Project on Managing the Atom

China's Nuclear Security: Progress, Challenges, and Next Steps

Hui Zhang

HARVARD Kennedy School
Belfer Center for Science and International Affairs

March 2016

Project on Managing the Atom

Belfer Center for Science and International Affairs
Harvard Kennedy School

79 JFK Street
Cambridge, MA 02138

617-495-4219

atom@hks.harvard.edu
http://www. belfercenter.org/mta

Zhang, Hui. "China's Nuclear Security: Progress, Challenges, and Next Steps" Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, March 2016.

Design & Layout by Josh Anderson

Cover photo: The gate of the Center of Excellence on Nuclear Security in the State Nuclear Security Technology Center in Beijing, China, March 18, 2016. REUTERS/Kim Kyung-Hoon

This report was funded by the Carnegie Corporation of New York and the John D. and Catherine T. MacArthur Foundation.

Project on Managing the Atom

China's Nuclear Security:
Progress, Challenges, and Next Steps

Hui Zhang

HARVARD Kennedy School
Belfer Center for Science and International Affairs

March 2016

About the Author

Hui Zhang is a Senior Research Associate with the Project on Managing the Atom in the Belfer Center for Science and International Affairs at Harvard University's John F. Kennedy School of Government, where he is leading a research initiative on China's nuclear policies. His research interests include verification techniques of nuclear arms control, the control of fissile material, nuclear terrorism, nuclear safeguards and non-proliferation, nuclear fuel cycle and reprocessing policies, and China's nuclear future. Dr. Zhang is the author of a number of technical reports and book chapters, and dozens of articles in academic journals and the print media including *Science and Global Security, Arms Control Today, Bulletin of the Atomic Scientists, Disarmament Diplomacy, Disarmament Forum, The Nonproliferation Review, Washington Quarterly, Journal of Nuclear Materials Management*, and *China Security.*

Acknowledgments

Many Chinese nuclear experts who prefer to remain anonymous participated in interviews and discussions on nuclear security during the preparation of this report. The author is grateful for their insights and suggestions. He also thanks Matthew Bunn and Martin Malin for helpful discussions and comments on the draft of this report. Brett Cox provided editorial assistance. Josh Anderson assisted with layout and production. 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.

Table of Contents

Executive Summary

Nuclear and radiological terrorism remain serious threats to Chinese and world security. Since the 2010 Nuclear Security Summit, Chinese leaders have paid increasing attention to the challenge of preventing nuclear and radiological terrorism. Chinese president Xi Jinping and his predecessor Hu Jintao actively participated in the last three summits and pledged at the summits to strengthen nuclear security. In particular, since 2010, in large part due to the nuclear security summits, China has made important progress on nuclear security, but there is still substantial room for improvement.

Major Progress on Nuclear Security

In recent years, China has made improvements in areas ranging from its legal framework for nuclear security to its approaches to physical protection and material accounting to bolstering nuclear security culture:

- Over the last two years, China has worked actively on legislation and a policy framework relevant to nuclear security. In 2015 China issued new laws on national security and terrorism. It has also developed policies to create an effective system for nuclear emergency response. China is also speeding up the process to approve the Atomic Energy Law, the Nuclear Safety Law (also covering nuclear security), and revised nuclear security regulations.

- In recent years, China has invested in important improvements in its physical protection, material control, and material accounting (MPC&A) technologies, and has updated monitoring and equipment at nuclear facilities. China's nuclear security and control measures include an approach based on a design basis threat, and require facilities to conduct in-depth vulnerability assessments.

- Chinese leaders have repeatedly emphasized the importance of promoting nuclear security culture. The China Atomic Energy Authority (CAEA) has greatly increased training activities and no-notice inspections as a means of building a strong security culture.

- China's improvement in nuclear security has benefited significantly from cooperation between the CAEA and the United States Department of Energy (DoE). In particular, the Center of Excellence (CoE) on Nuclear Security near Beijing is an important product of the nuclear security summits. 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, throughout the Asia-Pacific region, and even globally.

- At the 2014 Nuclear Security Summit, President Xi announced that China will invite the IAEA to conduct an International Physical Protection Advisory Service (IPPAS) mission in China. Presently, China and the IAEA are discussing detailsof a peer review at a nuclear power plant. The IPPAS mission is now planned for late 2016.

Major Challenges

While China has substantially advanced its nuclear security during last several years, significant challenges still remain:

- China has changed a number of important parts of its nuclear security requirements and instructions to operators in recent years, including the 2008 guidance requiring operators to defend against a regulator-reviewed design basis threat (DBT). But the underlying regulations that provide the legal basis for their requirements have not been updated since the 9/11 attacks.

- There are still significant challenges to China's efforts to establish an effective nationwide MPC&A system. Although the 2008 guidelines require a DBT, the operators typically design site-specific DBTs on a case-by-case basis, without any national DBT to serve as a guide. Moreover, no Chinese regulations require realistic force-on-force exercises at nuclear facilities. China's MC&A system for bulk processing facilities (e.g. reprocessing plants) may not be sufficient to detect material being stolen in small amounts at a time. The problems with material accounting at China's pilot reprocessing plant demonstrate the challenge.

- Although strengthening cyber security at nuclear facilities has recently been receiving attention, China has not yet written specific regulations and guidelines with provisions

in this area. Currently, the licensing process for nuclear facilities does not cover cyber security for systems relevant to safety and security.

- China still faces substantial challenges in its efforts to build a robust nuclear security culture. Many Chinese experts continue to doubt that there is a credible threat to Chinese nuclear materials and facilities. Complacency is still widespread among a significant number of senior officials within its nuclear industry. Problems like secrecy and corruption remain challenges to China's nuclear establishment.

- While China-U.S. cooperation has produced important achievements, the defense labs and facilities in China that control most of China's weapons-usable fissile materials—and all of its nuclear weapons—have not been formally participating since the 1990s, when the United States raised allegations of Chinese spying. Individuals from some of these institutions reportedly participated in joint workshops and discussions, and the China Atomic Energy Authority, which does participate, regulates both the civilian and military sectors, but deeper cooperation between the U.S. and Chinese weapons laboratories and facilities would significantly enhance nuclear security progress.

- Much information regarding China's nuclear security policies and practices still remains unpublicized. Chinese reports required by UN Security Council Resolution 1540 are, like those of many countries, far too general to provide meaningful international assurance that nuclear security is being properly handled.

Recommendations: Next Steps for Improvement

At the 2014 nuclear security summit, President Xi emphasized, that "the more we do to enhance nuclear security, the less chance we will leave to terrorists." Converting the top Chinese leader's stated commitment into practical, sustainable reality will require China to undertake a number of steps to further improve China's nuclear security.

Improving Security and Control

- China needs to update and clarify its DBT requirements for all military and civilian nuclear facilities by establishing a national-level DBT. Operators must 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. China should have at least a minimum DBT standard that includes protection against a modest group of well-armed and well-trained outsiders (capable of operating as more than one team), a well-placed insider, and outsiders and an insider working together, using a broad range of possible tactics.

- China should update its 1987 regulations and 1990 rules by issuing rules and regulations that are clearer, more stringent, based on at least the minimum DBT standard noted above, and incorporate new IAEA guidelines. Although Beijing has pledged to adopt almost all of the existing international legal frameworks to prevent nuclear terrorism, China needs to effectively incorporate these frameworks into its domestic regulations and rules to strengthen its nuclear security on the ground—and establish an effective system of enforcement.

- China should use realistic "force-on-force" exercises at operating facilities to test its nuclear security systems' ability to detect and defeat intelligent adversaries using asymmetric attacks.

- The government should make sure nuclear operators have an accounting system that will detect the removal of small quantities and be able to localize the removal in time and space, and be capable of identifying which insiders had access. Every operator should also have an effective program for personnel reliability screening.

Improving Cyber Security Requirements at Nuclear Facilities

To address the growing threat of cyberattacks and the possible consequences of a cyber-assisted theft of nuclear materials or sabotage of nuclear facilities, China should take the following steps:

- China should incorporate cyber security protections in its new nuclear regulations and guidelines. The nuclear licensing process should explicitly require cyber security protections.

- Cyber security should be fully integrated into the physical protection and accounting systems. Cyber security should be an integral component of the DBT.

- The nuclear regulators should conduct cyber threat assessments for nuclear facilities in cooperation with national intelligence organizations. To ensure effective cyber protections, the regulators should also establish programs to test the system's performance, and enforce cyber security plans via regular inspections of cyber security programs.

- While promoting nuclear security culture, it should also address cyber security culture, cyber security training, and education.

Promoting Nuclear Security Culture

The government and operators should take the following serious steps to build nuclear security culture at relevant facilities and organizations in China (though this is not an exclusive list):

- China needs to take further steps to combat complacency, including: regularly reviewing nuclear security practice and systems; conducting self-assessments and drawing lessons from real incidents and security exercises; and conducting realistic performance tests.

- Each staff member should not only scrupulously abide by the existing nuclear security regime, but also maintain a questioning attitude and insist upon personal accountability.

- China should conduct regular security exercises 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, the reality that all security systems have vulnerabilities, and the importance and seriousness of nuclear security.

- Operators in China should take steps to strengthen teamwork and cooperation among all personnel involved in security. All staff should understand how their particular roles and equipment contribute to maintaining security.

Increasing International Cooperation and Confidence

China should take further measures to build confidence in the international community that a robust nuclear security program is in place (without compromising sensitive information). Steps should include:

- China should release more information about its nuclear security policies and practices. For example, China could release details of its nuclear security regulations, threat assessments, approaches to assessing and testing nuclear security performance, annual reports on implementation of and compliance with those regulations, and other details necessary for UNSCR 1540 reports.

- China should allow experts organized by the IAEA or by bilateral agreement to conduct reviews of the country's nuclear security arrangements on a regular basis and for different types of nuclear facilities.

- China should encourage more of its nuclear security professionals and institutions to participate in international workshops and training exercises—such as those sponsored by the World Institute for Nuclear Security.

- China should join the new initiative on Strengthening Nuclear Security Implementation as other 35 countries pledged at the 2014 Nuclear Security Summit, including incorporating the principles and guidelines of the IAEA regarding nuclear security into its national laws; and allowing teams of international experts to periodically evaluate its security procedures.

- China should continue and expand cooperation in the civilian sector. In particular, China and the United States should use the newly established CoE as a forum for best-practice exchanges, technical cooperation, research and development projects, and regional and global personnel training.

- U.S.-China cooperation should be expanded to include participation by China's weapons labs and other defense-sector facilities and institutions. The most important areas for expanded U.S.-China cooperation should include starting lab-to-lab cooperation, expanding work to strengthen security culture, and exchanging visits at actual sites (starting with less sensitive ones).

Introduction

Nuclear and radiological terrorism remain serious threats to Chinese and world security.[1] World leaders will gather for the fourth and last Nuclear Security Summit, in Washington, D.C., on March 31 and April 1, 2016, to continue trying to strengthen measures to deal with the evolving threat. Since the 2010 Nuclear Security Summit, Chinese leaders have paid increasing attention to the challenge of preventing nuclear and radiological terrorism. Chinese president Xi Jinping and his predecessor Hu Jintao actively participated in the last three summits and pledged at the summits to strengthen nuclear security. President Xi will participate personally in the coming summit.

At the 2014 summit in The Hague, President Xi stated that China "must follow a sensible, coordinated and balanced approach to nuclear security and put it on the track of sound and sustainable development."[2] He emphasized four points, which together reflect Beijing's policy in this area:

1. "We should place equal emphasis on development and security, and develop nuclear energy on the premise of security." President Xi emphasized that without effective safety and security, the "bright future" of nuclear energy "will be overshadowed by dark clouds or even ruined by resulting disasters."

2. "We should place equal emphasis on rights and obligations, and push forward international nuclear security efforts on the basis of respecting the rights and interests of all countries." Here, President Xi emphasized that while "nothing can be accomplished without following norms and standards," countries faced different security challenges and have the "right to adopt nuclear security policies and measures best suited to their specific conditions."

3. "We should place equal emphasis on independent and collaborative efforts, and seek universal nuclear security through "win-win" cooperation." President Xi

1 See, for example, discussion in Matthew Bunn, Martin B. Malin Nickolas Roth, and William H. Tobey, *Preventing Nuclear Terrorism: Continuous Improvement or Dangerous Decline?* (Cambridge, MA: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, March 2016). This paper draws on an earlier 2014 study, Hui Zhang and Tuosheng Zhang, *Securing China's Nuclear Future* (Cambridge, MA: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, March 2014), http://belfercenter.ksg.harvard.edu/files/securingchinasnuclearfutureenglish.pdf (accessed March 20, 2016).

2 Xi Jinping, "Statement at the Nuclear Security Summit at The Hague," People's Republic of China, Ministry of Foreign Affairs, March 25, 2014, http://www.fmprc.gov.cn/mfa_eng/wjdt_665385/zyjh_665391/t1140583.shtml (accessed February 27, 2016).

emphasized on the one hand that nuclear security was mainly a national responsibility, but on the other hand could be strengthened by international cooperation. Using a Chinese saying that "the amount of water a bucket can hold is determined by its shortest plank," Xi warned that nuclear material stolen anywhere could be "a threat to the whole world," necessitating common efforts to "make sure that no one falls behind" on nuclear security.

4. "We should place equal emphasis on treating symptoms and addressing causes, and advance the nuclear security endeavor in all respects with the goal of removing the associated risks at the root." Here, President Xi argued for increased cooperation to "foster a peaceful and stable international environment," develop "modern, low-risk nuclear security technologies," maintain balanced supply and demand of nuclear materials, "strengthen nonproliferation efforts and export control," and "deepen international cooperation against nuclear terrorism."

Over the last decade China has made significant progress in strengthening nuclear security. In particular, since 2010, in large part due to the nuclear security summits, nuclear security issues have received greatly increased national attention and awareness. In 2014, President Xi emphasized that nuclear security should be an important element in China's national security strategy.[3] China has been actively working on several national laws and regulations related to nuclear security. Days before the 2016 Washington summit, China commissioned a Center of Excellence (CoE) on Nuclear Security in Beijing, a joint project with the United States, initiated at the first nuclear security summit in 2010.[4] Last year, China completed a project to convert an HEU-fueled research reactor, also a product of cooperation with the United States at the first nuclear security summit. In short, China's commitment to nuclear security is now well established. In spite of these advances, however, significant gaps remain in China's efforts to prevent nuclear and radiological terrorism, leaving substantial room for improvement.

As a nuclear-weapon state, a rising global power undertaking rapid nuclear power growth and facing growing terrorist threats, China's approach to strengthening the security of its nuclear weapons, materials, and facilities is important not only inside of China, but also outside, influencing other countries' approaches.

3 Liu Yongde, "Speeding up the preparation of 'Atomic Energy Law' is a glorious mission entrusted by history," China Nuclear Energy Association, November 30, 2015, http://www.caea.gov.cn/n16/n1223/797938.html (in Chinese) (accessed February 27, 2016).

4 The center opened officially on March 18, 2016. See, "U.S. Energy Secretary Moniz and Chinese Atomic Energy Authority Open New Nuclear Security Training Facility," Department of Energy, March 18, 2016, http://energy.gov/articles/us-energy-secretary-moniz-and-chinese-atomic-energy-authority-open-new-nuclear-security (accessed March 20, 2016).

This report, which updates a 2014 assessment, examines China's major progress in improving nuclear security, highlights the key challenges China is facing, and recommends a number of next steps.[5] The first section describes the increasing threat of nuclear terrorism in China and discusses the problem of widespread corruption. The second section focuses on an assessment of progress in strengthening nuclear security in areas including national laws and regulations, protection and control measures, nuclear cyber security, nuclear security culture, international cooperation, and international assurance. It also highlights major gaps in each noted area. Finally, the third section offers recommendations for improving China's nuclear security and control, strengthening nuclear cyber security, promoting nuclear security culture, and increasing international assurance through international cooperation.

5 See Zhang and Zhang, *Securing China's Nuclear Future.*

The Threat of Nuclear Terrorism in China

While the world has made important progress in recent decades in reducing nuclear terrorism risks, the danger still remains real and serous.[6] Al Qaeda is still active. The organization pursued nuclear weapons in the past, repeatedly attempted to acquire the materials and expertise needed to make them. It may try to do so again in the future. Although the Islamic State has not yet demonstrated a clear intent to acquire nuclear weapons, its apocalyptic ideology is worrisome, and its capabilities—with more money, more territory, and more world people responding to its call to join the jihad than al Qaeda ever had—could give it a greater chance of succeeding if it did to turn to nuclear weapons than previous terrorists have had.

The International Atomic Energy Agency (IAEA) has documented 16 cases of theft or loss of HEU or plutonium, though more may have occurred.[7] At the 2014 Nuclear Security Summit, the world's leaders argued that achieving effective nuclear security "remains one of the most important challenges in the years to come."[8]

Although China has made important strides in nuclear security over the last decade, China's leaders do not appear to have been driven, at least initially, by a perception that nuclear terrorism was a serious threat. Many Chinese nuclear experts believed the probability of terrorists or non-state actors acquiring nuclear weapons or fissile materials inside China to be extremely low, especially in comparison with the "dirty bomb" threat.[9] The majority of Chinese nuclear experts are less concerned about nuclear terrorism than those in the West. Instead, a major driver of the development of China's nuclear security measures was the need to fulfill international pledges.[10] Chinese experts argue that, as a responsible country, China's participation in international legal instruments relevant to nuclear security was motivated by a desire to improve its international image. Another

6 For an up-to-date assessment of the threat of nuclear terrorism, see Bunn, Malin, Roth, and Tobey, *Preventing Nuclear Terrorism: Continuous Improvement or Dangerous Decline?*

7 "IAEA Incident and Trafficking Database: Incidents of Nuclear and Other Radioactive Material out of Regulatory Control 2015 Fact Sheet" (Vienna: International Atomic Energy Agency, 2015), http://www-ns.iaea.org/downloads/security/itdb-fact-sheet.pdf (accessed February 12, 2016).

8 "The Hague Nuclear Security Summit Communiqué," U.S. Department of State, March 25, 2014, http://www.state.gov/documents/organization/237002.pdf (accessed February 27, 2016).

9 Liu Senling, "Status of Research on Nuclear Security Technology in CIAE," (paper presented at Harvard-Peking University Workshop on Nuclear Security, Beijing, China, October 13–14, 2011).

10 Interviews with Chinese nuclear experts, October 2012 and August 2013.

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. As some experts note, given the fact that the nuclear terrorism threat is a top priority in Washington, Beijing's cooperation with Washington benefits the Sino-U.S. relationship.[11]

Although a dirty bomb attack is more likely than terrorist use of an actual nuclear bomb, the consequences of the latter would be vastly greater. Moreover, as discussed below, the possibility of insider theft of nuclear materials cannot be ruled out, particularly as China is facing a pervasive corruption problem. Further, the nature of terrorist attacks within China has significantly changed since 2013. Attacks are no longer confined to the Xinjiang region but rather extend nationwide. They now target not only officials and policemen but also civilians, and terrorists have gone from using knives to car bombing and explosives. Thus, terrorist attacks by Chinese separatist groups, foreign organizations, or some combination may one day pose a real threat to China's nuclear facilities. Finally, even if China is not likely to be the target of a terrorist nuclear bomb, a nuclear or radiological attack in another country might still have effects on China. In particular, such an event could seriously undermine public acceptance and investor financing for nuclear energy, which has recently become a key element in China's clean energy strategy.

Influenced by nuclear security summits, the Chinese government is beginning to better understand the threat and pay much more attention to nuclear security.[12] At the 2014 Nuclear Security Summit, as noted earlier, President Xi stressed that weaknesses in nuclear security anywhere could pose a threat to all countries.[13]

Corruption Challenges

The possibility of insider theft of nuclear materials in China cannot be ruled out, especially as China increasingly grows into a market-oriented society contending with corruption. Indeed, the recent anti-corruption campaign in China, initiated in 2012, has shown the problem is widespread among both high-ranking officials and lower-level civil servants. As of 2015, Chinese authorities uncovered wrongdoing among some 100 high-ranking officials, including about a dozen high-ranking military officers, several

11 Interviews with Chinese nuclear experts, August 2013.

12 Communications with Chinese nuclear experts, February 2016.

13 Xi Jinping, "Statement at the Nuclear Security Summit at the Hague."

senior executives of state-owned companies, and four national leaders.[14] The national leaders include a former member of the Politburo Standing Committee, and two former vice chairman of the Central Military Commission. Over 100,000 people have been indicted for corruption, mostly politicians and officials.[15] Several prominent cases have plagued China's nuclear sector:

- Liu Tienan, a former vice-chairman of the National Development and Reform Commission (NDRC) and director of the National Energy Administration (NEA, under the NDRC), was jailed in 2013 for bribery and abuse of power.[16] NEA is the principal authority that presides over decisions on construction of nuclear power plants, and is responsible for drafting regulations on nuclear power plant safety.

- Hao Weiping, a former director of the nuclear power bureau established in 2012 under NEA, was accused in 2014 of bribery.[17]

- Kang Rixing, general manager from 2004-2009 of the China National Nuclear Corporation (CNNC), the most powerful of China's nuclear companies, was jailed in 2010 for bribery and abuse of power.[18]

- Shen Rugang, former vice general manager of the China General Nuclear Power Group (CGN), another major nuclear power firm, was accused in 2008 of corruption.[19]

- Du Weihua, former director of CNNC Plant 814 (a former military enrichment plant in Sichuan), is the subject of corruption complaints by the plant employees.[20]

---

14 Li Wenjing, "What's a Warning of the Ninety Ninth Sacked High-level Official?," *China.com*, March 21, 2015, http://media.china.com.cn/cmjujiao/2015-03-21/396575.html (in Chinese) (accessed February 27, 2016).

15 "Robber Barons, Beware," *The Economist,* October 24, 2015, http://www.economist.com/news/china/21676814-crackdown-corruption-has-spread-anxiety-among-chinas-business-elite-robber-barons-beware (accessed February 27, 2016).

16 "Liu Tienan, Former Deputy Director of NDRC, Sentenced to Life Imprisonment," *Chinanews.com,* December 10, 2014, http://www.chinanews.com/fz/2014/12-10/6862378.shtml (in Chinese) (accessed February 27, 2016).

17 Yanyao Bin, "Former Nuclear Director Bribery Trial, Said the Shanxi Coal Bosses are Sacks Give Money," Get-top-news.com, November 27, 2015, http://www.get-top-news.com/news-11052415.html (in Chinese) (accessed February27, 2016).

18 Lin Chunting, "How Large Is the Iceberg Underneath the Water of Nuclear Power Corruption?, *China Business News*, April 24, 2014, http://www.sinoergy.com/bianji1/2239/ (in Chinese) (accessed February 27, 2016).

19 Chunting, "How Large the Iceberg?"

20 "Reporting Du Weihua Corruption Materials," http://blog.sina.com.cn/s/blog_90cc18d30102vnjt.html (in Chinese) (accessed February 27, 2016).

None of these instances of corruption related to attempts to steal or sell weapons-usable nuclear material. But an atmosphere in which senior nuclear officials are willing to break the law for monetary gain raises obvious concerns. These incidents suggest that the Chinese nuclear sector could face a serious challenge from officials or employees working inside the nuclear establishment. 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.[21] Insiders are perhaps the most difficult type of adversary to deal with, because insiders are those authorized to access areas containing nuclear materials, are trusted by other employees, and may know the weaknesses of the security system and how they might be exploited. Insiders are potentially capable of utilizing tactics including but not limited to deception, breach or avoidance of physical barriers, and conspiracy with other insiders or outsiders.[22]

Xinjiang Terrorists

Terrorist attacks from outside groups may someday pose a real threat to China's nuclear facilities. China faces a growing threat from extremists in the predominantly Muslim Uighur community who want to form a separate state called East Turkestan in the Chinese autonomous region of Xinjiang. The East Turkestan Islamic Movement (ETIM) claimed responsibility for more than 200 acts of terrorism between 1990 and 2001.[23]

Since 2013, members of the East Turkestan Islamic Movement have carried out more than forty attacks, resulting in several hundred deaths. Typical events include:

---

21 The linkage between corruption and nuclear security is suggested, for example, in Nuclear Threat Initiative, *NTI Nuclear Materials Security Index: Building a Framework for Assurance, Accountability, and Action,* Second Edition (Washington, D.C.,: Nuclear Threat Initiative, January 2016), http://ntiindex.org/wp-content/ uploads/2014/01/2014-NTI-Index-Report.pdf (accessed March 20, 2016).

22 Matthew Bunn and Scott Sagan,"A Worst Practices Guide to Insider Threats: Lessons from Past Mistakes" (Cambridge, MA: American Academy of Arts and Sciences, March 2014), https://www.amacad.org/multimedia/pdfs/publications/researchpapersmonographs/insiderThreats.pdf (accessed March 20, 2016); Lonnie Moore, "Dealing with the Insider Threat," (paper presented 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, Shenzhen, China, January 15–18, 2013); International Atomic Energy Agency, *Preventive and Protective Measures Against Insider Threats*, IAEA Nuclear Security Series No. 8 (Vienna: IAEA, 2008), http://www-pub.iaea.org/MTCD/publications/ PDF/pub1359_web.pdf (accessed February 27, 2016); and World Institute for Nuclear Security, *Managing Internal Threats: A WINS International Best Practice Guide for Your Organization*, Rev. 1.0 (Vienna: WINS, 2010).

23 "The First Determined Lists of 'East Turkestan' Terror Organizations and Terrorists," Ministry of Public Security of the People's Republic of China, December 15, 2003, http://www.mps.gov.cn/n16/n983040/n1988498/1988553.html (in Chinese) (accessed February 27, 2016).

- October 28, 2013: A car crashed into a group of tourists in Beijing's Tiananmen Square, killing five people (including three inside the car) and injuring 38.[24] The ETIM claimed responsibility for this suicide attack.[25] Beijing described it as the first terrorist attack in Beijing's recent history.[26] More importantly, the attack targeted China's symbols of power.[27]

- March 1, 2014: A group of eight knife-wielding men and women pulled out long-bladed knives and stabbed and slashed passengers at Kunming railway station (the capital city of Yunnan province), resulting in the deaths of 29 civilians and 4 attackers with over 140 others injured.[28]

- April 30, 2014: ETIM conducted a suicide bomb attack on the Urumqi railway station (in the capital of Xinjiang province), killing three and injuring 79.

- May 22, 2014: A car bomb attack on an open-air market in Urumqi killed 31 and injured 94. This attack was commanded from abroad by ETIM.[29]

Since 2013, the nature of domestic terrorist attacks has changed. Incidents are more geographically dispersed, the targets are more diverse, and the methods of attack have varied. Religiously inspired terrorist attacks have become significantly more frequent, more violent, and more sophisticated.[30] From the 1990s to the late 2000s, most of the terrorist acts were limited to Xinjiang locals. However, recent attacks have been spreading over several large cities beyond Xinjiang including Beijing, Kunming, and Guangzhou (the capital of Guangdong). The types of targets are also expanding. In the past, most of the targets focused on government buildings and police stations. But, recently the attacks have

24 "Tiananmen crash: China police 'seek Xinjiang suspects'", *BBC News,* October 29, 2013, http://www.bbc.com/news/world-asia-china-24722898 (accessed February 27, 2016).

25 Jonathan Kaiman, "Islamist group claims responsibility for attack on China's Tiananmen Square," *The Guardian,* November 25, 2013, http://www.theguardian.com/world/2013/nov/25/islamist-china-tiananmen-beijing-attack (accessed February 27, 2016).

26 Christopher Bodeen, "China: East Turkestan movement behind deadly crash," *Associated Press*, November 1, 2013. http://bigstory.ap.org/article/china-east-turkestan-movement-behind-deadly-crash (accessed February 27, 2016).

27 Marc Julienne, Moritz Rudolf, Johannes Buckow, "The Terrorist Threat in China; A closer look at the nature of the terrorist threat facing China," *The Diplomat*, May 26, 2015, http://thediplomat.com/2015/05/the-terrorist-threat-in-china/ (accessed February 27, 2016).

28 "Kunming terrorist attack suspects captured," *Xinhaunet.com*, March 3, 2014. http://news.xinhuanet.com/english/china/2014-03/03/c_133157281.htm (accessed February 27, 2016).

29 "How serious are Chinese terrorist attacks?" *Sina.cn*, August 3, 2014. http://news.sina.cn/zl/2014-08-03/zl-iavxeafr5459314.d.html (in Chinese) (accessed February 27, 2016).

30 "The overall situation of anti-terrorism is more severe," *China.com*, June 19, 2014. http://opinion.china.com.cn/opinion_49_101749.html (in Chinese) (accessed February 27, 2016).

extended to civilians, for example, in train stations and super markets, and have resulted in a dramatic increase in the number of civilian casualties. The type of attacks has changed significantly. In the past, attackers relied mainly on simpler tools including knives and axes. But recently, attackers have engaged in suicide bombings, car bombings, and have used grenades and other explosives. Nevertheless, so far, China has not seen complex terrorist attacks such as the terrorist attacks on heavily guarded targets.

Terrorists operating in Xinjiang are also known to have close relations with international groups. Beijing has confirmed that the ETIM has long received training, financial assistance, and support from al Qaeda.[31] Moreover, hundreds of Xinjiang's Uighur Muslims are reportedly fighting alongside the Islamic State in the Middle East.[32] Some of them, after receiving terrorist training and gaining actual combat experience, return for attacks in China.[33] Also, terrorist attacks inside China could be inspired or supported by the Islamic State due to its connections with local groups. Returning militants have recently been arrested in Xinjiang.[34]

In the years to come, it is plausible that terrorist groups might be able to put together an attack on civilian nuclear facilities, in particular a nuclear power plant—especially as the number of such plants rapidly increases.[35] The Fukushima accident may also increase terrorists' interest in targeting China's powerreactors.

In addition, China's neighbors in Central Asia and Pakistan have served as safe havens for ETIM members. These countries also are home to a high level of terrorist activity and have been at the center of nuclear smuggling and proliferation activities. It is possible that East Turkestan extremists could acquire fissile material or nuclear weapons from their bases in these areas, which they could also use to plan and launch attacks.[36]

---

31 PRC Ministry of Public Security, "The First Determined Lists of 'East Turkestan' Terror Organizations and Terrorists."

32 Michael Martina, "About 300 Chinese Said Fighting Alongside Islamic State in Middle East," *Reuters*, December 15, 2014, http://www.reuters.com/article/us-mideast-crisis-china-idUSKBN0JT0UX20141215 (accessed March 22, 2016).

33 Jack Moore, "Xinjiang's Uighur Muslims Receiving 'Terrorist Training' From Isis Fighters for Attacks in China," *International Business Times*, September 22, 2014. http://www.ibtimes.co.uk/xinjiangs-uighur-muslims-receiving-terrorist-training-isis-fighters-attacks-china-1466594 (accessed February 27, 2016).

34 Andrea Chen, "Muslim militants who joined Islamic State in Middle East 'arrested in Xinjiang'," *South China Morning Post*, March 11, 2015. http://www.scmp.com/news/china/article/1734203/islamic-state-members-arrested-xinjiang-says-chinese-government-official (accessed February 27, 2016).

35 As of February 2016, China had 30 power reactors (27 GWe) in operation with 24 units under construction (27 GWe). China leads the world in terms of the pace of nuclear development and new reactor construction. China officially plans its total nuclear capacity to be 58 GWe by 2020 plus 30 GWe under construction, and a new target for a total capacity about 120–150 GWe by 2030. Many more reactors are under consideration for construction in the coming decades.

36 China Foundation for International & Strategy Studies (CFISS), *Combating Nuclear Terrorism—Non-state Actors' Nuclear Proliferation and Nuclear Security* (Beijing: Social Science Academic Press, 2012). pp. 134 (in Chinese).

In short, both the domestic threats to China's nuclear materials and facilities and the nuclear dangers that foreign terrorists might pose to China are rapidly evolving. Chinese nuclear security planners must design security systems able to continue to provide effective protection as these threats continue to evolve in the future.

China's Nuclear Security: Progress and Challenges

China has made significant progress on improving its nuclear security. Major factors that motivated China's efforts to further improve its nuclear security system include Chinese leaders' increased attention on the topic due to the summit process, the rapid growth in nuclear power, increasing domestic terrorist activities, cooperation with the United States, concern with China's global image as a rising power, commitments to undertake new international legal obligations, and recommendations from the IAEA.[37]

Progress on China's Nuclear Laws and Regulations

Major New Developments

Over the last two years China has made significant progress on updating its nuclear security regulations (see Table 1).[38] At each of the last three summits, Chinese leaders addressed China's continued improvement of its legal framework. In part as a result of the momentum created by the summits, on April 15, 2014, President Xi Jinping emphasized, for the first time, the integration of nuclear safety and security with the national security system. He highlighted this change at the first meeting of the Central National Security Commission, established in November of 2013 (Xi is the commission chairman).[39] Recently, China has not only issued a number of new laws and policies relevant to nuclear security, but also has sped up work on the promulgation of a new Nuclear Safety Law (covering nuclear security) and a new Nuclear Security Regulation. The major progress made over the last two years includes:

- **Nuclear Emergency Preparedness Plan.** In January 2016, China issued a White Paper which aims to create an effective system for nuclear emergency response.[40] The White Paper emphasizes that China will establish a national nuclear emergency rescue team of over 300 people, responsible for undertaking unexpected rescue

37 Communications with Chinese nuclear safety and security experts, November 2012 , January 2013, and February 2016.

38 In China, legal documents are classified into four tiers: statutory law requiring approval by the National People's Congress; State Council regulations; departmental rules; and regulator's guidance or publications.

39 Liu Yongde, "Speeding up the preparation of "Atomic Energy Law."

40 China State Council, White Paper on Nuclear Emergency Preparedness, January 27, 2016. http://www.scio.gov.cn/zxbd/wz/Document/1466424/1466424.htm (in Chinese) (accessed February 27, 2016).

missions and emergency treatment tasks in serious nuclear accident scenarios. This is China's first-ever White Paper in the nuclear safety and security area. Influenced by the nuclear security summits and the Fukushima nuclear accident, China has paid much more attention to nuclear emergency response. In August 2012, China issued a revision to its Nuclear Emergency Response and Preparedness document of 2006. In June 2015, China conducted a nuclear emergency exercise code-named "Shield 2015," which comprehensively reviewed China's nuclear accident response preparedness and capability.[41]

- **New National Security Law.** On July 1, 2015, China issued a new National Security Law,[42] the first meaningful law of its type. The law calls for "ensuring citizens' safety from the threat of nuclear and nuclear attacks and accident hazards" by "strengthening management, oversight and protection of nuclear materials, nuclear activities, and disposal of nuclear waste," and by "increasing the capacity to respond to nuclear incidents." Also, the new law strengthens cyber security for critical national infrastructure (which includes nuclear facilities though, they are not mentioned specifically).

- **New Counter-Terrorism Law.** On December 27, 2015, China issued a new National Counter Terrorism Law,[43] which emphasizes that the "state opposes all forms of terrorism and bans any terrorist organizations." Though not aimed at nuclear terrorism specifically, the new law provides the legal basis for strengthening implementation and enforcement of measures for preventing nuclear terrorism in China.

- **Draft Atomic Energy Law.** China is speeding up the process of approving its first Atomic Energy Law, which will provide an overall legal framework to govern the use of nuclear energy and related safety and security issues. This new law was submitted to the State Council at the end of 2014 and officially accepted for passage. In 2015, the law was included in the State Council legislative work plan.[44] Currently, the Atomic Energy Law is going through legislative review procedures, and is expected to be promulgated in 2016.

- **Draft Nuclear Safety Law.** Over the last two years, China's National Nuclear Safety Administration (NNSA) led work on the country's first Nuclear Safety Law (which

41 "'Shield 2015' conducts successfully a nuclear emergency exercise," June 26, 2015, http://scitech.people.com.cn/n/2015/0626/c1007-27213439.html (in Chinese) (accessed February 27, 2016).

42 "China National Security Law," *Xinhua Net*, July 1, http://news.xinhuanet.com/politics/2015-07/01/c_1115787801.htm (in Chinese) (accessed February 27, 2016).

43 "National Counter Terrorism Law," *Xinhua Net*, December 27, 2015, http://news.xinhuanet.com/politics/2015-12/27/c_128571798.htm (in Chinese) (accessed February 27, 2016).

44 Communications with NNSA nuclear experts, February 2016.

includes nuclear security). The law was submitted to the National People's Congress in 2015. It is expected to be approved in 2016-2017.[45]

- **Revised Nuclear Security Regulations.** The China Atomic Energy Authority (CAEA) has led work over the last two years on revisions to China's nuclear security regulations. The revised draft was submitted to the State Council in 2015, and is expected to be issued just after the approval of the Nuclear Safety Law (which will serve as the legal foundation for the regulations). The new regulations are expected to have more specific nuclear security requirements.

- **Revised Material Control and Accounting Guidelines.** NNSA is considering an update of its guidelines on MC&A, which were issued in 2008, and is considering the development of new guidelines including for cyber security at civilian nuclear facilities. Also, CAEA recently issued a number of documents regarding the management of nuclear materials.

China is increasing the capacity of its two major regulators: the China Atomic Energy Authority and the National Nuclear Safety Administration.[46] 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.[47] The SNSTC is also responsible for establishing and managing the new Center of Excellence on Nuclear Security. The establishment of SNSTC and the CoE significantly enhance CAEA's technical capacity on nuclear security and accounting. In the past, CAEA relied mainly on technical support from the China Institute of Atomic Energy (CIAE), one of the entities CAEA regulates.

Meanwhile, NNSA will increase its technical support capacity. The NNSA receives technical support from the Nuclear Safety and Radiation Center (NSRC). The government has made a decision to expand the NSRC to a much larger National Base for Research and Development of Nuclear and Radiological Safety and Security Monitoring Technologies. Land preparation for the new national base is now underway. The new research base is expected to begin operating in 2018.[48] One focus of the national base will be R&D on

45 Communications with NNSA nuclear experts, February 2016.

46 See more details on China's nuclear regulators' responsibilities for nuclear security in Zhang and Zhang, *Securing China's Nuclear Future.*

47 Deng Ge, Director of the SNSTC, "Management of China's Nuclear Security," (paper presented at Workshop on the Safety and Security of China's Nuclear Facilities, Shenzhen, China, January 15–18, 2013).

48 Communications with NNSA nuclear experts, March 2016.

nuclear safety and security technology, applying those technologies to Chinese facilities partly through exchanges and technology demonstrations at the CoE.

Major Challenges

While China is making progress on improving its legal framework, there have not been many updates of regulations and rules on the security of nuclear materials and facilities—with the exception of physical protection guidelines issued in 2008. All related regulations and rules were issued before the 9/11 attacks, and do not mention the threat of nuclear terrorism. The 2008 guidelines on physical protection still leave some major gaps including a lack of a national design basis threat (DBT) requirement.

Moreover, while Beijing has committed to almost all of the existing international legal frameworks to prevent nuclear terrorism (box below), China still needs to effectively

China's International Nuclear Security Commitments

China has joined all international legal instruments relevant to nuclear security. In practice, the obligation to fulfill those international pledges has been a 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 CPPNM.
- 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 (1999), Resolution 1373 (2001), Resolution 1540 (2004), and Resolution 1887 (2009).

Table 1: Legal Framework for China's Nuclear Safety and Security

Tiers of Requirements	Current Status	Notes

Statutory Law	• Not completed. Atomic Energy Law under legislative review, to be promulgated in 2016.
	• Nuclear Safety Law, submitted in 2015, to be approved in 2016–2017
	• Other laws with indirect relevance:
	  • Law on the Prevention and Control of Radioactive Pollution (June 28, 2003)
	  • Emergency Response Law (August 30, 2007)
	  • China National Security Law (July 1,2015)
	  • National Counter Terrorism Law (December 27,2015)
		Requires approval by National People's Congress.
		
		Approval process more difficult than for administrative regulations.

Regulations	• Nuclear Security Regulations, submitted in 2015, possible approval in 2017 • 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 Control (1990) • Rules on Power Plant Radioactive Waste Management Safety (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, 2008) • Physical protection for nuclear material transportation (HAD 501-05, 2008) • Material accounting for reprocessing plant of spent fuels from nuclear power reactors (HAF-J0018, 1990) • Intrusion alarm system of the nuclear facilities perimeter (HAD 501-03, 2005) • Access Control of Nuclear Facilities (HAD 501-04, 2004) • The standard format and content of nuclear facilities safety analysis report on the physical protection and the balances of nuclear materials (HAD 501-06, 2008)	Updated more regularly than regulations and rules. While guidelines are not legally binding, they are considered compulsory.

integrate the international frameworks into its domestic regulations and rules to strengthen its nuclear security on the ground. This implementation process has gone slowly.

Improving Security and Control[49]

Major Improvements

Over the last six years, China has invested a large sum of money to improve its physical protection, material control, and material accounting technologies and to update monitoring and equipment at nuclear facilities (in particular, at fuel cycle facilities).[50] China continues to adopt a mix of well-trained personnel with up-to-date techniques and technology. China is mastering modern concepts and approaches to nuclear security and accounting.

The major progress of China's nuclear security and control measures include:

- **A security approach based on a design basis threat.** Before the September 11 attacks, China's nuclear facilities were designed mainly to withstand natural disasters and accidents. In 2008, the NNSA issued its Nuclear Facility Physical Protection Guidelines which call on all civilian nuclear facilities to apply a security approach based on a DBT including outsiders, insiders, and both working together.[51] Over the last several years, this approach has been further improved through workshops and exchanges held in cooperation with the United States and others.[52] Like the AP1000 design, the new Chinese-designed third generation power reactors, including the Hualong One design, are able to withstand impact by commercial planes.[53]

- **Application of modern concepts of physical protection.** China is now using systems-engineering approaches to analyze vulnerabilities and design defenses to address

49 This section relies mainly on an earlier 2014 study, Hui Zhang and Tuosheng Zhang, *Securing China's Nuclear Future,* and with updates over the last two years.

50 China spent hundreds of millions of dollars from its dedicated nuclear security fund to update its security system between 2010 and 2016 (communications with NNSA nuclear experts, March 2016).

51 "Nuclear Facility Physical Protection Guidelines," Chinese National Nuclear Safety Administration (NNSA) (in Chinese), 2008.

52 Communications with China nuclear security experts, March 2016.

53 "The third generation nuclear power rector, Hualong One, can withstand the impact of large aircraft," *Xinhuanet.com*, March 8, 2015, http://news.xinhuanet.com/energy/2015-03/08/c_127557408.htm (in Chinese) (accessed February 27, 2016).

them. Chinese regulators require the operators of nuclear facilities to establish physical protection systems that would assure coordination among the three elements of detection, delay, and response.[54]

- **Advanced equipment and technology for physical protection**. With increasing financial investment over last several years, China's nuclear facilities, including its fuel cycle facilities, have applied advanced detection technologies and techniques, including enhanced perimeter detection, access control, and video feed assessment.[55]China has updated physical protection technology across its civilian facilities. For example, China has now installed detection systems for radioactive material and prohibited items 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. [56]

- **Requiring facilities to conduct in-depth vulnerability assessments.** Since 2008, Chinese nuclear operators have been required to do 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.[57] Also, 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. Since 2014, when President Xi highlighted nuclear safety and security as an important element in China's national security strategy, CAEA has taken actions to check the effectiveness of security systems at several nuclear facilities. In July 2014, CAEA conducted a no-notice inspection at the Daya Bay nuclear plant (one of eight selected nuclear plants), to check the plant's protection and control system.[58] The results of the inspection were not released publicly

54 Chinese NNSA, "Nuclear Facility Physical Protection Guidelines."

55 Communications with NNSA nuclear safety and security experts, February 2016.

56 Interview with expert on nuclear security aspects of the Daya Bay nuclear power plant, January 2013. Yun Zhou, "The Security Implications of China's Nuclear Energy Expansion," *Nonproliferation Review,* Vol. 17, No. 2, (July 2010), pp. 347–363.

57 Liu Daming, "China National Nuclear Material Control System," (presentation at Harvard-Peking University Workshop on Nuclear Security, Beijing, China, October 13–14, 2011).

58 "CAEA inspected randomly nuclear security situation at Daya Bay nuclear power base," *CGN news*, July 18, 2014, http://www.cgnpc.com.cn/n471046/n471126/n471156/c684516/content.html (in Chinese) (accessed February 27, 2016).

- **Application of graded protection measures.** Physical protection measures are now being applied according to the relative attractiveness of the materials being protected, the nature of nuclear materials and facilities, and the potential consequences of theft or sabotage**.** Table 2 and Table 3 shows the three categories of nuclear materials and nuclear facilities in China and the corresponding physical protection measures required. For instance, the operators of Category I nuclear materials and facilities are required to have hardened central alarm stations, armed response forces on duty 24 hours a day, and a "two man and double-lock" rule for vital areas.[59]

- **Updates to material control and accounting (MC&A) systems.** China established its nuclear materials control and accounting system based on the 1990 "Rules for Implementation of the Regulations on Nuclear Materials Control"[60] 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."[61] NNSA is now considering an update on the guidance.[62]

Remaining Gaps

While China has made significant improvements in its nuclear security and nuclear material accounting systems, major gaps still remain, including:

- **Still no national DBT requirement.** Although the 2008 guidelines require a DBT, they contain no national-level DBT that operators must protect against, and no clearly defined standards for how each nuclear facility should design a DBT 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.[63] As NNSA Director Li Ganjie noted, the existing DBT for nuclear power plants could have produced designs that are unable to resist attacks from large-scale and well-organized terrorist groups with powerful weapons.[64] The forthcoming Atomic Energy Law and Nuclear Safety Law are not expected to address this specific

59 Chinese NNSA, "Nuclear Facility Physical Protection Guidelines."

60 "Rules for Implementation of the Regulations on Nuclear Materials Control in the People's Republic of China," Chinese NNSA, Chinese Ministry of Energy, and the Commission for Science, Technology, and Industry for National Defense, September 25, 1990, http://www.caea.gov.cn/n16/n1130/77224.html (in Chinese) (accessed February 27, 2016)

61 "The Standard Format and Content of Nuclear Facilities Safety Analysis Report on MC&A," Chinese NNSA, 2008 (in Chinese).

62 Communications with China NNSA nuclear experts, March 2016.

63 Author interviews with Chinese nuclear security experts, Beijing, October 2011 and November 2012.

64 Li Ganjie, "Nuclear Security: The New Challenges for Security of Nuclear Power Plants" (presentation at IAEA meeting, 2008), http://www-pub.iaea.org/mtcd/meetings/PDFplus/2008/cn168/Presentations/Session3_Li.pdf (in Chinese) (accessed February 27, 2016).

Table 2: 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).

Table 3: 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.

issue. It is not clear if the on-going Nuclear Security Regulations will address it in some way. The physical protection guidelines deal with those specifics. But, at the moment, NNSA has no plan to update its 2008 physical protection guidelines.[65]

- **No force-on-force exercises**. While operators currently are required to do in-depth vulnerability assessments and performance tests of individual components of their security systems, these do not include realistic force-on-force exercises, as INFCIRC/225/Revision 5—the most recent version of this document from the International Atomic Energy Agency (IAEA)—recommends.[66] No Chinese regulations require such tests,[67] which are vital for identifying the strengths and weaknesses of security procedures. The newly established NNSTC will conduct such exercises, at specific training sites.[68] These exercises, however, will mainly serve to train guard forces and will not probe how well security performs at operating facilities. In the U.S. experience, force-on-force exercises often reveal problems that were not obvious from these other means. One key factor within the U.S. Department of Energy and Nuclear Regulatory Commission in improving the security systems of nuclear facilities has been requiring the correction of vulnerabilities revealed during the realistic tests.[69]

- **Limited effectiveness of MC&A system for bulk processing facilities (e.g. for reprocessing).** The most significant challenge to China's efforts to establish an effective nationwide MC&A system is posed by its bulk processing facilities. The operations of China's pilot reprocessing plant demonstrate the challenge. In December 2010, China conducted a hot test of its pilot reprocessing facility located at Plant 404--the former Jiuquan plutonium production complex at Gansu province, which has a capacity of 50 metric tons of heavy metal per year (tHM/year).[70] Although reprocessing operations stopped after only 10 days, beginning in December 2010, many problems, including a very high percentage of material unaccounted for (MUF), were identified.[71] Moreover,

65 Communications with Chinese NNSA nuclear experts, March 2016.

66 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/pub-lications/PDF/Pub1481_web.pdf (accessed February 27, 2016).

67 Communications with Chinese nuclear experts on China's MPC&A, October 2011.

68 Author interviews with Chinese nuclear security experts, Beijing, January 2013 and July 2014.

69 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.

70 Matthew Bunn, Hui Zhang, and Li Kang, *The Cost of Reprocessing in China* (Cambridge, MA: Report for Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, January 2016), http://belfercenter.ksg.harvard.edu/files/The%20Cost%20of%20Reprocessing-Digital-PDF.pdf (accessed February 27, 2016).

71 Author interviews with Chinese nuclear security experts, Beijing, Spring 2013.

China's civilian pilot reprocessing plant was not designed for maximum security when construction began in 1995. It shares some facilities with a previous military reprocessing plant that was not designed with an up-to-date material protection, control, and accounting system. Further, unlike operators of nuclear power plants whose budgets benefit through market sales of electricity, this pilot reprocessing plant is 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. Thus, one major concern about the pilot reprocessing plant, should it begin separating plutonium on a larger scale in the future, is that it might be possible for insiders to remove plutonium without detection.

Since 2015 China has started preparations for a demonstration reprocessing plant with a capacity of 200 tHM/year at Jinta near Jiuquan city of Gansu province, which is expected to be in operation by 2020.[72] In recent years, the China National Nuclear Corporation has also been negotiating with France's AREVA on the construction of a commercial reprocessing plant (800 tHM/year). If this plant goes forward, it might be in operation around 2030.[73] It would be even more difficult to establish an effective MC&A system at these facilities than at the much smaller pilot facility.[74] For the annual physical inventory, measurement uncertainties at a reprocessing plant are typically in the range of one percent of plutonium throughout, amounting to 20 kilograms of plutonium per year at a facility with a throughput of 200 tHM/year. Hence, modern MC&A systems for large reprocessing plants incorporate a variety of techniques for near-real-time accounting and process monitoring. Protections against insider theft at modern facilities also include a range of camera monitoring of key areas, portal monitors at all exits to detect any removal of nuclear material, access controls, and more. China would need to develop and implement all of these systems to provide effective security for large reprocessing plants. Experience suggests that designing such systems in from the outset is essential, but it is not clear whether this

72 Yue Qi, "China establishes its first national nuclear technology industrial park and begins industrialization of spent fuel reprocessing in Gansu," *National Business Daily*, August 25, 2015, http://www.nbd.com.cn/articles/2015-08-25/940911.html (in Chinese) (accessed February 27, 2016); Hui Zhang, "China is said to be building a demonstration commercial reprocessing plant," *IPFM Blog*, September 25, 2015, http://fissilematerials.org/blog/2015/09/china_is_said_to_be_build.html (accessed February 27, 2016).

73 "Sino-French nuclear negotiations moves forward and evaluation of the seismic safety at coastal sites starts," *BJZTB.gov,* August 25, 2015, http://www.bjztb.gov.cn/news/201508/t9420808.htm (in Chinese) (accessed February 27, 2016.

74 Hui Zhang, "Chinese Reprocessing and Nuclear Security Issues," (presentation at the Institute of Nuclear Materials Management 55th Annual Meeting, Atlanta, GA, July 24, 2014), http://belfercenter.ksg.harvard.edu/files/ChinaReprocessing-INMM2014_hzhang.pdf (accessed February 27, 2016).

has yet been done for the 200 tHM/year plant.[75] 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 measures beyond accounting alone to prevent insider theft.

Building China's Nuclear Cyber Security

Recently, strengthening cyber security at nuclear facilities has become an important topic in the nuclear security area.[76] Nuclear operations and security systems are becoming increasingly reliant on digital controls. Meanwhile, the incidents of cyberattacks are rising in all sectors, and attacks on nuclear facilities in particular are also rising, with the Stuxnet attack being the most publicized.[77] To address concerns about cyberattacks on nuclear facilities, the 2016 NTI Index treats cyber security for the first time as an important factor in assessing a country's nuclear security status. The 2016 Index emphasizes that a cyber-attack "could facilitate the theft of nuclear materials or an act of sabotage."[78] In practice, recently, a number of countries, including the United States and Russia, have updated their regulations or rules regarding cyber security at nuclear facilities.[79]

China, however, has not yet written nuclear regulations and guidelines with provisions specific to cyber security at nuclear facilities. In general, like other industries, nuclear facilities are required to have cyber security plans. Unlike in the United States and Russia,

75 See, for example, Michael H. Ehinger and Shirley J. Johnson, "Lessons Learned in International Safeguards—Implementation of Safeguards at the Rokkasho Reprocessing Plant," ORNL/TM-2010/23, Oak Ridge National Laboratory, December 2009, pp. 12–13, https://fas.org/nuke/guide/japan/nuke/rokkasho.pdf (in Chinese) (accessed March 20, 2016). There has been no suggestion that China plans to put the 200 tHM plant under safeguards. Yet if there were going to be a fissile cutoff treaty, safeguards at operating reprocessing plants would be essential—and they won't work very well if they haven't been designed in from the outset.

76 Cyber security is defined as all processes and mechanisms by which any digital equipment, information or service is protected from unintended or unauthorized access, change or destruction. Cyber security as a component of nuclear security means the range of measures enacted to prevent, detect, or respond to the theft of Category I nuclear material or the sabotage of a nuclear facility that could result in catastrophic consequences through cyber-attacks, either alone or combined with physical attacks. See Institute for Safety and Security, Cyber Security at Nuclear Facilities: National Approaches (Brandenburg, Germany: Institute for Security and Safety at the University of Brandenburg and the Nuclear Threat Initiative, June 2015), http://www.nti.org/media/pdfs/Cyber_Security_in_Nuclear_FINAL.pdf?_=1445548675 (accessed February 27, 2016).

77 Caroline Baylon, Roger Brunt, and David Livingstone, *Cyber Security at Civil Nuclear Facilities Understanding the Risks,* Chatham House Report, September 2015, https://www.chathamhouse.org/sites/files/chathamhouse/field/field_document/20151005Cyber securityNuclearBaylonBruntLivingstoneUpdate.pdf (accessed March 11, 2016).

78 Nuclear Threat Initiative, *The 2016 NTI Nuclear Security Index: Theft and Sabotage,* January 2016. http://ntiindex.org/wp-content/uploads/2016/02/NTI_2016-Index_021116.pdf (accessed February 27, 2016).

79 For instance, the U.S. Nuclear Regulatory Commission issued in 2009 a new regulation regarding cyber security. See U.S. NRC Regulations: Title 10, Code of Federal Regulations (2009) NRC, Final Rule in 2009. Specifically, see §73.54 Protection of Digital Computer and Communication Systems and Networks (10 C.F.R. 73.54), http://www.nrc.gov/reading-rm/doc-collections/cfr/part073/part073-0054.html (accessed February 27, 2016).

however, currently the licensing process for nuclear facilities in China does not cover cyber security for systems relevant to safety and security, though regulators are beginning to pay attention to these issues. It is not clear how cyber security will be addressed in new regulations. China's NNSA is considering new guidance or regulations that may cover nuclear cyber security based on U.S. NRC regulations (e.g. U.S. NRC: 10 CFR 73.54).[80]

In aftermath of the Stuxnet attack, the Snowden revelations, and disputes between China and the United States on cyber security issues, China is accelerating the development of national legislation focusing on cyber security. In July 2015, China issued its draft National Cyber Security Law for review—in which it emphasizes the importance of cyber security in fields including the electric power system.[81] Also, the new National Security Law issued in 2015 addressed cyber security for critical infrastructure (which is assumed to include nuclear facilities, though they are not specifically mentioned).

China has also issued a number of policies, regulations, and guidance documents relevant to cyber security, but they all generally refer to the security of computer and information systems, and do not include specific provisions that relate to protecting against hacks that would compromise physical protection or material accounting, for example.

Promoting Nuclear Security Culture

To make sure that nuclear security systems are actually implemented effectively, the development of a strong security culture is imperative.[82] Chinese leaders have repeatedly emphasized the importance of promoting nuclear security culture at the last three nuclear security summits. From 2007 to 2013, CAEA and U.S Department of Energy (DOE) conducted several workshops on nuclear security culture.[83] In particular, the nuclear summits have significantly increased Chinese awareness of the importance of nuclear security. Since 2014, after President Xi addressed the issue of nuclear safety and security in the national security strategy, CAEA has paid more attention to building nuclear security culture

80 Communications with NNSA experts, February 2016.

81 "China National Cyber Security Law (draft)", *PRC National People's Conference,* July 2015, http://www.npc.gov.cn/npc/xinwen/lfgz/flca/2015-07/06/content_1940614.htm (in Chinese) (accessed February 27, 2016).

82 International Atomic Energy Agency, "Nuclear Security Culture," (Vienna: IAEA, 2008), http://www-pub.iaea.org/MTCD/publications/PDF/Pub1347_web.pdf (accessed February 27, 2016).

83 Ge Deng, *et al.*, "Ten Years of Successful Bilateral Cooperation on Nuclear Safeguards and Security between the China Atomic Energy Authority and the United States Department of Energy National Nuclear Security Administration," (presentation at the Institute of Nuclear Materials Management 56th Annual Meeting, Indian Wells, CA, July 12–16, 2015).

through various approaches including greatly increasing training activities and no-notice inspections.[84] In 2015, CAEA held an important meeting focusing on the promotion of nuclear security culture and strengthening nuclear security at nuclear facilities. Following this meeting, CAEA organized a series of on-site lectures by nuclear security experts for several nuclear power plants.[85]

But major challenges remain. 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.[86] Many Chinese experts continue to doubt that there is a credible threat to Chinese nuclear materials and facilities. They believe that the probability of terrorists gaining access to fissile material inside China and using it to make a crude nuclear bomb is very low. The experts argue that the technologies necessary to manufacture, deliver, and detonate such a weapon would be too difficult to obtain.[87] China also faces the challenge of complacency among a significant number of senior officials within its nuclear industry. They believe that China already has strict nuclear security systems that have worked well and have been "accident free" 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. Some managers doubt whether it is worth the money and time to establish and maintain a stronger security system. In some cases, the guards turned off detectors at portals for enrichment facilities to reduce their usage to avoid the need for frequent replacement.[88] In some cases, operators or relevant personnel who want to maintain a good record and avoid punishment downplay or conceal some faults.[89]

---

84 Communications with NNSA and CAEA nuclear security experts, February 2016.

85 For instance, the CAEA conducted a two-day training workshop for mangers and security staff (September 16–17, 2015) at Hongyanhe nuclear power plant in Liaoning province. The training courses included ten lectures, covering topics ranging from the realistic threat of nuclear terrorism, to building nuclear security culture, to international and domestic nuclear legislation and regulation systems, and implementation of physical protection. See "Experts of National Nuclear Security Technology Center Conducting a Focus Training at Hongyanhe Nuclear Power Plant," *CGN News,* http://www.lhnp.com.cn/n1776/n1779/c1126431/content.html (in Chinese) (accessed February 27, 2016). Also, CAEA conducted on August 18, 2015, a one-day training workshop at Fanchenggang nuclear power plant. See "Conducting Trainings for Building Nuclear Security Culture at Fangchenggang Nuclear Power Plant," *CGN news*, August 20,2015, http://www.fcgnp.com.cn/n1584/n1585/c1097132/content.html (in Chinese) (accessed February 27, 2016).

86 IAEA, "Nuclear Security Culture: Implementing Guide" (Vienna: IAEA, 2008), http://www-pub.iaea.org/MTCD/publications/PDF/Pub1347_web.pdf (accessed February 27, 2016). See also World Institute for Nuclear Security, *Nuclear Security Culture: A WINS Best Practice Guide for Your Organization,* Rev. 1.4 (Vienna: WINS, September 2009).

87 Author interviews with Chinese nuclear security experts, Beijing, October 2011, and January 2013.

88 Communications with Chinese nuclear regulatory official, October 2012.

89 Communications with Chinese nuclear safety and security experts, February 2016.

Traditionally, in large state owned enterprises in China, in particular in the nuclear industry which is developed from defense sector, it is not uncommon for decisions to be dominated by personal edict, rather than according to rules and regulations—everyone obeys the leader's orders and follows the leader's will (right or wrong).[90] This feature is a huge challenge to building a healthy security culture—which requires people not only to abide by the rules scrupulously, but also to have a skeptical and questioning attitude.

Moreover, a tradition of secrecy is still widespread in the nuclear industry, in particular for nuclear security topics which touch much more sensitive information than is the case with nuclear safety. In plants where operations have been switched from military to civilian control, the operators may still be used to keeping everything secret and will not willingly share problems with outsiders, including inspectors.[91] Such an attitude, with less transparency and less communication, is not beneficial to the establishment of a strong nuclear security culture.

Progress on International Confidence

Releasing and exchanging more information on nuclear security in China (without compromising sensitive information) is important to assure the international community that China's weapons and weapons-useable nuclear materials are adequately protected. Beijing's traditional secrecy about nuclear issues has negatively affected China's international image. In recent reports from the Nuclear Threat Initiative, China received relatively poor overall marks, largely because of its lack of nuclear transparency.[92] China's strategy of opacity will continue to prevent deeper international cooperation, in particular, involving the military sector.

However, China has recently taken positive steps to increase international confidence. At the 2014 Nuclear Security Summit, President Xi announced that China will invite the IAEA to conduct an International Physical Protection Advisory Service (IPPAS) mission in China.[93] Presently, China and the IAEA are discussing details of a peer review at the

90 *Instructions for Building Nuclear Safety Culture for Nuclear Relevant Organizations* (draft) (China: Chinese National Nuclear Safety Administration, November 7, 2013), http: //www.mep.gov.cn/gkml/hbb/haqj/201311/W020131112508661538468.pdf (in Chinese) (accessed March 11, 2016).

91 Communications with Chinese nuclear regulator, December 2012.

92 For example, China is rated 19th, just below Russia, in the most recent NTI Index "Theft Index." See Nuclear Threat Initiative, *The 2016 NTI Nuclear Security Index*.

93 Xi Jinping, "Statement at the Nuclear Security Summit at The Hague."

Qinshan nuclear power plant.[94] The IPPAS mission is now planned for late 2016 (third quarter).[95] The IPPAS mission can provide an in-depth evaluation and help to further strengthen a participating country's nuclear security system. In addition, since 2010, dozens of Chinese experts have become members of the World Institute for Nuclear Security (WINS), and some have participated in WINS workshops.

Unfortunately, much information regarding China's nuclear security policies and practices remains unpublicized, such as annual reports on nuclear security or implementation details. Chinese reports required by Resolution 1540 are, like those of many countries, far too general to provide meaningful international assurance.

Progress on International Cooperation

Over the last decade, China has greatly improved its nuclear security system, and has benefited significantly from cooperation between the CAEA and the US DOE.[96] In particular, the new Center of Excellence on Nuclear Security outside Beijing is an important product of the nuclear security summits—initiated at the first nuclear security summit and opening just days before the last. From the beginning, one major reason for China's willingness to cooperate with the US in nuclear security is China's interest in showing leadership and its role as a responsible stakeholder. Simultaneously, this cooperation has also improved China's relationship with the United States.

Since 2004, when China and the United States renewed cooperation under the 1997 "U.S.-China Peaceful Uses of Nuclear Technology (PUNT) Agreement," the United States and China have undertaken an extensive series of exchanges: visits to a range of US facilities to observe nuclear security and accounting approaches; in-depth training workshops and discussions on approaches to and protection against insider threats, the design of physical protection systems, steps to strengthen security culture, and more; a second joint demonstration of advanced material protection, control, and accounting of nuclear materials technology in 2005; work to strengthen security and accounting regulations and inspections in China; and cooperation to build the Center of Excellence

94 Communications with Chinese nuclear safety and security experts, February 2016.

95 Communications with an IAEA official, March 2016.

96 Zhang and Zhang, *Securing China's Nuclear Future*. p. 49–52.

on Nuclear Security. [97] In addition, China has cooperated extensively with the IAEA on issues ranging from safety and security training, to detection and emergency response, to regulations and standards.

Achievements Since the First Nuclear Security Summit

In particular, motivated mainly by the nuclear security summits, over the last six years U.S.-China cooperation has reached several milestones:

- Barack Obama and then-president Hu Jintao 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 National Nuclear Security Technology Center of the CAEA, established in November 2011, assumed responsibility for the construction, management, and operation of the CoE. The CoE broke ground on October 29, 2013, and was commissioned on March 18, 2016. The U.S. DOE has provided equipment for training on MPC&A systems; the U.S. Department of Defense is providing equipment for environmental testing, a mock emergency operations center, and a response force training facility. China is responsible for all other aspects of constructing, outfitting, and operating the CoE.[98] CAEA and DOE are jointly developing training curricula and lesson plans for safeguards and security training to regulatory staff and facility operators. The center will be the largest and most advanced in the Asia-Pacific region. The center will serve as a unique forum for exchanging technical information, sharing best practices, developing training courses, and promoting technical collaboration to enhance nuclear security in China, throughout the Asia-Pacific region, or even globally.

- 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.[99]

---

97 Deng, *et al.*, "Ten Years of Successful Bilateral Cooperation." See also Arian L. Pregenzer, *Technical Cooperation on Nuclear Security between the United States and China,* Sandia Report, SAND2011-9267, December 2011, http://prod.sandia.gov/techlib/access-control.cgi/2011/119267.pdf (accessed March 20, 2016).

98 Deng, *et al.*, "Ten Years of Successful CAEA and DoE Cooperation."

99 "National Progress Report on Nuclear Security of the People's Republic of China," Issued by China at the second Nuclear Security Summit, Seoul, Republic of Korea, March 27, 2012, http://www.state.gov/documents/organization/246077.pdf (accessed March 20, 2016).

- 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.[100]

- In September 2010, after the first nuclear summit, CAEA and DOE signed an agreement to convert a Miniature Neutron Source Reactor (MNSR) in China from using HEU to LEU fuel. This project was completed in 2015 and is a direct result of the summits. Based on lessons and experience acquired from this cooperative project, China is working on the conversion of its remaining MNSRs. Moreover, in 2014, China, Ghana, and the IAEA signed the agreement on supply of LEU to the research reactor in Ghana. Currently, China and the United States are working on the conversion of Ghana's MNSR. Once the project is completed, China plans to convert other exported research reactors in other countries.[101]

Major Challenges

While China-U.S. cooperation has produced important achievements, the defense labs and facilities that control most of China's weapons-usable fissile materials—and all of its nuclear weapons—have not been formally participating since their cooperation was cut off following U.S. charges of Chinese spying in the 1990s. Individuals from some of these institutions have reportedly participated in some of the joint workshops and discussions, and the China Atomic Energy Authority, which does participate, regulates both the civilian and military sectors. But deeper cooperation between the U.S. and Chinese weapons laboratories and facilities would significantly enhance nuclear security progress.

The two governments conducted a lab-to-lab program of cooperation from 1995 to 1998.[102] The program was designed to help create in China an interest in strengthening its security systems by demonstrating the advantages of a modern system for material protection, control and accounting. However, the collaborative program was terminated in

100 "National Progress Report on Nuclear Security of the People's Republic of China."

101 "Statement by Mr. Xu Dazhe, the Head of the Chinese Delegation to the 59th IAEA General Conference," Vienna, September 14, 2015, https://www.iaea.org/sites/default/files/china2015_ver1.pdf (accessed February 27, 2016).

102 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.

the aftermath of the 1999 Cox Committee Report, which alleged Chinese espionage at US nuclear weapons laboratories.[103] Since the "lab-to-lab" program ended, direct cooperation on nuclear security and control of China's military materials and facilities and nuclear weapons has not been discussed.

As a condition for restarting the lab-to-lab program, Beijing has asked Washington to agree that the program was legal and mutually beneficial.[104] Washington has proposed a number of statements focusing more on the future, which have not been satisfactory to Beijing. The two countries have been unable to find ways of overcoming this political obstacle. Thus, while China and the United States have cooperated extensively on nuclear security over the last decade, there still has not been official cooperation between the U.S. and Chinese defense sector labs and facilities.

103 See, *Final Report of the U.S. House of Representatives Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China* (Washington, D.C.,: Government Printing Office, May 1999), http://www.house.gov/coxreport (accessed February 27, 2016).

104 Communications with Chinese nuclear weapons experts, October 2014.

Recommendations: Next Steps for Improvement

Over the last decade China has substantially advanced its nuclear security, but there is still room for improvement.[105] At the 2014 nuclear security summit, President Xi Jinping emphasized, that "the more we do to enhance nuclear security, the less chance we will leave to terrorists." He further pledged that "China will stay firmly committed to strengthening its own nuclear security capability" and "to building the international nuclear security system."[106] Converting the top Chinese leader's political commitment 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, ensuring that all of 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. A number of steps would be helpful to further improve China's nuclear security.

Improving Security and Control

Establishing a national design basis threat. As noted earlier, China has no national-level DBT; each operator is responsible for designing a DBT tailored to its local conditions. China should update and clarify its DBT requirements for all military and civilian nuclear facilities by establishing a national-level DBT. Operators should be required to 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. China should have at least a minimum DBT standard that includes protection against one modest group of well-armed and well-trained outsiders (capable of operating as more than one team), a well-placed insider, and outsiders and an insider working together, using a broad range of possible tactics.[107]

105 Many of the recommendations in this section are drawn from an earlier report: Zhang and Zhang, *Securing China's Nuclear Future*." This section also draws on the recommendations in Bunn, Malin, Roth, and Tobey, *Preventing Nuclear Terrorism: Continuous Improvement or Dangerous Decline?*

106 Xi Jinping, "Statement at the Nuclear Security Summit at The Hague."

107 Matthew Bunn and Evgeniy 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).

Updating and enforcing regulations. China should update its 1987 regulations and 1990 rules by issuing rules and regulations that are clearer and more stringent. They should be based on at least the minimum DBT standard noted above, and incorporate the latest IAEA guidelines.[108] China should move expeditiously to update its 2008 guidelines on physical protection to integrate the new IAEA guidelines, including conducting force-on-force exercises, as suggested (discussed in more detail below).

To ensure the new regulations and rules are effectively implemented for facilities and transporters with nuclear weapons and weapon-usable fissile materials, China would need an effective system of enforcement and a constantly developing and improving nuclear security system. The government and operators should take several steps to reach these goals. For example, 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 security performance review of the companies being evaluated for contracts involving work with nuclear weapons, weapons-usable materials, or major nuclear facilities that might be sabotaged.

Finally, the government should ensure that regulatory responsibilities and functions are clearly defined and coordinated. Regulators should have adequate legal authority, technical and managerial competence, financing, and human resources to carry out their responsibilities effectively, efficiently, and independently.

Conducting realistic "force-on-force" exercises. As the IAEA's INFCIRC/225/Rev. 5 recommends, China should use realistic "force-on-force" exercises to test its nuclear security systems' ability to detect and defeat intelligent adversaries trying to find ways to defeat the systems. Such "force-on-force" exercises are a good test of security at nuclear sites, as they go beyond the vulnerability assessments and performance tests of individual components of security systems, and instead test the security system as a whole. China may lack the experience and capabilities to carry out such tests at its sites, while simultane¬ously maintaining safe and secure operation of the nuclear facility being tested.[109] However, the experi¬ence of the United States in conducting such tests demonstrates that they can be done safely. Chinese experts and officials could learn more about the practice of "force-on-force" exercises through CAEA-DOE cooperation.

108 Hui Zhang, "Why China Should Observe the Nuclear Security Summit Pledge." *Bulletin of the Atomic Scientists*, April 21, 2014, http://thebulletin.org/why-china-should-observe-nuclear-security-summit-pledge7076 (accessed February 27, 2016).

109 Author interviews with Chinese nuclear security experts, Beijing, October 2011, and January 2013.

Improving security at bulk processing facilities. 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 (e.g., fuel fabrication, enrichment, and reprocessing). 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.[110] Thus, it is essential for China to take effective measures at these facilities to reduce the chances of insider theft. China should improve its approach to material control and accounting at its bulk processing facilities. Disruptions of the operations at China's pilot reprocessing plant and the high percentage of material unaccounted for in its initial reprocessing run demonstrate the challenge. Improved security will be particularly important if China moves toward large-scale reprocessing facilities (e.g., 200tHM/year and 800 tHM/year). The government should make sure the operator has an accounting system that will detect the removal of even a small quantity of weapons-useable nuclear material, be able to localize the removal in time and space, and be capable of identifying which insiders had access.

Nuclear facility operators should be required to take steps to decrease vulnerability to insiders who have intent to do harm.[111] In particular, to strengthen access control, every operator should have an effective program for personnel reliability screening in cooperation with relevant government departments. Regulations should require a range of other measures to protect against insider theft and sabotage. In particular, the regulations should mandate 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.

Improving Cyber Security Requirements at Nuclear Facilities

Given the growing threat of cyberattacks and the possible consequences of a cyber-assisted theft of nuclear materials or sabotage of nuclear facilities, China should improve its nuclear security to address the threat of cyberattacks and take the following steps:[112]

110 See, for example, Bunn, Malin, Roth, and Tobey, *Preventing Nuclear Terrorism,* p. 59.

111 Zhang and Zhang, *Securing China's Nuclear Future*, p. 55.

112 See, for example, Institute for Safety and Security and NTI, *Cyber Security at Nuclear Facilities: National Approaches.*

- China should update and issue new nuclear regulations and guidelines explicitly incorporating cyber security. It can refer to suggestions by international organizations (e.g., IAEA and WINS) or to the practice of other nations (e.g., regulations of the U.S. Nuclear Regulatory Commission).[113] The nuclear licensing process should explicitly include cyber security. Where needed, the nuclear supply chain, and not just nuclear facilities themselves, should also be regulated.

- Cyber security should be fully integrated into the physical protection and accounting system. Cyber security should be an integrated component of the DBT.

- The nuclear regulators should conduct cyber threat assessments for nuclear facilities in cooperation with national intelligence organizations. To ensure effective cyber protections, the regulators should also establish programs to test the system's performance, and enforce cyber security plans via regular inspections of cyber security programs.

- While promoting nuclear security culture, it should also address cyber security culture, cyber security training, and education.

Bolstering Nuclear Security Culture

At the previous three nuclear security summits, Chinese leaders repeatedly emphasized enhancing nuclear security culture. However, China needs to do more to build a strong and sustainable nuclear security culture.[114] The government should ensure each operator establishes a targeted program to assess and improve its facility's security culture. As a licensee, the requirement of establishing and maintaining a nuclear security culture is management's responsibility. The government and operators should take the following serious steps (though this is not an exclusive list):

- Combating complacency: 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

113 International Atomic Energy Agency, Computer Security at Nuclear Facilities, IAEA Nuclear Security Series No. 17 (Vienna: IAEA, 2011), http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1527_web.pdf (accessed March 22, 2016). There are also several publications available, for example, *Security of IT and IC Systems at Nuclear Facilities*, World Institute of Nuclear Security, 2014.

114 See, for example, Bunn, Malin, Roth, and Tobey, *Preventing Nuclear Terrorism,* p.112.

world—should become complacent about its nuclear security.[115] China needs to take further steps to prevent complacency, including: regularly reviewing nuclear security practice and systems, conducting self-assessments, and compiling lessons learned from real incidents and security exercises.

- National leaders and operators should commit to maintaining the priority of nuclear security, and follow up that commitment with specific actions, making clear that security is as much of a priority as safety and successful operations. The goal should be to convince each security-relevant staff member not only to scrupulously abide by the existing nuclear security regime, but also to actively and continuously find ways to improve it.

- Staff members should be provided extra motivation via rewards and recognition aimed at: encouraging vigilance, questioning attitudes and personal accountability; encouraging personnel to report any event that could affect nuclear security; and ensuring that all personnel are accountable for their behavior and motivated to ensure nuclear security. 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 the importance and seriousness of nuclear security.

- 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 the importance and seriousness of nuclear security.

- Conducting realistic performance tests will help strengthen security culture for guards and other employees who witness the seriousness with which security risks are addressed, and see plausible ways the security system might be breached.

115 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, Office of the Inspector General U.S. Department of Energy, *Inquiry Into the Security Breach at the National Nuclear Security Administration's Y-12 National Security Complex,* DOE/IG-0868 (Washington, D.C., DOE, August 2012),http://energy.gov/sites/prod/files/IG-0868_0.pdf (accessed February 27, 2016); 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 U.S. nuclear weapons program.

- Operators should seek to strengthen teamwork and cooperation among all personnel involved in security. All staff should understand how their particular roles contribute to maintaining security.

Increasing International Confidence

China should take further measures (without compromising sensitive information) to build confidence in the international community that a robust nuclear security program is in place. For example, the steps should include:

- China should release more information about its nuclear security policies and practices. For example, China could release details of its nuclear security regulations, threat assessments, approaches to assessing facilities security performance, annual reports on implementation of and compliance with nuclear security regulations, and other specifics. These could be included in China's UNSCR 1540 reports or published in other forums.

- Beyond the currently planned IPPAS mission for a power reactor, China should allow experts organized by the IAEA to conduct reviews of the country's nuclear security arrangements on a regular basis and for different types of nuclear facilities. The IPPAS missions would review and compare China's physical protection measures with international guidelines and best practices and make recommendations for improvements.

- Moreover, 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 such as HEU-fueled reactors and the pilot reprocessing plant; the United States could invite China to a similar set of reviews at selected U.S. facilities.

- China should further encourage more relevant nuclear security professionals and institutions to participate in international workshops and training exercises—such as those sponsored by the WINS. Moreover, China could share information with others confidentially or publicly about approaches, procedures, regulations, best practices, and lessons learned.

- China should join the new initiative on Strengthening Nuclear Security Implementation along with the other 35 countries that pledged at the 2014 Nuclear Security Summit (and now also Jordan). Doing so will require incorporating the principles and guidelines of the IAEA regarding nuclear security into its national laws; and allowing teams of international experts to periodically evaluate its security procedures.[116]

Strengthening International Cooperation

China should continue and expand international cooperation. China's improvement of nuclear security has benefited greatly from international cooperation, in particular, between the CAEA and both the US DOE and the IAEA.

In particular, China and the United States should use the newly established CoE as a forum for best-practice exchanges, technical cooperation, research and development projects, and regional and global personnel training.

More importantly, U.S.-China cooperation needs to be expanded to include more focused work related to the defense sector that deals with nuclear weapons and the most sensitive nuclear materials, including restarting the lab-to-lab program conducted from 1995–1998. The most important areas for U.S.-China cooperation should include starting lab-to-lab cooperation, expanding work to strengthen security culture, and exchanging visits at actual sites (starting with less sensitive ones).

However, Beijing and Washington need to find ways to overcome the current political obstacle to cooperation between their weapons laboratories. Is the dangerous threat of nuclear terrorism not great enough for abandoning the past political disputes? At the 2014 Nuclear Security Summit, President Xi stressed that increased cooperation regarding the nuclear security of one country is beneficial to all nations. As Xi pointed out, "The loss of nuclear material in one country can be a threat to the whole world." President Barack Obama has emphasized that the biggest threat to US security is the possibility of a terrorist organization obtaining a nuclear weapon. The three Nuclear Security Summits have raised the nuclear security issues to the top leaders in Beijing and Washington and enhanced consensus on the danger of nuclear terrorism. It is the time for both capitals to overcome the political obstacle and to extend cooperation on nuclear security to the military sector. There are good reasons for Beijing to move forward. Given the fact that the

116 Zhang, "Why China Should Observe the Nuclear Security Summit Pledge."

nuclear terrorism threat is a top priority in Washington, Beijing's cooperation on the issue would benefit the Sino-U.S. relationship. Moreover, the increase in terrorism in China may someday pose serious threats to Chinese nuclear facilities. This possibility is particularly troubling because of the fact that by 2030, China will be home to the largest number of nuclear reactors in the world. Further, Beijing's active participation in building a robust global nuclear security system would improve its international image.

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.

The Project on Managing the Atom
Belfer Center for Science and International Affairs
John F. Kennedy School of Government
Harvard University
79 JFK Street; Mailbox 134
Cambridge, MA 02138

Phone: 617-495-4219
E-mail: atom@hks.harvard.edu
Website: http://belfercenter.org/mta

Belfer Center for Science and International Affairs
Harvard Kennedy School
79 JFK Street
Cambridge, MA 02138
Fax: (617) 495-8963
Email: belfer_center@hks.harvard.edu
Website: http://belfercenter.org