment needed for an effective MC&A system.[115]

Securing Transport of Nuclear Materials

Securing nuclear materials on the road is more difficult than at fixed sites. The 1990 "Rules" for the control of nuclear materials list measures for protecting nuclear materials transport. For instance, shipments of Category I nuclear material must be accompanied by an armed escort group. The "Rules" are applicable to shipments of all nuclear materials, including in the military sector.

Until the middle of 2005, Chinese nuclear experts worried that China lacked a complete system for the physical protection of nuclear materials transport. Security measures were adopted on a case-by-case approach and technical prevention measures were inadequate; they did not include either a tracking system or an effective communications system.[116] However, some of the above issues and others have been addressed in the "Guidelines of Physical Protection of Nuclear Materials Transport" issued in 2008 by the NNSA.[117] It is not clear if these new guidelines apply to nuclear materials in the military sector as well, but it is possible to assume that military security measures should be no weaker than those discussed here.

Under the new 2008 transport guidelines, the transporter is responsible for license applications and obtaining approval of the physical protection measures it provides for nuclear material transport. Transport plans should include a threat analysis and definition of the DBT. The DBT analysis should assess risks and consequences during the transport. The DBT should be defined based on identification of possible threat levels, protection levels needed for each category of nuclear materials, and the security situation along the transport route. The DBT should also evaluate threat elements such as motivation, operational scale, and likely weapons and tools of criminals.[118] However, the unclassified DBT requirement under the new guidelines is still very general, and no detailed and specific standards are provided or suggested.

The transport guidelines mandate that the transport route for Category I nuclear materials should avoid areas affected by a natural disaster, complicated public security situations, tourist

[115] Communications with Chinese nuclear experts, January 2013.

[116] Pan, *Management of Nuclear and Radiological Terrorism Incidents*.

[117] NNSA, "Guidelines of Physical Protection of Nuclear Materials Transport issued," 2008.

[118] NNSA, "Guidelines of Physical Protection of Nuclear Materials Transport issued," 2008.

and scenic destinations, and densely populated regions. The route should be easily accessible to potential support forces, such as local police departments and emergency response teams. A transport mode should be selected based on a preference for the shortest transit time and the least numbers of transits.

Category I nuclear materials should be escorted during transit by at least four armed guards with proper equipment and training. During transit, in particular during stopovers, containers holding nuclear materials should be monitored continuously and the integrity of locks and seals should be checked at stipulated intervals to ensure no illegal transfer of, or damage to, the nuclear materials.[119] Local public security bureaus must also be informed of security plans. The transporter must also develop an emergency response plan that provides for a well-trained response force with proper equipment and the capability to arrive on the scene quickly.

Besides these improvements to management measures, technical means of securing transport have also been strengthened. As required by the 2008 transport guidelines, the road, rail, and waterway transport of Category I nuclear materials must involve a transportation monitoring center equipped with global satellite communications and positioning systems to allow for timely tracking of the location and security of the convoy. In addition, transport vehicles should be equipped with internal intrusion detection and alarm systems, and escort personnel should monitor the security of the nuclear materials at all times.[120]

In practice, nuclear materials transportation activity within China primarily consists of transfers between plants that refine, convert, enrich, and fabricate uranium fuel. All of these movements involve only natural or low-enriched uranium, and pose very limited security concerns. Of the remaining activity, some can be attributed to the delivery of fresh fuel to nuclear power reactors, either from a domestic source or another state—France or Russia—and again these only involve LEU fuel. Shipments of weapons-usable materials or fuels are very limited. A very small number of research reactors are fueled with limited quantities of HEU, and China is in the process of converting them to use LEU. The pilot reprocessing plant has produced or would produce a limited amount of plutonium which is currently in storage and will be used in the fabrication of MOX fuel for a facility to be built nearby. In addition, most weapons-useable nuclear materials for military purposes are likely stored near weapons manufacturing facilities and thus there are probably very few shipments of those materials.

There was one shipment of HEU fuel from Russia to China to provide for the first load of the China Experimental Fast Reactor (CEFR) at the CIAE near Beijing. China plans to fuel the CEFR with MOX fuels made by its pilot MOX facility in the future. Once the MOX fuel loads are ready for transportation—a prospect still years away—from a site in the northwest part of the country to the Beijing area where the CEFR is located, security concerns raised by the 3,000 km trip will likely rise to the fore. Furthermore, when larger commercial reprocessing facilities, larger MOX plants, plutonium fabrication plants, and commercial FBRs come on-line, the shipment of MOX fuels and metal plutonium fuels will pose major security concerns.

The security of spent fuel transport is another source of concern. Between 1995 and 2002, China shipped discharge from research reactors and naval reactors, as well as other spent fuel, to the

[119] NNSA, "Guidelines of Physical Protection of Nuclear Materials Transport issued," 2008.
[120] NNSA, "Guidelines of Physical Protection of Nuclear Materials Transport issued," 2008.

wet storage pool connected to the pilot reprocessing plant.[121] The pool currently has a storage capacity of 500 tons for spent fuel from nuclear power plants and 50 tons for fuel from other sources, and this capacity is expanding. Since September 2003, when the spent fuel pools at the Daya Bay nuclear power reactors were nearing capacity, China has transported spent fuel from that facility to the pilot reprocessing plant as well, and by June 2013, it had conducted over thirty such shipments, or approximately three shipments per year. The designated transporter has been the Qingyan Environmental Technical Engineering Limited Company, which is owned by the CNNC and was established in 1995. The two containers used in the shipments are NAC-STC transport casks purchased in 2000 from the United States. Each container can transport 26 assemblies of spent fuel (approximately 460 kg in each assembly).[122] At present these shipments are conducted only by road, over 3,700 km from Daya Bay to the pilot reprocessing plant. However, if China pursues a reprocessing strategy instead of a dry storage plan in the near future, more spent fuel from nuclear power plants would need to be transported. China would then likely consider a combination of modes of transport, including roads, railways, and waterways.

In 2005, Chinese experts assessed the security risks associated with the transport of spent fuel and concluded that convoys could be vulnerable to threats including attempts to explode, burn, or sabotage the containers and contents. A successful attack could lead to a significant release of radioactive materials with severe environmental, as well as political, social, and public psychology, impacts.[123]

In June 2003, China issued its ‘‘Nuclear Reactor Spent Fuel Road Transport Management Interim Regulations,’’ which provide additional detail on the responsibilities of the transporter and license application process, as well as implementation, management, and relevant rewards and penalties for spent fuel transport.[124] Major security measures mandated include the setup of a dedicated group responsible for physical protection during transport; escort by police cars in front and behind the transport trucks, maintaining line-of-sight with the protected packages; and protection and guarding by armed personnel during all periods of the shipment, including during stopovers or occasional stops.[125] The responsibilities of the MPS mainly extend to approving transport applications and developing a special security program for each trip. The police bureaus along transport routes are tasked with strict implementation of the security program designed by MPS. One official from the Ministry of Environmental Protection has emphasized that spent fuel transportation has so far posed no problems.[126]

In 2005, Chinese experts warned that current security practices for spent fuel transportation may not be sufficient for addressing plausible threats—as is also the case with transportation of Category I materials—and recommended certain improvements.”[127] While the 2008 transport guidelines have addressed those issues for the transport of nuclear materials, it is not clear if those guidelines are also applicable to transport of spent fuel. In addition, it is not clear what the designated DBT for securing spent fuels transports is, nor is there a clear and specific DBT

[121] Pan, *Management of Nuclear and Radiological Terrorism Incidents.*PP. 53.
[122] Communications with Chinese nuclear safety expert, June 2013.
[123] Pan, *Management of Nuclear and Radiological Terrorism Incidents*.PP. 53-53.
[124] Zou, “Preventing Nuclear Terrorism: A View from China.”
[125] Pan , et al., *Management of Nuclear and Radiological Terrorism Incidents*.PP. 26.
[126] Li, “The Current Status and Plan of China Nuclear Security.”
[127] Pan, et al., Management of Nuclear and Radiological Terrorism Incidents.PP. 26.

Armed guards and police protecting a spent fuel convoy while at a stopping point. (Source: Ministry of Public Security.)

requirement. The MPS currently develops a unique security program for each shipment.[128] China needs to develop technical guidelines (if it has not yet done so) for spent fuel transportation, akin to those for the transportation of nuclear materials. Moreover, China needs to have a complete security regime for spent fuel transport, including a clear and unified minimum DBT requirement.

International Cooperation

China has joined almost all major international agreements and legal instruments related to nuclear security and nuclear non-proliferation; this participation has been a major driver of efforts to develop China's nuclear security regime. Meanwhile, another major driver of improvements to China's nuclear security and control system has been international cooperation, in particular with the United States and the IAEA.

US-Chinese cooperation on nuclear security began in 1995–1998, mainly through the US-China "Lab-to-Lab Collaborative Program."[129] The program mainly involved scientists from the China Academy of Engineering Physics (China's Los Alamos) and the US national nuclear weapons labs. The program was designed to help create in China an interest in strengthening its security systems by demonstrating the advantages of a modern MPC&A system. Under the program, several workshops on MPC&A techniques were held at the Institute of Applied Physics and Computational Mathematics in Beijing, and the CAEP also sent a few visiting scholars to US labs to study physical protection concepts and MC&A approaches. In 1998 a demonstration facility for MPC&A technology, designed to show how technologies could be integrated into

[128] Li, "The Current Status and Plan of China Nuclear Security."
[129] Nancy Prindle, "U.S. and China on Nuclear Arms Control and Nonproliferation: Building on Common Technical Interests," in James Brown, ed., *Arms Control Issues for the Twenty-First Century* (Albuquerque, N.M.: SNL Publication, SAND 97-2619, 1997); Nathan Busch, "China's Fissile Material Protection, Control, and Accounting: The Case for Renewed Collaboration," *Nonproliferation Review*, Vol. 9, No. 3, (Fall/Winter 2002), pp. 89-106.

a comprehensive system for protecting nuclear materials, was installed at the CIAE in Beijing. However, the collaborative program was terminated in the aftermath of the 1999 Cox Committee Report which alleged Chinese espionage at US nuclear weapons laboratories.[130] The Cox report was strongly deplored by the Chinese government and was also criticized by some US experts.[131]

Despite these difficulties, China expanded its cooperation with both the IAEA and the US DOE in the wake of the 9/11 attacks.[132] Because the dispute over past charges of espionage was never resolved, the CAEP does not formally participate in discussions with US experts, whose main counterparts are now the CAEA and its supporting institution, the CIAE. Nevertheless, representatives of both civilian and defense facilities take part in these discussions.

In recent years, China's cooperation with the US DOE has included an extensive series of exchanges, including visits to a range of US facilities to observe nuclear security and accounting approaches; in-depth training and discussion workshops on everything from approaches to protecting against insider threats, to the design of physical protection systems, to steps to strengthen security culture; a second joint demonstration of advanced MPC&A technology in 2005; work to strengthen security and accounting regulations and inspections in China; and, most recently, cooperation to build a Center of Excellence (CoE) on Nuclear Security. Presidents Hu Jintao and Barack Obama announced cooperation on the CoE at the Nuclear Security Summit in Washington in 2010. In January 2011, China and the United States signed a memorandum of understanding on the project. The center will serve as a forum for exchanging technical information, sharing best practices, developing training courses, and promoting technical collaboration to enhance nuclear security in China and throughout Asia. The National Nuclear Security Technology Center of the CAEA, established in November 2011, is responsible for the construction, management, and operation of the CoE. The CoE broke ground on October 29, 2013, and should be completed in 2015.[133]

US-Chinese MPC&A cooperation is quite different in nature from US cooperation with Russia in the same area. Because China has a large and growing economy, the United States has not been funding major MPC&A upgrades in China (with a few exceptions, such as the technical demonstrations and the work on the CoE). Instead, cooperation has centered on discussions, exchanges of best practices, training, and related activities, with China implementing any resulting upgrade recommendations with its own resources. Because the United States is not funding work at major Chinese nuclear facilities–and because of Chinese concerns for secrecy–the cooperation has not focused on US visits to sensitive Chinese sites. Hence, the US understanding of Chinese practices is largely based on what Chinese experts choose to share in the discussions, rather than on-the-ground observations.

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[130] See, US House of Representatives Select Committee on US National Security and Military/Commercial Concerns with the People's Republic of China, "Final Report," May 1999, http://www.house.gov/coxreport (accessed March 7, 2014).

[131] Information Office of the State Council of the People's Republic of China, "Facts Speak Louder Than Words and Lies Would Collapse on Themselves,"July 15, 1999, http://www.china-embassy.org/eng/zmgx/zmgx/Political%20 Relationship/t35103.htm (accessed March 7, 2014); Alastair Iain Johnston, W. K. H. Panofsky, Marco Di Capua, and Lewis R. Franklin, *The Cox Committee Report: An Assessment* (Stanford, C.A.: Stanford University, December 1999), http://iis-db.stanford.edu/pubs/10331/cox.pdf (accessed March 7, 2014).

[132] Liu Daming, "Overview of the China-US Cooperation on Nuclear security," (presentation at Harvard-Peking University Workshop on Nuclear Security, October 13-14, 2011).

[133] "Construction on China-U.S. Nuclear Security Center Begins," *Xinhua*, October 29, 2013,

http://news.xinhuanet.com/english/china/2013-10/29/c_132841259.htm (accessed March 7, 2014).

US-China cooperation has included the following milestones:

- In July 2003, China and the United States signed a "Container Security Initiative" which has been implemented since 2005 in Shanghai, Shenzhen, and Hong Kong.
- In 2004, China and the United States renewed cooperation under the 1997 "US-China Peaceful Uses of Nuclear Technology (PUNT) Agreement," which had been suspended over the espionage allegations. This agreement provides the framework for much of the MPC&A cooperation now underway. The framework focuses on civilian nuclear cooperation, including promotion of technical cooperation on export controls for nuclear materials and MPC&A for nuclear materials and facilities. Since cooperation on MPC&A under PUNT was resumed in 2004, technical cooperation has been expanded significantly in the civilian nuclear area. In April 2013, the 8th Joint Coordinating Committee meeting of the PUNT Agreement was held in Beijing. The five PUNT working groups have discussed new issue areas for potential cooperation, and agreed on the need for strengthened technical collaboration on nuclear energy technologies, safeguards and security, environment and waste management, nuclear emergency management, and radioactive source security.
- In 2007–2008, the United States and China cooperated extensively on security preparations for the Beijing Olympics.
- After the 2010 Washington Nuclear Security Summit, China and the US jointly published "Technical Guidance on the Nuclear Export Control Lists" to help educate Chinese staff involved in nuclear export controls.
- In January 2011, China and the United States signed a "Memorandum of Understanding for Cooperation in Jointly Establishing the Radiation Detection Training Center of China Customs"; the center was established before the March 2012 Seoul Nuclear Security Summit.
- On December 7, 2011, China and the United States inaugurated a "Megaport Initiative" to enhance special nuclear and radioactive materials detection capabilities at the container cargo port in Shanghai. China and the United States have also jointly implemented the Yangshan Port Pilot Program in Shanghai.

China has also cooperated extensively with the IAEA on issues ranging from safety and security training, to preparations for the 2008 Olympics, to detection and emergency response, to regulations and standards.[134] In 2006, the CAEA and IAEA established a Joint Training Center on Nuclear Safeguards and Security, hosted by the CIAE, with the aim of strengthening training capabilities for nuclear safeguards and security. In August 2010, China and the IAEA signed a "Practical arrangement on Nuclear Security cooperation" that initiated in 2007. It intensifies cooperation in areas such as the development of nuclear security regulations and standards, capacity building, and training.

China has greatly improved its MPC&A systems since the 9/11 attacks, benefitting significantly from CAEA cooperation with foreign entities, in particular the US DOE and the IAEA. While current cooperation focuses mainly on the Chinese civilian sector, personnel from defense

[134] Zhu, "China's nuclear security and international cooperation"; CFISS, *Combating Nuclear Terrorism—Non-state actors' nuclear proliferation and nuclear security.*

facilities participate as well. It is reasonable to assume that best practices associated with MPC&A principles learned through cooperation will be applied to fissile materials and facilities in the military sector as well, in part because the CAEA is responsible for controlling fissile materials nationwide in both military and civilian stockpiles and can transfer lessons from one to the other. Thus, it is imperative to maintain and strengthen CAEA cooperation with the US DOE and the IAEA.

Ultimately, however, without knowing what real problems exist in the military sector, the indirect benefits of cooperation on the civilian sector for the military sector will continue to be limited.

Direct cooperation on nuclear security and control of China's nuclear weapons has not been touched upon. China treats its weapons-program MPC&A system as very sensitive and secret.

Chinese nuclear experts believe that the nuclear security regime within the military sector is much more secure than the civilian regime, because nuclear weapons, weapons-grade materials, and related facilities are the "most valuable stuff" in China. The government has reported "accident-free" operations for the past fifty years. However, even if China's nuclear security arrangements generally appear to be good, the country must still work to minimize any vulnerabilities that might be exploited by terrorists, or corrupt insiders, and to assure other nations that its nuclear weapons and materials are protected against the range of threats they might plausibly face.

Chapter IV: Recommendations for Improving China's Nuclear Security

Since the 9/11 attacks, China has substantially advanced its nuclear security system, with a switch in focus from the traditional "guns, gates, and guards" approach to an effective mixed approach that combines well-trained personnel with modern techniques and a requirement to perform systematic vulnerability assessments. While the available information on Chinese nuclear security is encouraging, there is still room for improvement.

Of course, China is not alone in needing to improve its nuclear security policies and practices. The protesters' breach of the US Y-12 National Security Complex in July 2012 demonstrates clearly that no country—not even the United States, which may have the most advanced nuclear security system in the world—should become complacent about its nuclear security.[135]

Converting President Hu's political commitment from the 2012 nuclear security summit into practical, sustainable reality will require China to assess its nuclear sector's vulnerabilities along several dimensions ranging from regulatory arrangements, to physical infrastructure, to security culture. China should take further steps to install a complete, reliable, and effective security system to ensure that all its nuclear weapons, weapon-usable nuclear materials, nuclear facilities, and nuclear transports are effectively protected against the full spectrum of plausible terrorist and criminal threats. We suggest the following measures be taken to improve China's existing nuclear security system.

1. Updating and Clarifying the Requirements for Design Basis Threat

China needs to update and clarify its design basis threat requirements for all military and civilian nuclear facilities. Although China's 2008 guidelines for nuclear security require DBTs for all civilian nuclear facilities to include consideration of insider and outsider threats, the guidelines' standards for establishing a facility's design basis threat are neither as specific nor as clear as they should be. As described earlier, current practice is that each facility develops its own facility-specific DBT, which is reviewed and approved by national regulators. We recommend that China establish a national-level DBT, as exists in the United States and many other countries. Individual facilities are poorly equipped to understand the full spectrum of threats that national authorities and intelligence agencies may know about, and substantial variation from one facility to another could leave dangerous weak points that adversaries could exploit. Modest adjustments to the national DBT could be made, with the approval of regulators, to reflect the particular circumstances at individual sites.

[135] On July 28, 2012, three anti-nuclear activists including an 82 year-old nun got past fences and security sensors surrounding the Y-12 facility and accessed the wall of the building where 100s of tons of HEU are stored (See, US Department of Energy, Office of Inspector General, Office of Audits and Inspections, "Special Report: Inquiry into the Security Breach at the National Nuclear Security Administration's Y-12 National Security Complex," August 2012, http://energy.gov/sites/prod/files/IG-0868_0.pdf (accessed March 7, 2014); John Huotari, "Y-12 protesters allegedly enter high-security area, spray paint, splash blood," *Oak Ridge Today*, July 28, 2012). The Y-12 break in prompted DOE to reappraise security measures across the US nuclear weapons program.

China's current DBTs for nuclear facilities—like those in most other countries–would be unable to resist extreme adversary scenarios, such as a large commercial aircraft smashing into a facility.[136] Moreover, because certain Chinese nuclear fuel cycle facilities, including the pilot reprocessing plant, share some of their facilities with old military nuclear plants, and because the security systems for the old facilities were generally not designed to meet the current requirements, the adjoining new facilities would probably find it very difficult to have a complete and effective security system with the defense-in-depth and balance principles required in the 2008 guidelines.[137] As Li Ganjie, the director of the NNSA has noted, the existing design basis threat at civilian facilities might be insufficient to repel attacks from larger and better-organized terrorist groups, or attacks involving powerful weapons.[138]

Due to this vulnerability, China should review and upgrade the criteria used for designing physical protection for its nuclear facilities. Operators should develop and implement security plans that provide effective protection against a threat that includes the full spectrum of plausible adversaries and tactics—including not just brute force attacks but also deception, and stealth, from both insiders and outsiders working together.

To plan and implement effective DBTs, China should significantly enhance its R&D investments in nuclear security. It should also adopt and adapt the best practices from other nations through bilateral and international cooperation like in the "lab to lab" program between China and the United States and through participation in the World Institute for Nuclear Security (WINS).

Some nuclear experts in China may argue that it is not necessary to have national DBT standards because of the different situations at various nuclear sites. Indeed, it is difficult to judge what kinds of threats are worth spending money to protect against. However, we recommend investing in measures to protect against actions that terrorists and criminals have routinely carried out in attacks and thefts elsewhere around the world. Such actions include use of multiple teams (with one team acting as a diversion or preventing response forces from arriving along the road); use of armor-piercing rocket-propelled grenades (devastating against guard shacks and guard fighting positions unless they are designed with RPGs in mind); use of explosives to blow through walls and security doors; deception attacks, where the adversaries have official-looking uniforms and IDs, possibly even official-looking paperwork saying something is to be loaded onto their truck; use of insiders, including to get information on the security system; and use of unusual vehicles (such as helicopters).[139]

Eventually, it is imperative to have at least a minimum DBT standard that includes protection against one modest group of well-armed and well-trained outsiders; a well-placed insider; and both outsiders and an insider working together, using a broad range of possible tactics.[140]

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136 Pan, *Management of Nuclear and Radiological Terrorism Incidents*. pp.28–34; Li, "Nuclear Security: The New Challenges for Security of Nuclear Power Plants."

137 Communications with a Chinese nuclear regulator, March 2013.

138 Li, "Nuclear Security: The New Challenges for Security of Nuclear Power Plants."

139 Matthew Bunn and Evgeniy P Maslin, "All Stocks of Weapons-Usable Nuclear Materials Worldwide Must Be Protected against Global Terrorist Threats," *Journal of Nuclear Materials Management*, Vol. 39, No. 2, (Winter 2011).

140 Bunn and Maslin, "All Stocks of Weapons-Usable Nuclear Materials Worldwide Must be Protected against Global Terrorist Threats."

2. Reducing Internal Risks

Based on past experience, all of the real cases of theft of HEU or plutonium were perpetrated by insiders or with insider cooperation.[141] A number of known cases of sabotage at nuclear facilities (none intended to spread radiation) were perpetrated by insiders as well. Thus, it is essential to maintain a strong program to protect against the insider threat.

China reportedly has personnel reliability programs in place in its nuclear facilities. But the parameters of these programs are secret. China should make available general information about these programs, both as a deterrent to terrorists and as a source of reassurance to other governments that China takes nuclear security seriously. Operators of nuclear facilities should be required to take steps to decrease vulnerability to insiders with intent to do harm. In particular, in cooperation with relevant government departments, every operator should have an effective program for personnel reliability screening to strengthen access control.[142] For example, security and other personnel with access to vital areas should be subject to periodic drug testing, background checks, and psychological or mental fitness tests, and they should be vetted at both specified and random intervals. In the United States, the "root causes" of insider issues are often found to include mental and emotional stresses and financial problems; investigations in China should cover these issues and others specific to China's culture and situation. The license conditions for facility operators should specify that personnel should report suspicious behavior to a clearly designated authority.

While personnel reliability programs are important, managers should not assume that they can eliminate the insider threat by themselves—both because they may miss some insider adversaries (as was the case with Aldrich Ames and Robert Hanssen in the U.S. intelligence agencies, for example) and because even trustworthy insiders could be blackmailed or coerced. Regulations should also require a range of other measures to protect against insider theft and sabotage. In particular, constant surveillance of inner areas and vital areas when they are occupied, using either a two-person surveillance system or a technological surveillance system including devices such as closed circuit television, or preferably both, should be required at all facilities. Some specific proposals for protection against insider threats are listed in Box 4-1.[143]

3. Improving Material Control and Accounting

To prevent terrorists from acquiring nuclear materials, China should improve its approach to material control and accounting at its bulk processing facilities (e.g., fuel fabrication, enrichment, and reprocessing). This would be particularly important if China moves toward large-scale use of separated plutonium in the civil sector. For example, the operation of China's pilot reprocessing plant resulted in very high levels of MUF. Those facilities are facing major challenges, including shortages of modern equipment, technologies, and personnel with the needed training; these problems are rooted mainly in inadequate funding. (Unlike nuclear power plants that earn

[141] Moore, "Dealing with the insider threat"; International Atomic Energy Agency, *Preventive and Protective Measures Against Insider Threats*; World Institute for Nuclear Security, *Managing Internal Threats*; Bunn and Glynn, "Preventing Insider Theft."

[142] Moore, "Dealing with the insider threat"; International Atomic Energy Agency, *Preventive and Protective Measures Against Insider Threats*; World Institute for Nuclear Security, *Managing Internal Threats*; Bunn and Glynn, "Preventing Insider Theft."

[143] Moore, "Dealing with the insider threat."

Box 4-1: Specific Proposals to Deal with Insider Threats

Measures to protect against insider threats should include:

- Two- or three-person surveillance systems.
- Closed Circuit Television and audio surveillance systems, with recording and long-term archival capability and real-time surveillance by a knowledgeable officer.
- Technical and physical screening of personnel for weapons, radiation shielding, and nuclear/radioactive materials.
- Restrictions against closely related personnel working in nuclear material access areas, and in other related departments such as nuclear materials accounting or security.
- Specific "insider threat" background investigations performed by a separate agency. Insiders should be reinvestigated yearly, and the emphasis of the investigation should be varied. These investigations should be based on the issues that are frequently the "root causes" of insider issues, including, e.g., mental and emotional stresses, financial problems, etc.
- Programs to prevent or mitigate "root cause" issues and stresses.
- Psychological testing for specific insider threat (root cause) criteria (annually).
- Frequent material accounting reviews and verification by other departments.
- Legal authority, training, and capability for protective forces to detain and investigate individuals, and even use deadly force in appropriate circumstances.
- Increased legal/criminal penalties for nuclear theft and sabotage.
- Requirements in DBT to protect against threat of more than one insider and one insider with an outsider.
- DBT implementation with substantial effective insider threat-resistant design features, including a two-person technical and human/guard controls, and physical features to defend against a "break-out" scenario (emergency egress portals).
- Insider threat-based requirements and protections that are mandatory and embodied in regulations that are consistent across national/regional agencies (equalizing the threat resistant environment across nation).

Many of these measures were described by Lonnie Moore in, "Dealing with the Insider Threat," slides presented at a workshop on the safety and security of China's nuclear facilities, January 15-18, 2013, Shenzhen, China.

higher profits, fuel cycle facilities are dependent mainly on government support.) The government should make sure the operator has an accounting system that will detect if any significant quantity is removed, and be able to localize the removal in time and space, and identify which insiders had access.

Nuclear security experts have emphasized that it is far easier for insiders to steal small amounts of material over time without anyone noticing at such bulk processing facilities. In nearly every case in which authorities have seized stolen HEU or separated plutonium, the material has been in bulk form, such as powder, apparently stolen without detection by insiders from bulk processing facilities.[144] Thus, it is essential for China to take effective MC&A measures to reduce the chances of insider theft.

[144] Bunn, Harrell, and Malin, *Progress on Securing Nuclear Weapons.*

4. Updating and Enforcing Regulations

Aside from the 2008 guidelines for material protection, control, and accounting, most of China's major regulations and rules governing the control of nuclear materials were issued two decades ago, many years before the 9/11 attacks. China should update its 1987 regulations and 1990 rules, and issue rules and regulations that are more stringent and clear, based on at least the minimum DBT standard described above, to protect against the potential threat of nuclear terrorism. The regulations should be strong enough that, if followed, effective nuclear security would result.

While Beijing has committed to almost all of the existing international legal frameworks to prevent nuclear terrorism, China needs to effectively integrate the international frameworks into its domestic regulations and rules to strengthen its nuclear security on the ground.

Implementation and enforcement of new regulations and rules are more difficult than establishing them. The government and operators should take measures to assure effective implementation of laws and regulations. For example, within the government, the regulators should be adequately staffed with personnel possessing appropriate expertise. The government should have a regime of clear rewards and strict penalties to ensure compliance with its regulations and with international norms. The enforcement regime should include a review of records of the security performance of the companies being evaluated for contracts involving work with nuclear weapons or materials. In addition, China should have ability to deploy and coordinate effective responses to threats to nuclear facilities or nuclear materials in transit. Finally, regulators should review implementation practices to confirm that operators can protect against the DBT for a given nuclear facility. Just as with nuclear safety, the focus should be on continual improvement, constantly working to find and fix remaining vulnerabilities and find more effective approaches.[145]

Over the long term, China needs to increase the independence of the agencies responsible for regulating nuclear security. China currently has three primary agencies (CAEA, NNSA, and MPS) responsible for nuclear security with overlapping roles and authorities for the various nuclear facilities and activities in question. For example, both the CAEA and the NNSA have responsibilities for the security of nuclear materials and facilities in the civilian sector. Meanwhile, CAEA is also responsible for promoting nuclear energy development. This is contrary to the principle of independence of the regulator from nuclear energy promotion, enshrined in the Nuclear Safety Convention. Although the NNSA is an independent regulator, its authority is weakened by a lack of human and financial resources.

To minimize the risk of miscommunication and confusion, China should have a single nuclear security regulatory body for the civilian sector (the military already has only one) that possesses the adequate legal authority, technical and managerial competence, financing, and human resources to carry out its responsibilities effectively, efficiently, and independently. In practice, this should include shifting CAEA's regulatory roles in the civilian sector to the NNSA.

Finally, China should eventually adopt a comprehensive atomic energy law to provide a stronger legal foundation to govern the use of nuclear energy and safety and security. The new law should

[145] Matthew Bunn, Martin Malin, Nickolas Roth, and William Tobey, *Advancing Nuclear Security: Evaluating Progress and Setting New Goals*. (Cambridge MA: Project on Managing the Atom, Belfer Center for Science and International Affairs, March 2014).

ensure that regulatory responsibilities and functions are clearly defined and coordinated, and enhance the independence, authority, and effectiveness of its nuclear safety regulators.

5. Further Consolidation of Nuclear Material Stocks

Nuclear security experts have emphasized that one key element of preventing nuclear theft and nuclear terrorism is to reduce the number of buildings and sites where nuclear weapons and weapon-usable nuclear materials exist. A country can achieve higher nuclear security at lower cost by having fewer places to guard.[146]

China has a modest number of nuclear weapons and a modest stock of weapons-usable nuclear material in a fairly small number of places. But China should nonetheless assess every military and civilian location that houses HEU, separated plutonium, or nuclear weapons and consider further how to minimize the number of those locations and ensure their security. In particular, China should speed up the conversion of its HEU-fueled research reactors and should also help to convert the miniature neutron source reactors it has exported. Further, Beijing should take a leading role in building an international consensus for phasing out and ultimately banning the civilian use of HEU.

China should also consider delaying its plans for commercial reprocessing. Instead of the current consolidated control of weapons-useable material, commercial-scale reprocessing in China would require frequent transport and storage of separated plutonium all over the country. Sufficient uranium is available for decades to come, if not longer, and dry cask storage offers a flexible, safe, and low-cost option that can postpone for decades the need for reprocessing or direct disposal, allowing time for interest to accrue and technology to develop. China has no convincing rationale for rushing to build commercial-scale reprocessing facilities or plutonium breeder reactors in the next couple of decades. A move toward breeders and reprocessing would be a move away from more effective consolidation of nuclear materials.[147]

6. Conducting Realistic Performance Tests

Nuclear security systems at Chinese sites have not been subject to realistic tests in which intelligent adversaries try to find ways to defeat them. China should conduct on-site realistic performance tests in which adversary teams try to penetrate a given facility's security system. Currently operators are required to do in-depth vulnerability assessments and performance tests of individual components of their security systems, but these do not include the realistic "force-on-force" exercises. No Chinese regulations require such tests, which are vital for identifying the strengths and weaknesses of security procedures. The latest revision of the IAEA's physical protection recommendations urges all states to carry out such force-on-force exercises to test security at their nuclear sites.[148]

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[146] Matthew Bunn and Eben Harrell, *Consolidation: Thwarting Nuclear Theft* (Cambridge, M.A.: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, March 2012), http://belfercenter.ksg.harvard.edu/files/Consolidation_Thwarting_Nuclear_Theft_corrected.pdf (accessed March 7, 2014).
[147] Hui Zhang, "Rethinking Chinese Policy on Commercial Reprocessing," (presentation at the 18th Pacific Basin Nuclear Conference, Busan, Republic of Korea, March 18–23, 2012), http://belfercenter.ksg.harvard.edu/files/ChinaReprocessing_hzhang.pdf (accessed March 7, 2014).
[148] International Atomic Energy Agency, *Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities*, INFCIRC/225/Rev.5 (Vienna: IAEA, 2011), http://www-pub.iaea.org/MTCD/publications/PDF/Pub1481_web.pdf (accessed March 7, 2014).

The newly established National Nuclear Security Technology Center, responsible for the construction, management, and operation of China's Center of Excellence (COE) on Nuclear Security, will conduct such exercises at the COE.[149] However, these will mainly serve to train guard forces and will not probe how well security performs at operating facilities. Table-top computer simulations and vulnerability assessment alone can reveal only those vulnerabilities imagined by the assessors; in the US experience, force-on-force exercises often reveal problems that were not obvious from these other means. One key driver to improving DOE and NRC's nuclear facilities' security systems has been requiring the correction of vulnerabilities revealed during the realistic tests.[150]

China may lack the experience and capabilities to carry out such tests at sites while simultaneously maintaining safe and secure operation of the nuclear facilities.[151] However, the US experience of such tests demonstrates that this can be done.

Chinese experts and officials could also learn more about the practice of "force-on-force" exercises through CAEA-DOE cooperation. For example, the United States could follow up on visits where Chinese experts have witnessed exercises at test facilities, like the ones to be conducted at the COE. It could invite Chinese experts to witness force-on-force exercises at operating US sites, as the United States has done with other countries, including France and Japan. A Chinese team has reportedly already observed one of the force-on-force exercises at Canada's Bruce Power reactor site.[152]

7. Strengthening Nuclear Security Culture

To ensure that nuclear security systems are actually implemented effectively, the development of a strong security culture is imperative. Then President Hu Jintao emphasized the importance of "promoting nuclear security culture" at the 2010 Nuclear Security Summit. One key element of an effective nuclear security culture is that relevant individuals hold a deeply rooted belief that nuclear security is important and that insider and outsider threats are credible.[153]

Unfortunately, as noted earlier, many Chinese experts continue to doubt that there is a credible threat to Chinese nuclear materials and facilities. Some experts view China's commitments to upgrading nuclear security as more of a response to an international requirement than to a serious

[149] Communications with Chinese nuclear security experts, January 2013.

[150] Oleg Bukharin, "Physical Protection Performance Testing: Assessing U.S. NRC Experience," *Journal of Nuclear Materials Management*, Vol. 28, No. 4 (Summer 2000), pp. 21-27.See also Matthew Bunn, "Beyond Crises: The Unending Challenge of Controlling Nuclear Weapons and Materials," in Henry D. Sokolski and Bruno Tertrais, ed., *Nuclear Weapons Security Crises: What Does History Teach?* (Carlisle, Penn.: U.S. Army Strategic Studies Institute, 2013).

[151] Communications with Chinese nuclear security experts, October 2011.

[152] Personal communication from Bruce Power expert to Matthew Bunn, June 2013.

[153] International Atomic Energy Agency, *Nuclear Security Culture: Implementing Guide* (Vienna: IAEA, 2008), http://www-pub.iaea.org/MTCD/publications/PDF/Pub1347_web.pdf (accessed March 7, 2014). The guide states that "The characteristics of nuclear security culture are the beliefs, attitudes, behavior and management systems, the proper assembly of which leads to more effective nuclear security. The foundation of nuclear security culture is a recognition—by those that have a role to play in regulating, managing or operating nuclear facilities or activities or even those that could be affected by these activities — that a credible threat exists and that nuclear security is important." See also World Institure for Nuclear Security, *Nuclear Security Culture: A WINS Best Practice Guide for Your Organization*, Rev. 1.4 (Vienna: WINS, September 2009).

threat; they argue that nuclear terrorism may be a problem for the United States, but it is not an urgent concern for China.[154] It is impossible to count on people to endeavor to prevent something that they do not believe is real. If those responsible for security believe that the threat of nuclear terrorism is real, it is more likely that they will take appropriate precautions. And, in Chinese culture, such an attitude would be a powerful determinant of behavior.

China also faces the challenge of complacency among a significant number of senior nuclear experts and within its nuclear industry. They believe that China already has strict nuclear security systems that have worked well and have been "free of accident" over the past 50 years. Some managers and employees at Chinese nuclear plants do not recognize the importance of advanced and stringent material protection, control, and accounting systems. In some cases, the guards turned off detectors at portals for enrichment facilities to reduce their usage to avoid the need for frequent replacement.[155] Also, some managers may doubt whether it is worth the money and time to establish and maintain a stronger security system.

Moreover, growth of the nuclear industry has created a serious shortage of adequately trained guards, security personnel and other necessary staff. As more employees are hired from other non- nuclear fields, the nuclear safety and security culture will be further diluted. In plants where operations have been switched from military to civilian purposes, the operators may still be used to keeping everything secret and will not willingly share problems with outsiders, including inspectors.[156]

Each operator should establish a targeted program to assess and improve its facility's security culture. In addition, China should conduct regular training programs at its nuclear facilities—not only to improve the guards' and security personnel's professional skills, but also to inform them about the threats of nuclear and radiological terrorism and to impress upon them that nuclear security is important and should be taken seriously. Force-on-force exercises also help strengthen security culture, not only for guards, but for other employees who witness the seriousness with which security risks are addressed and see plausible ways the security system might be overcome. Each staff member should not only scrupulously abide by the existing nuclear security regime, but also actively and continuously find further ways to improve it. Effective security is not only provided by advanced devices, but, even more importantly, by human choices.

8. International Assurance

China should consider making more information available on its nuclear security policies and practices to build international confidence that effective nuclear security is in place. Transparency is important for increasing public confidence in China's nuclear energy development, in particular, in the wake of the Fukushima nuclear accident. More information on nuclear security in China is important to assure the international community that China's nuclear security conditions are sound.

One major measure that some experts suggest will increase international assurance is for each country to make a declaration of nuclear material inventories (civilian and military).[157] China's

[154] Communications with CNNC nuclear experts in Beijing, October 2011.
[155] Communications with Chinese nuclear regulator, October 2012.
[156] Communications with Chinese nuclear regulator, December 2012.
[157] Nuclear Threat Initiative, *NTI Nuclear Materials Security Index (2012).*

stocks of HEU and separated plutonium are mainly intended for use in weapons and Beijing believes that secrecy enhances the deterrent effect of its small nuclear force.

Still, to increase international confidence in security conditions around its nuclear materials and facilities, China should make substantial amounts of information about its nuclear security conditions public, while nonetheless protecting sensitive information.[158] China could, for example, publish either annual reports on nuclear security or details of its nuclear security regulations.

Moreover, China should allow experts organized by the IAEA to conduct peer reviews of the country's nuclear security arrangements. These reviews have been found by many other states to be helpful in identifying options to improve nuclear security. China is considering whether to have an International Physical Protection Advisory Service (IPPAS) mission to China. It would be a constructive move for China to host such a mission soon. The IPPAS missions would review and compare China's physical protection measures with international guidelines and best practices and make recommendations for improvements. Also, China should consider inviting other IAEA missions including the International Nuclear Security Advisory Service (INSServ) mission and the State System for Accountancy and Control (SSAC) Advisory Service.

China should encourage its relevant nuclear security professionals to participate in WINS and other workshops and training that facilitate the identification and sharing of best practices.

China could also host reviews of its nuclear security arrangements by another country under a bilateral-type agreement or program. For instance, China and the United States could expand cooperation to include security reviews of agreed-upon facilities beginning with civilian sites with HEU-fueled reactors and the pilot reprocessing plant; the United States could invite China to a similar set of reviews at selected US facilities.

9. Balancing the Costs of Nuclear Security

The Chinese government should make sure that operators have sufficient financial and human resources to sustain effective security over the long term. And the operators should implement the security measures required by the government.

Operator concerns over costs are a major obstacle to the improvement of security systems.[159] However, enhancing security standards would only modestly increase the capital and operating costs for most nuclear facilities. By one estimate, most types of facilities can provide effective security with only a few percent of their annual operating budgets.[160] Moreover, the nuclear

[158] See, Nuclear Threat Initiative, "Non-Paper 2: Practical Proposals for Providing International Assurances," https://www.nti.org/media/pdfs/Non-Paper_2_-_Practical_Proposals_for_Providing_International_Assurances.pdf?_=1353439879 (accessed March 7, 2014); Robert Floyd, "Discussion Paper: Next Steps on International Assurances," May 2013, https://www.nti.org/media/pdfs/Next_Steps_on_International_Assurances_1.pdf (accessed March 7, 2014).

[159] The Chinese expert participating in a recent survey of nuclear security experts in many countries, for example, cited operator concerns over cost as by far the biggest constraint on strengthening nuclear security requirements. See Matthew Bunn and Eben Harrell, *Threat Perceptions and Drivers of Change in Nuclear Security Around the World: Results of a Survey* (Cambridge, Mass.: Project on Managing the Atom, Harvard University, March 2014), p. 29

[160] See Steven Lee, "The Development of the Supporting Infrastructure for Improved Nuclear and Radiological Material Security," *World Institute for Nuclear Security*, July 18, 2012, http://www.nsgeg.org/Development%20of%20Supporting%20Infrastructure%20for%20Improved%20Nuclear%20Security_WINS%20paper.pdf (accessed March 7, 2014)

industry should understand that nuclear power will not get the support it needs for large-scale growth unless the public is confident that there is no significant risk of sabotage or other acts of nuclear terrorism. Just as the accident at Fukushima Daiichi affected the nuclear power industry around the world, an act of nuclear terrorism anywhere will likely end public support for nuclear power everywhere.

Operators in China, in particular at certain fuel cycle facilities, face the challenge of having to invest additional resources to meet new and stricter security standards. Due to their poor profits, they are heavily dependent on government financing. They will not spend more on the new security measures unless the government requires them to do so. Therefore, the government should assess the costs of security given the threats the security system is required to protect against, clarify responsibilities and the apportionment of costs between the government and operators, and provide adequate resources to those operators who are in need. Through this action all operators are assured of having sufficient resources to provide effective security for their facilities. Meanwhile, the government should require the operators to implement effectively those security regulations and rules issued it has issued.

10. Strengthening Cooperation

China's improvement of nuclear security has benefited greatly from international cooperation, in particular, between the CAEA and both the US Department of Energy and the IAEA. The cooperation has taken a broad range of forms, including in-depth discussions, workshops, joint centers and programs, and exchanges of best practices. It has involved a wide range of issues, including physical protection measures, materials control and accounting, and security culture. This cooperation should continue and grow stronger.

In addition, US-Chinese cooperation needs to be expanded from the current civilian efforts to the military sector, since it is the military that has custody of the largest stocks of weapon-usable fissile materials—and all nuclear weapons. The 9/11 attacks should have provided an opportunity to expand cooperation between the United States and China on fighting terrorism and to restart the "lab-to-lab" type program on MPC&A, which would significantly benefit China's nuclear materials and facilities in the military sector. But this has yet to occur.

The two governments should restart the lab-to-lab program. As first steps, the program should begin with less sensitive activities that are identified as mutually beneficial. The two governments could conduct in-depth discussions and best practice exchanges on a number of areas, including applications of modern seals techniques and continuous remote monitoring approaches for the storage of nuclear warheads and sensitive nuclear materials; tracking and monitoring techniques for shipments of fissile materials; and safety and security measures protecting nuclear weapons and nuclear materials. As the lab-to-lab program moves forward, based on the experience from US-Russian cooperation, China and the United States may consider conducting mutual visits and joint work at some selected key sites. Others areas of focus could include DBT approaches for sensitive facilities, advanced MPC&A applied at some sites, updating regulations and procedures, and strengthening security culture at some sites.

Finally, China should strengthen its cooperation with the IAEA, including continuing and expanding its contribution to the IAEA Nuclear Security Fund, and sending an invitation to the IAEA to conduct reviews of the country's nuclear security arrangements, including an IPPAS mission. Also, China should consider contributing to nuclear security in other countries, including contributing to the UNSC 1540 Implementation Fund and actively supporting GICNT.

Box 4-2: Ideas for Enhanced US-China Cooperation on Nuclear Security

US-China cooperation could expand on a variety of fronts, including:

- Continuing in-depth discussions and best practice exchanges on how to establish a national-level DBT and carry out a more systematic and rigorous approach to applying it for each type of nuclear facility, focusing on those dealing with weapon-usable nuclear materials.
- Continuing in-depth discussions and best practice exchanges on how to decrease vulnerability to an insider threat, in particular at bulk processing facilities and storage facilities of weapon-usable fissile materials.
- Collaboration on applying updated material control and accounting systems and best practices to China's pilot reprocessing plant and also to a pilot MOX facility that is under construction.
- In-depth discussions and best practice exchanges on China's updating and enforcing new regulations, drafting an atomic energy law, strengthening the independence of regulatory bodies, and providing adequate legal authority, technical and managerial competence, and financial and human resources to ensure regulatory capacity.
- Assistance on adopting realistic performance tests including "force-on-force" exercises. Chinese experts should be invited to witness such exercises at US sites.
- Moving forward with cooperation on security culture, including implementing targeted programs to assess and improve security culture at each key site.
- In-depth discussions and best practice exchanges on how to increase international assurance about China's nuclear security conditions, including how China can make substantial amounts of information public while protecting sensitive information.

Moreover, China should seek to ensure that each facility and transporter handling sensitive nuclear materials participate in sharing nuclear security best practices, for example, through exchanges facilitated by WINS.

Looking Toward the Future

At the 2012 Nuclear Security Summit in Seoul, Chinese President Hu Jintao said, "In the future, China will [take further] nuclear security measures, make sure [of] the security of its own nuclear materials and facilities, [and] improve … overall nuclear security." China has made significant progress in strengthening nuclear security. Its concepts and strategies for addressing security threats have evolved since 9/11, and its focus on the problem has grown stronger in the last four years. China continues to upgrade its physical protection systems and improve its material control and accounting. And China has become more open to cooperation on nuclear security matters. But significant gaps remain in China's efforts to prevent nuclear and radiological terrorism. Its work should continue and be intensified to ensure a safe, secure, and prosperous future for all.

About the Project on Managing the Atom

The Project on Managing the Atom (MTA) is the Harvard Kennedy School's principal research group on nuclear policy issues. Established in 1996, the purpose of the MTA project is to provide leadership in advancing policy-relevant ideas and analysis for reducing the risks from nuclear and radiological terrorism; stopping nuclear proliferation and reducing nuclear arsenals; lowering the barriers to safe, secure, and peaceful nuclear-energy use; and addressing the connections among these problems. Through its fellows program, the MTA project also helps to prepare the next generation of leaders for work on nuclear policy problems. The MTA project provides its research, analysis, and commentary to policy makers, scholars, journalists, and the public.

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