IMPROVING CHINA'S NUCLEAR SECURITY

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ABSTRACT

China's approach to strengthening the security of its nuclear weapons, materials, and facilities is important in facilitating strong global action on nuclear security. At the 2014 Nuclear Security Summit in The Hague, Chinese President Xi Jinping made commitments to strengthening nuclear security. This paper will describe the status of China's nuclear security practices. In particular, it will assess improvements China made over the last two years. Finally, this paper will recommends steps to further improve China's nuclear security.

Since the 2010 Nuclear Security Summit (NSS), 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 four summits and pledged at the summits to strengthen nuclear security. In recent years, China has made important progress on nuclear security,[1] but there is still substantial room for improvement.

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. This paper focuses on China's major progress made over last two years in improving nuclear security, highlights the key challenges China is facing, and recommends a number of next steps.

[1] More developments of China's nuclear security can be read: 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; also updates in : Hui Zhang, *China's Nuclear Security: Progress, Challenges, and Next Steps.* Cambridge, Mass.: Report for Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, March 28, 2016. http://belfercenter.ksg.harvard.edu/files/Chinas%20Nuclear%20Security-Web.pdf.

Major Progress on Nuclear Security

In recent years, China has made improvements in areas including national laws and regulations, protection and control measures, nuclear security culture, international assurance, and international cooperation.

Nuclear laws and regulations. Over the last two years, China has worked actively on legislation and a policy frame-work relevant to nuclear security. Since April 2014, China has integrated nuclear safety and security with the national security system, and has defined the strategic significance of nuclear security.[2]

In January 2016, China issued a White Paper on Nuclear Emergency Preparedness Plan, which aims to create an effective system for nuclear emergency response.[3] The White Paper emphasizes that China will establish a national nuclear emergencyrescue team of over 300 people, responsible for undertaking unexpected rescue 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.

On July 1, 2015, China issued a new National Security Law,[4] which 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." Moreover, on December 27, 2015, China issued a new National Counter Terrorism Law, [5]which provides the legal basis for strengthening implementation and enforcement of measures for preventing nuclear terrorism in China.

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. In 2015, the law was included in the State Council legislative work plan. Currently, the Atomic Energy Law is going through legislative review procedures, and is expected to be pro mulgated in 2016. Also China works actively on the country's first Nuclear Safety Law (which includes nuclear security). The law was submitted to the National Peoples Congress in 2015. It is expected to be approved in 2016-2017.

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.The new regulations are expected to have more specific nuclear security requirements. Also, CAEA recently issued a number of documents regarding the managementof nuclear materials.

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[2] *National Progress Report: China*, March 31, 2016. http://www.nss2016.org/document-center-docs/2016/3/31/national-progress-report-china-1.

[3] 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).

[4] China National Security Law," *Xinhua Net*, July 1, http://news.xinhuanet.com/politics/2015-07/01/c_1115787801.htm (in Chinese).

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

MPC&A. In recent years, China has invested a large sum of money to improve its physical protection, material control, and material accounting (MPC&A) technologies and to update monitoring and equipment at nuclear facilities. China spent hundreds of millions of dollars from its dedicated nuclear security fund to update its security system between 2010 and 2016.[6]

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 new Chinese-designed third generation power reactors, including the Hualong One design, are able to withstand impact by commercial planes.[7] Since 2014, when President Xi highlighted nuclear safety and security as an important element in China's national security strategy,[8] 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.[9]

Capacity building on nuclear security. China is increasing the capacity of its two major regulators: the CAEA and the National Nuclear Safety Administration (NNSA). 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. The SNSTC is also responsible for establishing and managing the new Center of Excellence (CoE) on Nuclear Security. China and the US announced cooperation on the CoE near Beijing at the 2010 NSS in Washington in 2010. The CoE broke ground on October 29, 2013, and was commissioned on March 18, 2016. The center will be the largest and most advanced in the Asia-Pacific region. The center will serve as a unique forum for exchangingtechnical information, sharing best practices, developing training courses, and promoting technical collaboration to enhance nuclear security in China, through-out the Asia-Pacific region, or even globally. The establishment of SNSTC and the CoE significantly enhance CAEA's technical capacity on nuclear security and accounting.

Also, 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. One focus of the national base will be R&D on nuclear safety and security technology, applying those technologies to Chinese facilities partly through exchanges and technology demonstrations at the CoE. Land preparation for the new national base is now underway. The new research base is expected to begin operating in 2018.

The conversion of research reactors. In September 2010, CAEA and US DOE signed an

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[6] Communications with NNSA nuclear experts, March 2016.

[7] "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).

[8] 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).

[9] "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).

agreement to convert the Miniature Neutron Source Reactor (MNSR) in China Institute of Atomic Energy. The HEU fuels was discharged in September 2015. The conversion of this reactor to using LEU was completed in March 2016. Under cooperation with US, China commits to convert its remaining MNSR reactor at Shenzhen University. 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 US 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.

Nuclear security culture. At the 2016 summit, President Xi addressed that "the human factor is the most important element in the strengthening of global nuclear security architecture. The awareness of the rule of law, the sense of urgency, and the spirit of self-discipline and coordination are central to the nuclear security culture." [10]Since April 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 through various approaches including greatly increasing training activities and no-notice inspections. 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.[11]

International confidence. China has recently taken positive steps to increase international confidence. At the 2014 NSS, President Xi announced that China will invite the IAEA to conduct an International Physical Protection Advisory Service (IPPAS) mission in China. In September 2015, China formally invited the IAEA to undertake an IPPAS mission at both national and facility levels in China.[12] Presently, China and the IAEA are discussing details of a peer review at a nuclear power plant. The IPPAS mission is now planned for late 2016 (third quarter).[13]

Further, during the 2016 NSS, China announced it joined the strengthening nuclear security implementation initiative (SNSI). The SNSI, introduced within the IAEA as Information Circular 869 (INFCIRC/869), has been a major accomplishment of the summit process. By signing on to the SNSI, China pledges to follow IAEA nuclear security principles and guidelines in its national rules and regulations and allow teams of international experts to periodically evaluate its security procedures. This is an important step that will help China strengthen its nuclear security system and increase international confidence in that system.

International cooperation. Over the past decade, China's significant progress on nuclear security has been one of the benefits of cooperation with the US. Both countries have undertaken an extensive series of exchanges: visits to a range of US facilities to observe nuclear security and accounting

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[10] Xi Jinping, "Statement at the Fourth Nuclear Security Summit," April1, 2016, http://news.xinhuanet.com/english/2016-04/02/c_135245093.htm.

[11] 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) .Also, "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).

[12] *National Progress Report: China*, March 31, 2016.

[13] Communications with an IAEA official, March 2016.

approaches; in-depth training workshops and discussions on approaches to strengthening nuclear security; work to strengthen security and accounting regulations and inspections in China; and cooperation to build the Center of Excellence and convert the MNSRs.[14]

Moreover, China and the US announced a joint statement on nuclear security which during the 2016 NSS.[15] In the statement, they commit to intensifying cooperation to prevent nuclear terrorism and to continue advancing NSS goals. In particular, both countries declare they will conduct an annual dialogue on nuclear security, which will provide an important forum for both countries to discuss and strengthen nuclear security cooperation. In September 2015, President Xi Jinping and President Obama agreed to establish an annual bilateral nuclear security dialogue mechanism. They conducted successfully the first round of dialogue on February 20, 2016, in Stockholm, Sweden. Also in the joint statement, both countries commit to "continued engagement on nuclear security training and best practices to maximize the use and effectiveness of the COE." Both the United States and China commit to continuing cooperation to convert China's remaining MNSR, and other such reactors in Ghana and Nigeria. They also pledge to cooperate to fight smuggling of nuclear materials and to strengthen cooperation on securing radioactive sources.

In addition, China, for the first time ever, joined six "gift baskets" in the 2016 NSS,[16] which shows a distinctive switch in behavior compared with the previous three summits. The most important one is on Sustaining Action to Strengthen the Global Nuclear Security Architecture, which establishes a "Nuclear Security Contact Group" made up of senior officials. This group will "routinely consult and synchronize national actions in support of the commitments" made during the NSS process. Additionally, China made commitments to join other "gift baskets," including countering nuclear smuggling, implementation of UN Security Council Resolution 1540, supporting an LEU fuel bank, supporting nuclear security training and support centers, and strengthening cyber security at nuclear facilities.

Major Challenges

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

Still no national DBT requirement. 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 adrules were issued before the 9/11 attacks. The 2008 guidelines on physical protection still leave some major gaps. 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

[14] Zhang, China's *Nuclear Security: Progress, Challenges, and Next Steps.*
[15] U.S.-China Joint Statement on Nuclear Security Cooperation. https://www.whitehouse.gov/the-press-office/2016/03/31/us-china-joint-statement-nuclear-security-cooperation.
[16]Hui Zhang, "China Makes Significant Nuclear Security Pledges at 2016 Summit, "Nuclear *Security Matters*, April 8, 2016. http://nuclearsecuritymatters.belfercenter.org/blog/china-makes-significant-nuclear-security-pledges-2016-summit.

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. As NNSA Director Li Ganjie noted, the existing DBT fornuclear power plants could have produced designs that are unable to resist attacks fromlarge-scale and well-organized terrorist groups with powerful weapons.[17] It is not clear if the on-going Nuclear Security Regulations will address it in some way.

No force-on-force exercises. Currently, operators are not required to do realistic force-on-force exercises, asINFCIRC/225/Revision 5 recommends. No Chinese regulations require such tests, which are vital for identifying the strengths and weaknesses of security procedures. The newly established NNSTC will conduct such exercises at specific training sites. These exercises, however, will mainly serve to train guard forces and will not probe how well security performs at operating facilities.

Limited effectiveness of MC&A system. The most significant challenge to China's forts to establish an effective nationwide MC&A system could 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, which has a capacity of 50 metric tons of heavy metal per year (tHM/year). 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.[18] 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 site preparations for a demonstration reprocessing plant with a capacity of 200 tHM/year at Jinta, Gansu province, which is expected to be in operation by 2020.[19] In recent years, the China National Nuclear Corporation has also been negotiating with France's AREVA on the construction of a commercial reprocessing plant (800tHM/year). It would be even more difficult to establish an effective MC&A system at these facilities than at the much smaller pilot facility.

Nuclear 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.[20] 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). However, China has not yet written specific regulations and guidelines with provisions at nuclear facilities. In general, like other industries, nuclear facilities are

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[17] 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).

[18] Zhang and Zhang, *Securing China's Nuclear Future*.

[19] Hui Zhang, "China is said to be building a demonstration commercial reprocessing plant," IPFM blog, September 23, 2015. http://fissilematerials.org/blog/2015/09/china_is_said_to_be_build.html.

[20] "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).

required to have cyber security plans. However, currently the licensing process for nuclear facilities in China does not cover cyber security for systems relevant to safety and security, though nuclear regulators are beginning to pay attention to these issues. It is not clear how nuclear cyber security will be addressed in new regulations.

Challenges to nuclear security culture. 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. 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. 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 doubt whether it is worth the money and time to establish and maintaina 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.[21] In some cases, operators or relevant personnel who want to maintain a good record andavoid punishment downplay or conceal some faults.[22]

Moreover, in large state owned enterprises in China, in particular in the nuclear industry which is developed from defense sector, it is traditionally 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).[23]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.

Further, 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 thecase 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. Such an attitude, with less transparency and less communication, is not beneficial to the establishment of a strong nuclear security culture.

Recommendations

At the 2016 nuclear security summit, President Xi emphasized that, "the conclusion of the Nuclear Security Summit will not be the end of our endeavor, rather it will be the beginning of a new journey." Converting the top Chinese leader's stated commitment into practical, sustainable reality will require China to take further steps to improve China's nuclear security.

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[21] Zhang and Zhang, *Securing China's Nuclear Future*.

[22] Communications with Chinese nuclear safety and security experts, February 2016.

[23] *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)

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.[24]

- 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.

- 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. Regulations should also require a range of measures to protect against insider theft and sabotage.[25]

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.

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[24] 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).

[25] Zhang and Zhang, *Securing China's Nuclear Future*.

Promoting Nuclear Security Culture

- 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 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. 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 US could expand cooperation to include security reviews of agreed-upon facilities, beginning with civilian sites such as 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.

Strengthening International Cooperation

At the 2016 nuclear security summit, President Xi emphasized that, "Nuclear security incidents will have impacts that go beyond national borders. In the age of connectivity, no country can deal with such problems alone, and no country can stay immune from their impacts." China should continue and expand international cooperation. In particular, China and the US 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.

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.[26]

Individuals from some of these institutions reportedly participated in joint workshops and discussions, and the CAEA, 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 most important areas for U.S.-China cooperation should include restarting 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.

[26] 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.