A Personal Perspective of U.S.-China Nuclear Science and Security Cooperation

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The United States and the People's Republic of China (PRC) both pursued scientific cooperation following the political opening in the early 1970s. Cooperation in the nuclear sphere followed shortly for nuclear science, nuclear power, and civil nuclear safety and security. China was a latecomer in all and eager to learn. The United States was pre-eminent in all and eager to resume collaboration with China interrupted by the Chinese Communist Revolution in 1949. The U.S. National Academy of Sciences promoted scientific cooperation. The U.S. Nuclear Regulatory Commission (NRC) promoted cooperation for safety and regulation of nuclear power plants. American nuclear industry pursued business opportunities in China, and the U.S. nuclear weapons laboratories forged the first collaborations in the nuclear security arena.

Today, China possesses some of the most modern nuclear research facilities in the world and a rapidly increasing rate of scientific publications. It is a leader in nuclear energy and is currently building as much nuclear reactor capacity as the rest of the world combined. Through collaboration with the United States, China has developed a modern nuclear regulatory system. It has improved its practices to assure security and safeguards of its nuclear materials. It is now promoting international security and nonproliferation norms after some troublesome early dealings with Pakistan and possibly North Korea. China is a valued member of the International Atomic Energy Agency. And much to Washington's dismay, China is moving toward being a near-peer nuclear weapon state with Russia and the United States.

The United States, on the other hand, is struggling to maintain its leadership in nuclear power, having lost much of its construction and nuclear supply-chain expertise, as well as facing a shortage of required nuclear workforce. Its once pre-eminent position in scientific research is being challenged not only from the outside but also by U.S. government decisions to cut back on research funding in many key areas. Fortunately, the United States retains global leadership in nuclear security and non-proliferation. And its nuclear weapons arsenal continues to provide an effective deterrent to Russia and a rising China, although it is challenged to modernize its nuclear facilities and its re-manufacturing capabilities.

This article provides a history of nuclear cooperation with China focused on nuclear science and security dimensions[1] from the perspective of one observer with many years of experience in the U.S. nuclear weapons complex and with extensive travel to the world's other nuclear powers, including Russia. This history teaches a lesson very different from the conventional American wisdom that China's nuclear weapons program has succeeded primarily through imitation and grand theft of American nuclear knowhow and secrets. That

[1] A forthcoming companion James Martin Center for Nonproliferation Studies report authored by Y. Pan, W. Potter and S. Hecker provides an extensive history of cooperation in civilian nuclear power.

belief may be politically convenient but it underestimates China's capacity for independent innovation. It ignores the benefits of cooperation, which helped bring China into a position of a responsible global nuclear state.

Early U.S.-China scientific cooperation.

After intense secrecy on nuclear issues following the U.S. Manhattan Project and the Soviet Union joining the nuclear weapons club with a nuclear detonation on 29 August 1949, international nuclear cooperation was encouraged by President Eisenhower's 8 December 1953 United Nations *Atoms for Peace* speech.[2] Eisenhower was concerned that unregulated spread of nuclear power would permit weapon proliferation. He believed that sharing under strict regulation was a better approach. The Soviet Union was at first suspicious of Eisenhower's motives, but quickly joined with its own "Peaceful Atom" initiative. The Geneva Conferences on the Peaceful Use of Atomic Energy held in 1955 and 1958 brought thousands of scientists together to share research on civilian nuclear science and technology,[3] but none from the People's Republic of China (PRC) because it did not represent China at UN-led international peaceful use cooperation forums until the PRC gained a seat at the UN in October 1971. The PRC joined the International Atomic Energy Agency (IAEA) in 1984 and became a party to the Nuclear Nonproliferation Treaty (NPT) on 9 March 1992, more than 20 years after the treaty entered into force**.**

Mao Zedong considered Eisenhower's Atoms for Peace program to be hypocritical, imperialist propaganda by the United States. He had already linked up with the Soviet nuclear program, both for peaceful and military purposes. Nikita Khrushchev promised to provide the necessary assistance for a Chinese bomb. However, all came to a halt in the late 1950s with the Sino-Soviet split. At that point, China pursued its own nuclear weapons program in the spirit of self-reliance in science and technology.[4] China continued on its own to the first nuclear fission bomb explosion in October 1964 and its test of a hydrogen bomb in June 1967. In retrospect, the Sino-Soviet split helped to launch China's nuclear weapons program on a successful trajectory that would have been unlikely if it had continued to rely on Soviet help.

Whereas scientific cooperation between China and the United States occurred during the first half of the 20th century,[5] it ended abruptly with the Chinese Communist Revolution of 1949: the new ruling Chinese Communist Party (CCP) soon cut off most relations with Western governments, and with their scientific and educational establishments. Chinese nuclear scientists were mostly confined to studying and interacting with Soviet and Eastern Bloc scientists until the Sino-Soviet split. China participated in little scientific cooperation with the West. In 1963 the U.S. National Academy of Sciences (NAS) attempted to resume

[2] https://www.iaea.org/newscenter/multimedia/videos/atoms-peace-speech

[3] Siegfried S. Hecker, "Atoms for Peace: Vision, Reality and Legacy – A Nuclear Practitioner's Perspective." To be published in *Atoms for Peace: After Seven Decades, An Enduring Legacy,"* 2026.

[4] Xie Guang, *"China Today: Defence Science and Technology,"* National Defence Industry Press, Beijing, 1993.

[5] Zuoyue Wang, "*Transnational Science and National Security: Chinese American Scientists and U.S.–China Relations,"* Rutgers University Press, 2023.

scientific cooperation with Chinese counterparts suspended in 1949. In 1966, the Committee on Scholarly Communication with Mainland China (CSCMC) was formally launched with sponsorship, on the American side, from the Social Science Research Council (SSRC) and the American Council of Learned Societies (ACLS), alongside the NAS, where the group was housed. Little progress was made with the Chinese, who preferred to seek out cooperation with organizations such as the Federation of American Scientists, who were more closely aligned with their political views and were often critical of U.S. nuclear weapon policy. That changed when President Nixon's visit to Beijing in 1972 opened the door for both countries to explore cooperation.

In a London School of Economics article,[6] Pete Millwood made the case that scientific cooperation provided a catalyst for the two governments to establish formal relations nearly thirty years after the PRC was established. He shows that between 1966 and 1978, American scientists initially failed but ultimately succeeded in restarting scientific exchange and cooperation, dormant since 1949, with their Chinese counterparts. Government officials, including scientists, saw the symbolic and instrumental utility of using science and technology cooperation (and education) to achieve normalization with the 1979 normalization agreement and jointly balance against the Soviet Union.[7]

A rebranded NAS group called the Committee on Scholarly Communication with the People's Republic of China (CSCPRC) was finally able to make headway with the Chinese government resulting in the first visit of Chinese scientists to the U.S. in November 1972. Concurrently, Premier Zhou Enlai changed Chinese science policy, acceding to a petition from some of China's most prominent scientists to restart basic and theoretical research and end the Cultural Revolution's exclusive focus on developing practical applications for existing scientific knowledge.

Over the next five years, the interactions between the Chinese and American scientific communities increased significantly, but not without deep disagreement in the number of delegations and topics to be discussed. Nevertheless, between 1972 and 1977, roughly five delegations visited each country annually. By 1977, following Chairman Mao's death, President Carter's national security advisor, Z. Brzezinski, leveraged scientific cooperation to make an important contribution to Carter's political normalization with China.

American scientists were enthusiastic to rekindle cooperation with Chinese scientists. Wolfgang H.K. (Pief) Panofsky of Stanford's Linear Accelerator, Richard Garwin of IBM, and Frank Press of MIT were instrumental. Press, who later served as President Carter's science

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[6] Pete Millwood, "*An "Exceedingly Delicate Undertaking": Sino-American Science Diplomacy, 1966–78."* London School of Economics, https://www.tandfonline.com/doi/full/10.1080/14682745.2020.1798643
[7] The U.S.–China normalization agreement established full diplomatic relations between the United States and the People's Republic of China, with the U.S. formally recognizing Beijing as the sole legal government of China and severing official ties with Taiwan. It also created the political foundation for expanded cooperation—including scientific, technological, and eventually security-related exchanges—between the two countries.

advisor, played a particularly important role. Press traveled to China in the summer of 1978 as the new premier, Deng Xiaoping, declared that science and technology were the linchpins of China's Four Modernizations program.[8] He saw American science and technology as critical to his dream of modernizing China.

Frank Press proposed to the Chinese to collaborate in agriculture, resource exploration, seismology, high-energy physics, public health, and space science. The Press trip opened the door wide to cooperation with the United States. China also agreed to restart the student exchange program with the United States. The scientific rapprochement was followed in January 1979 with the formal normalization between the United States and China. In 1979, there was a tripling in the number of scientific exchanges.

China's interest in Los Alamos and other U.S. nuclear laboratories.
American nuclear laboratories were of great interest to Chinese nuclear scientists and high-energy physicists. Indeed, the Institute of High Energy Physics under the Chinese Academy of Sciences was established by Zhang Wenyu, deputy director of the China Institute of Atomic Energy (CIAE), shortly after his first visit to U.S. national laboratories in 1972. Set up with Soviet assistance, CIAE had contributed to China's nuclear weapons program during the 1950s and 60s. But by the 1970s, it had transitioned toward civilian nuclear research while the Ninth Academy, later renamed the China Academy of Engineering Physics (CAEP)[9], continued housing China's nuclear weapons program. Chinese universities, meanwhile, were home to nuclear scientists who straddled civilian and weapons-related research.

Chinese delegations that visited U.S. national laboratories starting in the 1970s consisted of scientists from all these institutes, academies, and universities. State-of-the-art accelerators for fundamental physics research at several of the labs were of particular interest. One of the strongest attractions for the Chinese was the Stanford Linear Accelerator Center (SLAC) headed by Panofsky, who forged a close relationship with Chinese scientists. At the Los Alamos Scientific Laboratory (which it was called before Congress changed the name to the Los Alamos National Laboratory in 1981) the Chinese were most interested in the Los Alamos Meson Physics Facility (LAMPF), a basic, medium-energy physics research center. They were also interested in the lab's fundamental theoretical nuclear physics studies conducted in the Theory Division (which had its roots in the Manhattan Project when it was directed by Nobel Laureate Hans Bethe).

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[8] Deng Xiaoping, "Emancipate the Mind, Seek Truth from Facts and Unite as One in Looking to the Future" (speech, Beijing, December 13, 1978), in *Selected Works of Deng Xiaoping (1975–1982)* (Beijing: Foreign Languages Press, 1984), 151–165.
[9] The Chinese Academy of Sciences (CAS) is the main organization in charge of the construction and operation of China's major research facilities. The China Academy of Engineering Physics (CAEP) is responsible for nuclear weapons R&D and reports to the General Armaments Department within the People's Liberation Army (PLA). The principal CAEP R&D site is in Mianyang, Sichuan Provice. The Institute of Applied Physics and Computational Mathematics (IAPCM), located in Beijing, conducts research for the CAEP, including on nuclear warhead design and arms control.

In May 1978, Lew Branscomb, member of the NAS and chair of the CSCPRC wrote to Los Alamos director Harold Agnew to ask him to host a 12-member Chinese scientific delegation that was to visit six U.S. laboratories in the summer of 1978. Although the mission of the Los Alamos laboratory was primarily for nuclear weapons R&D, it conducted forefront basic research and had housed scientific facilities outside the classified areas since the Manhattan Project. Branscomb told Agnew that the delegation was one of the most prestigious and high-level scientific delegations to visit the United States that year. Agnew hosted the Chinese delegation at the laboratory on July 10 and 11, 1978. The delegation was primarily interested in nuclear physics, controlled thermonuclear fusion research, and laser science at Los Alamos. Dr. Yang Fujia, Deputy Head of the Department of Nuclear Physics at Fudan University presented a talk on "2500-year-old Chinese sword: PIXIE (Proton-Induced X-ray Emission) analysis of its surfaces," and Chen Chun-hsien of the Chinese Academy of Sciences (Peking) gave a presentation on "Recent experiments at No. 6 Tokamak Device." The Los Alamos lab was one stop in the 1978 tour of many U.S. national laboratories and several universities.

In addition to nuclear and high-energy science, energy technology became a prospective area of cooperation as the two countries neared formal diplomatic normalization. In October, Energy Secretary James Schlesinger visited China with a 16-member team. The team consisted primarily of technical experts—the areas of interest were coal, hydroelectric power, renewable energy, oil & gas, high energy physics, nuclear physics and fusion. The Chinese were interested in exchanges related to all the above, plus nuclear energy.

Scientific exchange visits increased sharply after the signing of the U.S.-China Science and Technology agreement in January 1979. In April 1979, the American Nuclear Society hosted a Chinese delegation interested in nuclear energy and technology. That delegation visited Los Alamos on April 16 and 17, 1979. The laboratory briefings and tours included magnetic and laser fusion programs, the Los Alamos Meson Physics Facility for basic nuclear research, nuclear reactor and waste management programs, nuclear materials safeguards and reactor safety programs. Ten members of the New Energy Source Delegation (from the State Scientific and Technological Commission, Chinese Academy of Sciences, and other institutions and universities in China) were hosted for a grand tour of U.S. energy laboratories and facilities later in June 1979. Clearly, the two governments were now actively promoting scientific and technical collaboration.

The Los Alamos laboratory was one of the stops of this delegation not because it was a nuclear weapons laboratory but because it was deeply involved in basic research and renewable energy. During the visit on June 15, 1979, the laboratory featured its work in briefings on passive and active solar energy projects and its Hot Dry Rock geothermal energy project (including a field trip to the nearby Fenton Hill experimental site). The two sides exchanged publications in these fields. Care was taken, of course, not to give access to sensitive facilities or classified information during the visit. Chinese interest in the Los

Alamos energy programs showed it had interest in renewable energy, in which it has become a world leader some nearly 50 years later.

Several Los Alamos scientists forged good relations with the Chinese scientists resulting in the exchange of scientific publications and further exchange visits. One of the connections was made more than a dozen years earlier between American physicist J. Rayford (Ray) Nix and Yang Fujia from Fudan University. They were postdoctoral fellows in the same nuclear physics research group in 1964 at the Institute of Theoretical Physics (later called the Niels Bohr Institute) in Copenhagen, Denmark, under the tutelage of future Nobel Laureate Aage Bohr (son of Nobel Laureate Niels Bohr who advised Oppenheimer during the Manhattan Project).

After Copenhagen, Ray Nix returned briefly to UC Berkeley where he had earned his PhD in nuclear physics and then joined the Los Alamos Scientific Laboratory. Yang Fujia returned from Copenhagen to join the academic ranks of Fudan University where he built a well-respected nuclear physics program and led the Shanghai Institute for Nuclear Physics. He eventually became the president of Fudan University and then went on to other distinguished academic appointments and international advisory roles.[10]

Nix and Yang had stayed in touch after Copenhagen, but the warming of U.S.-China relations and Yang's participation in the delegation's visit to Los Alamos promised to open a new era. In an exchange of letters in December 1978 Nix wrote to Yang that "You must be equally as happy as I am to learn that the relations between our countries will become fully normalized on 1 January 1979. We can now look forward to even greater scientific exchange and friendship between our countries than before." Indeed, they helped to make it happen.

Their primary common interest was in nuclear physics and both were conducting research at the forefront of the field. But they had another common interest—namely nuclear weapons. Ray Nix, after all, worked in the Theory Division of the Los Alamos laboratory, renowned for the Manhattan Project and its continued role in the U.S. nuclear weapons program. The laboratory's director was Harold Agnew, a graduate student of Enrico Fermi's at the University of Chicago who participated in the Manhattan project and returned to Los Alamos after completing his PhD under Fermi, later becoming its third director in 1970. It was Agnew who would develop the first connections with scientists in China's nuclear weapons program. That connection was facilitated by Yang Fujia.

When Yang Fujia visited Los Alamos in July 1978, he represented the Shanghai Institute of Nuclear Physics. Yang's association with China's nuclear weapons program was not well known even within China, yet he became the main interlocutor between that program and the Los Alamos lab when he extended an invitation for Harold Agnew to visit China.

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[10] Yang Fujia served as Chancellor of the University of Nottingham, as founding Chancellor of University of Nottingham Ningbo China and on the Board of Directors of the U.S. Nuclear Threat Initiative (NTI).

The invitation to Agnew was made by Yang through his Los Alamos contacts. According to Agnew's account,[11] the invitation followed a dinner conversation he had with a member of a Chinese delegation visiting Washington in late January 1979. Agnew was invited to the banquet, likely because he had hosted the Chinese scientific delegation at Los Alamos the previous July. In addition, Agnew said that one of his former University of Chicago colleagues, Chen Ning (Frank) Yang (Chinese-American Nobel Laureate in Physics), who had convinced Zhou Enlai to set up China's high-energy physics program, was also there.

At the reception, Agnew met a Chinese scientist he called K.C. Wang.[12] Wang invited Agnew to join him and Frank Yang for the buffet dinner to chat. When Wang asked Agnew what his interests were, Agnew replied "defense science," to which Wang replied, "Oh, well, that's nice." Agnew didn't know that K.C. Wang was Wang Ganchang, one of the most prominent particle physicists in China. He was awarded a PhD in physics at the University of Berlin in 1934 under the supervision of Lise Meitner, one of the principal discoverers of nuclear fission in Germany in 1938. Wang was internationally known as K.C. Wang.

What Agnew also did not know was that after Wang returned to China, first to Tsinghua University, then Peking University, followed by founding the Institute of Modern Physics under the Chinese Academy of Sciences, he had led China's experimental efforts to build the bomb, under the purview of the Second Ministry of Machine Building. Wang Ganchang was later recognized by the Chinese government as one of the "Two Bombs, One Satellite" meritorious scientists. Beginning with these early visits, China brought to the United States not only real card-carrying scientists, but also a founder of the Chinese bomb program. It was that dinner meeting with Agnew that led to an invitation from Yang Fujia to visit China.

That visit took place in 1980, by which time Agnew had left the Los Alamos laboratory to become CEO of General Atomics. Agnew presented a talk at Fudan University on his way to a fusion conference in Japan. General Atomics had a large cooperative program with Japan on fusion energy. Yang Fujia invited Agnew to return to China. Agnew accepted but only if he could visit the Lop Nur nuclear test site. Yang was able to arrange the visit—the first by anyone from the West. Agnew said he came as a private citizen, not associated with any government agency. Agnew was accompanied on the trip by his wife, Beverly, but she stayed in a nearby town.

Agnew's description of his visit to Lop Nur in a remote part of China's northwest is colorful. He recounted "I walked in the tunnels and talked to their guys, watched them drilling holes down. Told them I was interested in geology. I picked up some corings because our guys, for seismic coupling, wanted to know what was the ground there. We'd never been there

[11] University of Nevada Las Vegas Test Site Oral History Project interview with Harold Agnew, https://special.library.unlv.edu/_flysystem/fedora/NTS%20Oral%20History%20Project/FINAL%20transcript%20copies/FINAL%20TRANSCRIPTS_revised_TOC/nts_000124.pdf

[12] Agnew claimed that he had met K.C. Wang the previous year during the visit of a Chinese scientific delegation to General Atomics in California.

before. And they said fine, so I took a couple of hunks, brought them home, and gave them to the guys at Los Alamos to analyze." It was a remarkable visit. Agnew said they gave him free access to the base. They did ask him lots of questions about Los Alamos and the American weapons program. Agnew said he told them very little. He did, however, take back to Washington their request for help with Permissive Action Link technology (the electronic code program to protect against an unauthorized nuclear detonation). Agnew said the Department of Energy officials denied such help citing it was not allowed by the Nuclear Nonproliferation Treaty. Agnew believed that was very short sighted.

At the time, it seemed remarkable that Yang Fujia, an academic at Fudan University, would be able to arrange a visit by a former head of the Los Alamos lab to one of China's most sensitive nuclear weapons sites. It was not until in Yang's 2022 Century Magazine obituary[13] that his early association with the nuclear weapons program was highlighted within China and better understood in the West. It featured his close connections to the founders of China's nuclear weapons program and his own work at the Lop Nur nuclear test site, including his involvement in a 1984 Chinese nuclear test. The obituary re-told Yang Fujia's story to friends of how he had been close to numerous nuclear physicist pioneers in China's nuclear weapons program. Several of them later received the "Two Bombs and One Satellite Medal of Merit," becoming revered as "Two Bombs Heroes." He specifically mentioned Qian Sanqiang, Deng Jiaxian, generally considered fathers of China's atomic bomb and Yu Min, called the father of China's hydrogen bomb. He considered them as having served both as mentors and as friends.

The obituary also explains that Yang got to Copenhagen thanks to Qian Sanqiang. In 1960, while visiting Fudan University in Shanghai, Qian tried to recruit Yang into the nuclear weapons program in Beijing. Fudan was reluctant to let Yang go. Qian agreed that Fudan University had important contributions to make to Chinese science and that Yang should stay at Fudan. It was Qian who later nominated Yang for a postdoctoral fellowship to study at the Institute of Theoretical Physics in Copenhagen from 1963 to 1965,[14] where he developed a friendship with American physicist Ray Nix.

When Harold Agnew left Los Alamos in June 1979, he turned the lab's China connection over to George A. (Jay) Keyworth, physics division leader at Los Alamos. Yang Fujia invited Keyworth to visit Fudan University. During a 1980 trip to Fudan, Keyworth was introduced by Yang to colleagues in the Chinese nuclear weapons program. Keyworth became President Reagan's science advisor in 1981. He passed the China contact at Los Alamos on to John Browne, his successor as physics division leader. Keyworth made an official visit to China in 1983 when he was President Reagan's science advisor.

In the meantime, in October 1981, Louis Rosen who had been recruited to Los Alamos during the Manhattan Project and now was the director and driving force of the Los Alamos

[13] Century Magazine focus on 2022-11-01. Original Huo Sitong Yangliu Century Magazine.
[14] Taken from Yang's description as repeated in his Century Magazine obituary.

Meson Physics Facility (LAMPF) was invited to China for a four-week tour to give lectures, visit scientific facilities and tour cultural sites, accompanied by his wife in October 1981. In the 1960s, Rosen had convinced the Atomic Energy Commission and Los Alamos laboratory management to build the world's most powerful, high-intensity-proton linear accelerator. This accelerator, the centerpiece of LAMPF, was capable of producing Pi-mesons at intensities up to 10,000 times over those produced by any other accelerator then in use. These mesons would be used to probe the structure and function of the nucleus and would keep Los Alamos at the forefront of nuclear physics for decades.

Rosen and colleagues turned LAMPF into a basic research user facility that regularly hosted about 1,000 external users annually, making international participation routine rather than exceptional. By the late 1980s, Chinese scientists were on-site at LAMPF as users/visitors from multiple Chinese institutions, including the Institute of Atomic Energy (CIAE), the Institute of High Energy Physics (IHEP), Nanjing University, and the Institute of Nuclear Research, Chinese Academy of Sciences.[15]

During his October 1981 trip to China, Rosen, a strong advocate for international scientific cooperation (having been one of the original members of the U.S.-USSR Joint Coordinating Committee for the Fundamental Properties of Matter), met with Chinese Vice Premier Fang Yi (then head of China's State Science and Technology Commission) who asked Rosen "if you had my job and you wanted to bring China abreast of the Western world in science and technology, what would you do?" Rosen responded "What I would do, Mr. Prime Minister, is each year identify some hundreds of the brightest young scientists and engineers and send them to centers of excellence in Europe, and Japan, and North America not for a day, or a week, or a month, but for at least a year, so that they can become immersed in frontier science and technology and most importantly understand the environment, the social and political environment, which is necessary for science and technology to prosper."[16]

Vice Premier Fang asked if Rosen would accept them at Los Alamos. Rosen quickly realized that was the primary reason that he was invited for such an extensive visit in the first place. Rosen said he managed to convince Washington that it was a good idea and Los Alamos was able to host longer-term Chinese scientists to work at LAMPF. He called it one of his most significant accomplishments. These collaborations at LAMPF marked the beginning of serious fundamental physics cooperation between Los Alamos and leading Chinese scientific institutes, which has served both countries well.

Strengthening cooperation on nuclear security.

Once China joined the IAEA in 1984, it opened another front of collaboration with the DOE nuclear laboratories to develop expertise in nuclear safeguards. The China Institute of

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[15] The "LAMPF Visitors During 1988" in the LAMPF annual report appendix include Chinese scientists Shaofei Lin (CIAE), Jianyang Liu (CIAE), Xijun Qiu (Academia Sinica), Xi-Zhang Feng (Institute of High Energy Physics), and Zongynan Zhou (Nanjing University).

[16] Voices of Manhattan Project, "Interview with Louis Rosen." https://ahf.nuclearmuseum.org/voices/oral-histories/louis-rosens-interview/

Atomic Energy (CIAE) was responsible for the technical aspects of China's compliance with the NPT after China joined the NPT in 1992. It was China's primary link to the IAEA. At DOE's direction, several of its laboratories began collaboration with the CIAE to develop nuclear measurement instrumentation and safeguards systems technologies in 1984. The Los Alamos National Laboratory began to work with the IAEA when Los Alamos safeguards pioneer Robert Keepin spent two years at the IAEA as Deputy Director General for Nuclear Safeguards in the early 1960s. His work at Los Alamos and the IAEA emphasized the practical deployment of nondestructive analysis (NDA) techniques (ones that can quantify, identify, or characterize nuclear materials without physically or chemically destroying or altering them) into IAEA safeguards practices that are used to independently verify that countries honor their legal commitments not to use nuclear material or technology for nuclear weapons. Keepin visited China in September 1984 to establish cooperation in nuclear safeguards.

Beginning in 1984 the DOE supported exchange visits and training for Chinese scientists at several DOE laboratories. These included Chinese participation in courses on State Systems of Accounting and Control (a national framework of administrative and technical measures used by a country to track and regulate its nuclear material.) DOE lab scientists visited China to present lectures and take part in discussions on nuclear materials control and accountability (MC&A), nondestructive assay (NDA) safeguards instrumentation, and IAEA safeguards. In addition, the DOE approved extended visits by Chinese safeguards specialists to its laboratories. By July 1994, five Chinese scientists had completed extended safeguards visits to Los Alamos and/or Brookhaven national laboratories (which subsequently also involved the Pacific Northwest National Laboratory). These Chinese scientists, led by Prof. Sun Zuxun who had spent a year on sabbatical leave at LAMPF and made several safeguards focused visits to Los Alamos, formed the foundation of China's safeguards system. They also established nuclear materials accountability programs, applied first to China's two nuclear power plants (the Qinshan and Daya-Bay plants).[17]

The early collaborations in nuclear safeguards and MC&A formed the foundation for continued collaboration between China and the United States in the civilian arena. It expanded with time to include many other areas, such as safety of radiation sources and preventing nuclear terrorism. The CIAE served as the principal technical arm for China's Center of Excellence for nuclear security in the 2010s. Without doubt, early outreach by the U.S. government to the Chinese nuclear establishment helped bring China into the modern era with regard to nuclear security. China's strong participation in related IAEA activities also played an essential role.

By 1994, China had joined the IAEA and signed the Nonproliferation Treaty and made progress toward meeting its nonproliferation obligations, but its nonproliferation behavior was still problematic. Export controls were weak and opaque. Some unsafeguarded

[17] G.W. Eccleston, E. Heaton, and R. Kempf, "Chronology of United States and Chinese Technical Safeguard Interactions," Informal Los Alamos report, July 26, 1994 (available from the author on request).

nuclear transfers and nuclear assistance to Iran and Pakistan continued. Domestic MPC&A was inadequate across China's civil and defense nuclear complexes. Domestic turmoil in the late 1980s underlined risks surrounding the security of nuclear weapons and material. The United States saw it in its interest to encourage and assist China in improving its nuclear security and nonproliferation practices. That occurred along parallel tracks—one through the Chinese civilian nuclear agencies, primarily the China Institute of Atomic Energy (CIAE), and the other through Chinese defense organizations, primarily the nuclear weapons program of the China Academy of Engineering Physics (CAEP).[18]

Yang Fujia, the Chinese nuclear weapons program and Los Alamos

As nuclear safeguards and scientific collaboration between China and Los Alamos flourished, Yang Fujia continued to forge ties between Los Alamos and the Chinese nuclear weapons establishment. Beginning with his first visit to Los Alamos in 1978 as a member of the Chinese delegation, invited by the U.S. National Academy of Sciences, it became clear that Yang was determined to forge close relations between Los Alamos and China's nuclear community. Over the years, he demonstrated detailed knowledge of China's nuclear weapons program, especially its test history, in his interactions with Los Alamos scientific staff. Yang had arranged a visit by Harold Agnew to the Lop Nur nuclear test site in 1982. In 1983, Yang invited John Browne, at the time leader of the Physics Division at Los Alamos, to visit China to keep the link to the Los Alamos nuclear weapons community alive. Browne visited Fudan University and several nuclear weapons program sites in 1985.

In June 1988, Professor Yang Fujia, by now an eminent nuclear physicist and international scholar, returned to the Los Alamos National Laboratory during my directorship of the laboratory (1986 through 1997) with five eminent scientists from CAEP (Dr. Zhang Deliang, Peng Hansheng, Yu Min—father of Chinese hydrogen bomb, Tao Zucong, and Zheng Shaotang). Yang Fujia's obituary, cited previously, featured a photo of the six Chinese visitors at Los Alamos. It was my first interaction with Chinese nuclear weapons program scientists.

In 1989, Yang Fujia again visited Los Alamos while Jay Keyworth, then based in Washington, D.C., was also visiting at the laboratory. Keyworth introduced John Hopkins, leader of the Los Alamos nuclear weapons program and formerly head of Los Alamos nuclear test program, to Yang Fujia, who invited Hopkins to visit the Lop Nur Nuclear Test Site. However, the trip was postponed because of China's suppression of the Tiananmen Square protests in the spring of 1989.

In June 1990, John Hopkins, with his wife Adele (an actinide chemist), and Los Alamos colleagues, H.T. Hawkins and Danny Stillman, and DOE Intelligence official, Robert Daniel, visited Lop Nur at the invitation of Yang Fujia. This visit strengthened relations between the Chinese CAEP and the Los Alamos National Laboratory. Hopkins and colleagues visited

[18] Wen L. Hsu, "The Impact of Government Restructuring on Chinese Nuclear Arms Control and Nonproliferation Policymaking," *Nonproliferation Review,* Fall 1999, p. 152.

several other CAEP sites, (including the CAEP Institute in Mianyang, Sichuan Province in the Southwest). The access Los Alamos visitors were given to the jewels of China's nuclear weapons program was extraordinary, especially since the Chinese knew that only John and Adele Hopkins were full-fledged Los Alamos nuclear weapons scientists. The other three had legitimate nuclear weapons credentials but were all associated with American foreign intelligence analysis.

It appears that along with the rest of the country, the nuclear weapons establishment followed Deng Xiaoping's China policy of "Reform and Opening Up." It was a key part of what Premier Zhou Enlai called the "Four Modernizations" —namely for Industry, Agriculture, National Defense, and Science & Technology. It was Zhou who insisted that China learn from advanced foreign science and technology while concurrently combining that with domestic creativity. After the Soviet-Sino split, he urged fellow citizens to learn from all countries. Yang Fujia must have taken all of this to heart as he courted relations with Los Alamos. We learned much more about the Chinese CAEP's motives for developing scientific ties during subsequent visits to China.[19]

In February 1994, Yang Fujia brought five visitors associated with the Chinese nuclear weapons program (including Gen. Qian Shaojun, head of the Commission on Science, Technology, and Industry on National Defense (COSTIND) and Dr. Hu Side of the CAEP) to the Los Alamos laboratory for discussion and tour of scientific facilities. They also visited the Lawrence Livermore and Sandia national laboratories. They had requested to visit the Nevada Test Site in reciprocity to the Hopkins visit to Lop Nur in 1990, but the DOE did not approve. Nevertheless, Yang Fujia invited me to visit Fudan University of which he had been appointed as president. General Qian also agreed to see me in Beijing.

In March, I visited Fudan University. I was eager to visit China's nuclear sites primarily because of my concerns about the security and safeguards of its nuclear materials in the weapons complex. It was just over two years prior that the Soviet Union dissolved resulting in Russia experiencing enormous political, economic and security turmoil. The U.S. government initiated the Nunn-Lugar Cooperative Threat Reduction program with Russia and several of the other former Soviet States to assist them to keep their nuclear weapons, materials, facilities and experts safe and secure. With our colleagues at the Lawrence Livermore and Sandia national laboratories, Los Alamos initiated a lab-to-lab cooperative program to work directly with the Russian nuclear weapons institutes to help them manage the enormous security risks.[20] The China visit, I hoped, would allow me to assess how big

[19] The motives of the Chinese scientific enterprise of seeking out Americans to learn as much as they could both about what the Americans did and how they did it is explained in the comprehensive Chinese book edited by Xie Guang, *"China Today: Defence Science and Technology,"* National Defence Industry Press, Beijing, 1993.
[20] Siegfried S. Hecker, ed. *Doomed to Cooperate: How American and Russian Scientists Joined Forces to Avert Some of the Greatest Post-Cold War Nuclear Dangers.* (Los Alamos Historical Society Bathtub Row Press, 2016).

these risks were in China's nuclear defense complex and if we could help to alleviate the risks.

It was my first trip to China. At Fudan University, discussions focused on scientific research. Although Chinese scientific development had been hindered by China's isolation and Mao's Cultural Revolution, as well as the aftermath of the 1989 Tiananmen Square protests, they were now moving out smartly on all fronts—and everything was being done at scale—from the number of students being educated, to the number of institutes being established, to the burgeoning industrial sector with virtually every American high-tech company setting up shop in China.[21]

In Beijing, I visited the China Institute of Atomic Energy (CIAE) and the CAEP Institute of Applied Physics and Mathematics (IAPCM). At the CIAE, run by the Chinese Academy of Sciences and the state's China National Nuclear Corporation (CNNC), I was hosted by CIAE president Sun Zuxun. He was one of the early Chinese visiting researchers at the Los Alamos LAMPF facility in 1982-83 and had brought a Chinese scientific delegation to Los Alamos in 1991. He appeared proud of never having been associated with the military program and told me that his institute does no defense work. It was founded in 1950 as the Institute of Modern Physics and has not been involved in weapons research since 1970.

A tour of their experimental facilities showed the influence of early Soviet cooperation — even the new buildings looked old and run down. Nuclear safety and security practices were lax or non-existent. That has changed dramatically as I have observed during some 40 visits in thirty years since.

The IAPCM is responsible for the theoretical research, modeling, and simulation of nuclear warheads under the jurisdiction of the CAEP. It is closely aligned with the principal CAEP institute in Mianyang. I had not met their leaders or scientists before. I did not meet with Hu Side, who visited Los Alamos in February, because he had just transitioned from the director of IAPCM to CAEP director in Mianyang.

I was surprised by how well connected IAPCM's scientists were with the outside world. For example, then director, Fu Hongyuan, had studied applied mathematics in Berlin. Deputy Director Du Shuhua had visited Los Alamos before and Prof. Zheng Shaotang had visited Los Alamos in 1984 and 1988. Prof. Shen Longjun, director of computational physics, spent a year at Yale University in 1983. Others had attended a recent American Physical Society meeting and met several Los Alamos ICF (Inertial Confinement Fusion) scientists. I also met Ms. Sun Xiangli, who was a master's student at IAPCM and later had visiting appointments with Prof. John Lewis' group at Stanford University. She has become one of

[21] S.S. Hecker, "Travel file 1994: Trip to Japan and China," Los Alamos National Laboratory archives, (available from the author on request).

the foremost experts on China's nuclear weapons policy[22] and the director of the Arms Control Research Division at the Center for Strategic Studies (CSS) of the China Academy of Engineering Physics.

In Beijing, I also met with Prof. Du Xiangwan, who was the vice president of the CAEP institute in Mianyang (and later became the vice president of the China Academy of Engineering). He was interested in cooperation with Los Alamos in arms control and nonproliferation. Du had represented China in Pugwash arms control seminars in Beijing.[23] He knew many of the American Pugwash leaders, such as Pief Panofsky, Frank von Hippel and Sid Drell. He had met Los Alamos leaders Harold Agnew, John Hopkins, Terry Hawkins and Danny Stillman during their visits to China. Du and I held wide-ranging discussions about challenges in the nuclear weapons enterprise. He was certain that China would sign the Comprehensive Test Ban Treaty (CTBT) but not until they conducted a few more nuclear tests (which they did before signing the CTBT in 1996). Du mentioned that the CAEP also collaborated with the Russian nuclear weapons institutes in areas such as explosively-driven pulsed power fusion research—like what Los Alamos was doing with the Russians at the time.[24]

At dinner discussions with Gen. Qian Shaojun, he told me that he was very pleased with his visit to Los Alamos and the other laboratories earlier in the year. Prof. Du's parting comments to me were "we are writing a paper together, and today we finished the introduction." They were expecting me to return soon. I was also eager to do so to get a closer look at China's nuclear weapons complex.

Indeed, that was initiated again by Yang Fujia. But first there was the matter of reporting back to Washington to see if I could convince key people in the government to support taking the next step in cooperation with the Chinese nuclear enterprise. We were fortunate to have Charles Curtis as the new Under Secretary of Energy as of February. He was very supportive of the lab-to-lab cooperation we were developing with the Russian nuclear weapons laboratories. My Los Alamos colleagues and I prepared a white paper on collaborations with China for his review[25] that I presented to Curtis in Washington in June.

The white paper reviewed the history of interactions between Los Alamos and the Chinese nuclear enterprises—both with civilian and defense institutions and scientists. The leaders

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[22] Sun Xiangli, *"New Challenges and a New Agenda for China's Arms Control."* https://doi.org/10.1142/9781938134050_0009

[23] Pugwash is an international network of scientists and public figures working—informally and across political divides—to reduce the risk of armed conflict, especially nuclear war.

[24] Over the years, I picked up several signs of close cooperation between the Russian and Chinese nuclear weapons institutes in the 1990s and beyond. It is apparent that at some point, most likely after the dissolution of the Soviet Union in December 1991, China and Russia reversed the complete separation of their nuclear weapons programs following the Soviet-Sino split.

[25] S.S. Hecker, "White Paper on Collaborations with China" prepared for Under Secretary Charles B. Curtis, May 31, 1994 (Los Alamos National Laboratory archives). Available from the author on request.

of the CAEP and COSTIND (associated directly with the military) were both eager to develop a better dialogue and look for areas of collaboration for mutual benefit. They were interested in collaborating in scientific research, nonproliferation research and analysis, and commercialization of laboratory technologies (which with the end of the Cold War had become a major topic at the DOE defense laboratories). We also received some overtures for collaboration in areas of nuclear weapons safety and security. Our Chinese colleagues were certain of China's intent to sign the Comprehensive Test Ban Treaty (CTBT), considered by the Clinton administration as one of the most important arms control agreements.

Based on our interactions and discussions with representatives of the Chinese nuclear weapons enterprise, we concluded that China's nuclear arsenal was built primarily with a focus on reliability. Safety was assured by operational means rather than by inherent safety by design. For example, it appeared that one-point safety[26] was not designed into their nuclear weapons, leaving them vulnerable to a variety of nuclear accidents and terrorist risks. They also apparently had not yet introduced insensitive high explosives into their weapon designs, making them dependent on strict operational safety protocols. As mentioned above, during Harold Agnew's visit to the Chinese nuclear test site, the Chinese specialists had expressed their interest in acquiring permissive action link (PAL) technology, which Agnew supported but was not able to convince the U.S. government to do. In the white paper, we opined that by 1994 the China may have received assistance with PALs from Russia.

The white paper made the case to Curtis (with copy to Energy Secretary Hazel O'Leary) that the DOE's strategic thrust of *reducing the global nuclear danger* requires cooperation with other nations. The principal American motives for collaboration with Russia and China were to enhance the safety and security of their nuclear enterprises and limit the proliferation of nuclear weapons, nuclear materials and nuclear weapons knowledge. These were the key drivers for the U.S.-Russia lab-to-lab program as well as a China lab-to-lab program, although with significant differences.

The U.S.-China Lab-to-Lab Technical Exchange Program.
Developing collaborations in nuclear nonproliferation practices and nuclear materials safeguards as well as preparing the way to the CTBT were in line with Clinton administration priorities and were supported by the U.S. State Department. Our proposal for developing lab-to-lab cooperation in these and related areas were strongly supported by DOE Under Secretary Curtis. It was also in step with a tri-lab effort by Los Alamos, Lawrence Livermore, and Sandia national labs to establish such an effort with the Chinese. The tri-lab effort was formed after the high-level Chinese CAEP delegation visited the three laboratories in February, subsequent to which a tri-lab steering committee was established and built on the Los Alamos white paper to develop a proposal of "Greater Cooperation

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[26] One-point safety is the requirement that if a nuclear weapon's high explosive is accidentally detonated at any single point, the weapon will not produce a significant nuclear yield.

with China — A Proposal for Lab-to-Lab Interactions" dated July 21, 1994 prepared for Gail Bradshaw of DOE NN-41, Negotiations and Analysis Division.

Under Secretary Curtis received the necessary support from the State Department by having key people in the DOE, such as Ken Luongo and Gail Bradshaw, work with Robert Einhorn, Deputy Assistant Secretary of State for Nonproliferation, Bureau of Political-Military Affairs. Einhorn issued the letter of approval for establishing scientific interactions between scientists at the DOE nuclear weapon laboratories and their counterparts in China in late July. In a 1998 article of the *Nonproliferation Review*, Sandia National Laboratory engineer, Nancy Prindle, states that the "U.S.-China Lab-to-Lab Technical Exchange Program" was born based on a July 1994 letter by Deputy Assistant Secretary of State Einhorn requesting the Department of Energy to establish scientific interactions with China."[27] Well, it wasn't quite that simple. It was the culmination of more than a decade of interactions between the scientists of DOE defense labs and the Chinese nuclear labs. It was based on our white paper to Under Secretary Curtis and the subsequent tri-lab steering committee proposal. Nevertheless, Einhorn's letter provided formal authorization to begin the program.

The next key step was my visit to the CAEP in Mianyang and several nuclear weapons organizations in Beijing. Again, it was Yang Fujia who initiated the invitation, except now he handed the visit over to Hu Side, who had just become head of the CAEP in Mianyang. Interestingly, in Yang's fax to me on May 22, 1994, he stated that Hu Side will handle the visit and although he (Yang Fujia) does not wish to be involved, he wanted to give me some advice. That advice was that if I come as a scientist, I will be able to work with Hu Side and the CAEP. If I come as an official, I need to contact COSTIND in Beijing directly. Then he added, "no mixing." Any official contact must be with COSTIND. In other words, scientific cooperation can be done directly. Official business must be conducted with the government. That was consistent with my experience, both in China and in Russia.

With this advice, Yang Fujia, who had been instrumental in establishing contact between the CAEP and Los Alamos, faded out of the picture. I met him again many years later when he had been asked to join the Board of the Nuclear Threat Initiative, a global security nonprofit dedicated to reducing nuclear/biological threats, located in Washington, DC, for which I was a Science Advisor.

On June 23, Director Hu Side sent me the formal invitation via fax to visit with four or five Los Alamos colleagues for 10 days in October. He thanked me for the warm hospitality extended to him and his colleagues when they visited Los Alamos in February and added that he viewed the upcoming visit "as a new step toward strengthened friendship and increased science—technology exchanges and cooperation between CAEP and LANL."

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[27] Nancy Prindle, "The U.S.-China Lab-to-Lab Technical Exchange Program, *The Nonproliferation Review/Spring-Summer 1998,* p. 111.

I traveled to China during the first week of October 1994 with four colleagues who presented talks in the areas of theoretical science (Richard Slansky), nuclear weapon stockpile stewardship (Rod Schultz), nonproliferation (H. Terry Hawkins), and environmental restoration programs (James Shipley). The Chinese gave similar overviews with emphasis on shock-wave physics, inertial confinement fusion (ICF), X-ray lasers, accelerator technologies and free-electron lasers, nonproliferation, and environmental protection.

The discussions, including ones during lunches and dinners, gave us valuable insight into China's nuclear weapon establishment, far beyond anything the U.S. had ever been given. We found the Chinese nuclear scientists to be much like us—motivated to do the best for their country's security and always putting a premium on doing good science, with the full realization that it must be done through international cooperation. They were keen on developing science cooperation with us at Los Alamos and the other DOE defense labs. Their scientists were candid, inquisitive, fully engaged, open and did not shy away from what we thought would be sensitive subjects, such as Tiananmen Square protests. They told us they were formulating an approach to nuclear weapons stockpile stewardship for the anticipated no-test environment in a manner similar to what we were doing in the United States. They said the time remaining before the expected signing of the CTBT was crucial, especially to be able to conduct a few more tests for what they said were nuclear weapons safety improvements.

I didn't know at the time that during the week we were in Mianyang, the CAEP conducted a nuclear test at the Lop Nur test site. In a recent book,[28] Harvard researcher Hui Zhang describes the nuclear tests conducted by China from 1992 to 1996, a period during which only China and France conducted nuclear tests. The United States, the UK and Russia observed self-declared moratoria on nuclear testing. According to Zhang, the seven tests[29] conducted by China were instrumental in modernizing its nuclear arsenal. The October 7, 1994 test at Lop Nur was called 21-811 by the Chinese. Zhang reports that the test was conducted to demonstrate the key principles for advanced, second-generations warheads, a substantial step forward that in subsequent years would enable China to build multiple warhead missiles. It wasn't until the July 29, 1996 test that China claimed to have demonstrated using insensitive high explosives in their nuclear devices, a very important safety improvement. Interestingly, in his book, Zhang displays a photograph of Hu Side outside the test tunnel likely for the preparation of that test. At the time of the October 1994 test, however, Hu hosted our Los Alamos delegation in Mianyang.

The visits to their labs, including some remote sites, were informative. The facilities were quite primitive, much like what I found in visits to the Russian nuclear weapons complex

[28] Hui Zhang, *The Untold Story of China's Nuclear Weapon Development and Testing*, MIT Press, 2025.
[29] Previous test history indicated that China conducted six nuclear tests during this time for a total of 45 nuclear tests. Zhang makes a convincing case that on June 8, 1996, China conducted two tests simultaneously, not previously known—thus giving the Chinese a total of 46 nuclear tests.

during the previous two years. Yet, they had clearly followed the developments in the United States, Russia and France on what new facilities and capabilities will be needed for a stockpile stewardship program once nuclear testing stops. Some of their experimental facilities were hidden in the hills (amidst the local pandas), having been located there after the Soviet-Sino split because they were concerned that the Soviets might bomb their sites. The CAEP had unusual flexibility in its charter and operations. It appeared to be self-regulated and self-inspected. We saw nothing during the trip, however, to question their claim of good safety and environmental record of operations.

In Beijing, we visited the IAPCM and had dinner and discussions with top officials from COSTIND, the military arm of the program. We also met three of the five senior (and legendary) scientific advisors to the CAEP—Wang Ganchang (who was responsible for the initial invitation for Harold Agnew to visit China), Yu Min, and Chen Nengkuan. General Huai Gaomu, the Vice Minister of COSTIND, stressed his support for collaboration between the CAEP and the United States.

I sent a detailed trip report to Charles Curtis upon my return and discussed the trip with him in person during my next visit to Washington. The China trip set the stage for potential future collaboration in science and technology of mutual interest. I reported that the CAEP had surprising independence. For example, the director had signature authority for foreign visits and collaborations with external scientific institutions and private companies (so long as these complied with Chinese law). Only when officials from foreign governments were involved did approval have to come from higher government officials. (This was precisely the advice I received from Yang Fujia). I concluded at the time and relayed this to Curtis, that the visit opened the potential of carefully chosen laboratory-to-laboratory collaborations between the U.S. and China.

I shared with Curtis the list of areas of potential collaboration between the CAEP and Los Alamos as compiled in a memo by our Chinese hosts. These included:

- Sustainable environment strategy study.
- Accelerator technology and applications.
- Laser technology and Inertial Confinement Fusion (ICF).
- Shock wave physics and materials studies.
- Computational physics.
- Neutron scattering for materials science and bioscience.
- Nuclear proliferation and safeguards of nuclear materials.
- Commercialization of technologies.

My recommendation to Curtis was that a lab-to-lab cooperative program should focus on the following areas for initial engagement:

- Scientific research (that is always the best place to start to build trust and a working relationship).
- Defense conversion. We had concluded that the best area would be in sustainable development.

- Nonproliferation. Technologies for better nuclear materials control and accountability were of highest priority.
- Nuclear weapons safety. Our Chinese hosts expressed particular interest in collaborating in areas such as intrinsic nuclear weapons safety and security.

Parallel with my recommendations to Curtis, the tri-lab steering committee worked with DOE and the State Department to define next steps with China. The steering committee developed a comprehensive proposal for lab-to-lab cooperation with the Chinese institutes involved in nuclear weapons activities. The Los Alamos representatives to the steering committee expressed concerns to me that what was to be a lab-to-lab program with the Chinese institutes would be overly structured and controlled by U.S. government agencies and look nothing like the lab-to-lab relations we had developed with the Russians, and what was envisioned by Charles Curtis and me.

Although I had high-level support from key individuals in the Clinton administration, the government bureaucracy was stifling. The State Department decided to keep the initial cooperation focused narrowly on nonproliferation and nuclear safeguards. The DOE instructed its laboratory scientists to coordinate all their interactions carefully with a U.S. interagency oversight group to ensure they are consistent with and supportive of U.S. China policy. Officials from the State Department, DOE, Department of Defense (DOD), National Security Council (NSC), Office of Science and Technology Policy (OSTP), and Arms Control and Disarmament Agency (ACDA) sat on the interagency oversight group. I had hoped that we could get more freedom of action from the government agencies by appealing directly to Charles Curtis, Deputy Secretary of Defense John Deutch, Assistant to the Secretary of Defense (Atomic Energy) Harold Smith and the State Department's director of the Arms Control and Disarmament Office, John Holum. Curtis was supportive but most of Washington was concerned about Chinese espionage and potential Chinese links to the missile and nuclear programs of Pakistan and North Korea.

Not only were our interactions heavily scrutinized by the interagency process, but the DOE bureaucracy chose to expand the tri-lab effort to its other multiprogram laboratories that had expertise in nuclear materials safeguards. The Chinese decided to similarly involve its civilian laboratories, such as the China Institute of Atomic Energy. At Los Alamos, we had to work within the interagency process and develop programs of cooperation in the approved areas. But in the process, we lost the close ties we had built with the Chinese nuclear weapons research and development scientists through reciprocal visits. We were not able to follow up on specific areas of scientific research discussed during our October visit and in subsequent correspondence. We hoped that once we were able to demonstrate productive collaborations in the permitted areas, we could return to what we had outlined during my October 1994 visit.

Nevertheless, collaboration in the nuclear sphere between U.S. and Chinese institutes began.[30] The Chinese established a steering group, which began meeting with counterparts from the United States in 1995. A series of workshops to identify common interests began in 1996 with joint projects beginning in 1997.[31] Mutually agreed objectives for cooperation included joint development and deployment of modern technology to benefit arms control and nonproliferation, building trust through better understanding of the operations and management of nuclear facilities in both countries, and establishing long- lasting professional relationships. Activities were carried out through formal meetings, workshops, and scientific exchanges such as lab visits and demonstrations. Topics for cooperation fell into several broad categories:

- Nuclear materials protection, control and accounting (MPC&A).
- Verification technologies to ensure compliance with agreements.
- Cooperative monitoring technologies.
- Export control.
- Energy and environment.

During the first two years, the program sponsored five major workshops, along with many smaller meetings.[32] The most important activity was the joint demonstration with the CIAE of MPC&A (nuclear materials protection, control and accounting) technologies for securing and safeguarding nuclear materials. It was held during one week in June 1998 at the CIAE in Beijing. The objective was to demonstrate to Chinese government and nuclear industry officials how technologies could be integrated in a comprehensive system for protecting nuclear materials. This demonstration was a major step toward greater nuclear scientific cooperation. The program had taken on several names. At the U.S. defense labs, we called it U.S.-China lab-to-lab cooperation. Others called it CLL, China lab-to-lab, and the U.S. government called it CACE, China Arms Control Exchange.

At Los Alamos, we were developing possible next steps for lab-to-lab cooperation and shared these with the DOE leadership. We had lost the most supportive official in the department when Charles Curtis, by then the deputy secretary, left the DOE in 1997. However, we gained a knowledgeable and influential supporter when MIT professor Ernest Moniz became Under Secretary in 1997. We made the case for expanded cooperation, first in programs such as nuclear materials safeguards, export control methodologies and proliferation-resistant fuel cycles. We proposed direct scientific and technical exchanges in areas such as CTBT verification, but also for wider scientific fields, such as environmental science and nuclear waste disposal. We believed these wider collaborations would be a good vehicle to establish the level of trust required to

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[30] Nancy Prindle, *Op. cit.*

[31] Arian L. Pregenzer, "Technical Cooperation on Nuclear Security between the United States and China: Review of the Past and Opportunities for the Future," Sandia National Laboratories Report, SAND2011-9267, December 2011.

[32] Wen L. Hsu, "The Impact of Government Restructuring on Chinese Nuclear Arms Control and Nonproliferation Policymaking," *The Nonproliferation Review/Fall 1999,* p. 152.

collaborate on the more sensitive nuclear topics such as nuclear weapons safety and security.

It all came crashing down with the Cox Report.
During the time that U.S. and Chinese nuclear experts were developing plans for increased cooperation, a Select Committee from the U.S. House of Representatives led by Rep. Christopher Cox (called U.S. National Security and Military/Commercial Concerns with the People's Republic of China —familiarly known as the Cox Commission) was formed in 1998. Its purpose was to investigate concerns over Chinese acquisition of sensitive U.S. missile and space technology from Loral Space & Communications and Hughes Electronics Corporation in connection with the launching of U.S. civilian satellites using Chinese launchers on Chinese territory. The issue was politically super-charged. Republican congressional members wanted to put the blame for the loss of sensitive technology on the Clinton administration's desire to engage China in strategic partnerships.

The missile technology exports and concerns about potential transfer of high-performance computing hardware and software were the trigger for the establishment of the Cox Commission. It was subsequently claimed that Loral did commit a serious export control violation and that China had gained "significant benefit" in improving the reliability of its launch vehicles—and by extension, ballistic missile guidance systems. Both Loral and Hughes were charged with violating the International Traffic in Arms Regulations (ITAR). In Jan. 2002, Loral settled with the government by paying a $14 million fine. Hughes was fined $32 million.

Although these concerns triggered the congressional investigation, they faded from public attention quickly. The investigation was broadened in October 1998 to include alleged security problems and possible espionage at the U.S. nuclear weapons laboratories resulting from revelations of a Chinese walk-in informant in 1995 to a U.S. CIA office in Taiwan. The walk-in provided evidence that the Chinese had acquired detailed information about the U.S. W-88 submarine-launched ballistic missile nuclear warhead and had information on seven U.S. nuclear warheads in all. It was suspected that the information came from the DOE defense laboratories. Information about the leak was closely held within the administration. National security advisor, Sandy Berger, was briefed in April 1996, and President Clinton was not informed until July 1997. Yet, to DOE's chief of counterintelligence, Notra Trulock,[33] it was the clarion call to go after Chinese nuclear spying. The DOE launched an investigation called "Kindred Spirit." Trulock was convinced that Chinese espionage and lax security at the laboratories led to the loss of information revealed by the walk-in Chinese informant. Trulock became a star witness for the Cox Commission and helped shape its findings.

[33] Before joining the counterintelligence office at DOE, Trulock spent several years in the counterintelligence office of the Los Alamos National Laboratory during my directorship of the laboratory. He left the laboratory allegedly because he was passed over for a promotion.

The Cox Commission Report, "U.S. National Security and Military/Commercial concerns with the People's Republic of China" was released in classified form on January 3, 1999.[34] Although the nuclear warhead spying revelations from the walk-in spy constituted only a small section of the voluminous Cox Report, they were featured in U.S. news media.[35] The report concluded that China had stolen design information on the United States' most advanced thermonuclear weapons, elements of which could be emulated by China in its next generation intercontinental ballistic missiles (ICBMs). The New York Times headline in the March 6, 1999 story by James Risen and Jeff Gerth, "BREACH AT LOS ALAMOS: A special report; China Stole Nuclear Secrets For Bombs, U.S. Aides Say" was a blockbuster and set off a political firestorm. In an unusually long *correction* on the Risen/Gerth article, however, the New York Times in January 2000, stated that "we fell short of our standards in our coverage of this story."[36]

Unfortunately, by the time of the correction, much of the damage of the story of Chinese spying at the Los Alamos lab had already been done. In the initial story, Risen and Gerth reported that the FBI had focused its suspicions on a Chinese American scientist at the Los Alamos National Laboratory. Two days later, the government announced that it had fired a Los Alamos scientist for ''serious security violations.'' Officials identified the man as Dr. Wen Ho Lee. Lee was indicted nine months later on charges that he had transferred huge amounts of restricted information to an easily accessible computer, although not for passing on this information to China. Although not charged with espionage, Lee was a primary suspect in an espionage investigation by the Justice Department, whose prosecutors persuaded a judge to hold him in solitary confinement without bail, stating that his release would pose a grave threat to the nuclear balance. Lee later pleaded guilty to one felony count of mishandling restricted nuclear weapon information and was released by the judge with an apology. To me, calling it a mishandling of restricted data did not do justice to the egregious security violations in which Lee engaged for many years while under the "watchful" eye of the FBI.

The Cox Report, the New York Times article and the Wen Ho Lee story with its sensational espionage accusations were prominent in national security news for several years. Many more inquiries were mounted, countless articles written, along with many books. I was no longer in charge of the Los Alamos laboratory when the New York Times article appeared. I returned to the research world at Los Alamos in November 1997 as a senior fellow. My successor, Dr. John Browne, had the misfortune of having to face extraordinary pressure

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[34] https://www.govinfo.gov/content/pkg/GPO-CRPT-105hrpt851/pdf/GPO-CRPT-105hrpt851.pdf?utm

[35] First report was in the Wall Street Journal in January 1999, but major story was in the New York Times on March 6, 1999, https://www.nytimes.com/1999/03/06/world/breach-los-alamos-special-report-china-stole-nuclear-secrets-for-bombs-us-aides.html

[36] https://www.nytimes.com/2000/09/26/us/from-the-editors-the-times-and-wen-ho-lee.html. The New Times stated that it showed insufficient skepticism toward government sources and partisan claims. It admitted a lack of balance and completeness in presenting the case. Among other shortcomings, the paper acknowledged it should have pushed harder to uncover weaknesses in the FBI's investigation.

from the government and the news media. Suffice it to say that the sensational accusations of Chinese espionage at Los Alamos were not proven then, nor have they been proven in the intervening nearly thirty years.

The problems with the Cox Report and the government's handling of the report were detailed in several investigations. A group of scholars at the Stanford University's Center for International Security and Cooperation faulted the Cox Report for making sweeping, alarming claims without adequate evidentiary context—leaving readers unable to judge how much China actually learned from espionage vs. open sources and leading to overstated or unwarranted conclusions. The Stanford Group concluded that "Some important and relevant facts are wrong and a number of conclusions are... unwarranted."[37]

A prestigious government panel headed by Admiral David Jeremiah concluded the following in its report to the Director of Central Intelligence:
- China did obtain classified U.S. nuclear-weapons information by espionage, which likely accelerated aspects of China's future nuclear-weapons development by letting it "focus down critical paths." The information included at least basic design information on several modern U.S. reentry vehicles, notably the W88 (Trident II).
- The panel judged it more likely China used U.S. information to inform its own designs rather than to copy U.S. warheads directly.
- Despite aggressive collection, there was no evidence at that time of modernization in China's deployed strategic force attributable to the stolen data (e.g., no MIRV—Multiple Independently Targeted Rentry Vehicles—deployment yet), though U.S. information could help MIRV development on future mobile missiles.
- Don't throw out scientific contacts: It urged a separate net assessment of U.S.–China formal and informal lab contacts (and with Russia), noting their potential value for safety, command-and-control, and nonproliferation—even while protecting secrets.[38]

Unfortunately, this sensible, authoritative assessment got lost in the political firestorm and news media frenzy, especially once Wen Ho Lee was incarcerated and went to trial. The most recent assessment of Chinese nuclear testing history[39] corroborates the Jeremiah Panel findings that the Chinese likely used U.S. information acquired by espionage to inform its own designs rather than having copied U.S. warheads directly. Zhang shows how the last series of Chinese nuclear tests in the 1990s were used to make what the Chinese called "breakthroughs" in design for lighter, smaller, safer warheads. These were part of a systematic process the Chinese used to prepare their nuclear arsenal for the no-testing era ushered in by the CTBT. On the basis of current public knowledge, it is not possible to

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[37] https://cisac.fsi.stanford.edu/publications/cox_committee_report_the_an_assessment
[38] Jeremiah, D. E., Drell, S. D., Habiger, E. E., & Garwin, R. L. (1999). *Report of the Select Panel on the Department of Energy Intelligence Community Damage Assessment: The People's Republic of China's Acquisition of U.S. Nuclear Weapons Information*. Washington, D.C.: Office of the Director of Central Intelligence. Released April 21, 1999.
[39] Zhang, *Op. cit*.

assess how much China's nuclear weapons program actually benefitted from the weapons design information transmitted by the walk-in.

The last-stated conclusion from the Jeremiah Panel not to throw out scientific contacts was totally ignored by the U.S. government, especially members of Congress. The scientific environment at Los Alamos, as well as the other DOE laboratories, took an especially heavy hit. And, for the focus of this article, the nascent scientific cooperation between the U.S. and Chinese nuclear weapons laboratories—the lab-to-lab scientific cooperation—stopped. It has yet to recover a quarter of a century later.

Attempts to resurrect lab-to-lab cooperation.

On the American side, contacts with the Chinese were strongly discouraged by government agencies and Congress. The Chinese government terminated all contacts with the DOE laboratories for the next few years. The U.S. Nuclear Regulatory Commission (NRC) continued to collaborate with their Chinese counterparts on civilian nuclear energy, including a visit by NRC commissioner Jeffrey S. Merrifield in the spring of 2001.

By late 2003, the George W. Bush administration was developing good high-level relations with China. Secretary of State Colin Powell reflected the optimistic American view when he said, "U.S. relations with China are the best they have been since President Nixon's first visit."[40] That feeling was strongly reinforced when Chinese Premier Wen Jiabao visited President George Bush at the White House on Dec. 9, 2003. I thought it was time to resurrect lab-to-lab collaboration. I was eager to see how much progress China had made in implementing modern nuclear security and safeguards upgrades to its facilities. The events of 9/11 had also highlighted the importance of the security of nuclear weapons and materials—along with the need for greater international cooperation to prevent nuclear terrorism. In addition, resurrecting lab-to-lab visits would provide us at least some measure of transparency about each country's nuclear program. China's nuclear defense complex and nuclear policies were particularly opaque.

That opportunity came in an unexpected manner through a Stanford University colleague, Professor John W. Lewis. Lewis was professor of political science and co-founder of Stanford's Center for International Security and Cooperation (CISAC) and one of this country's foremost authorities on China and North Korea. He had traveled to both numerous times for Track 1.5 (non-official, non-governmental) meetings and discussions. He had developed connections to China's nuclear weapon enterprise while writing what was at the time the definitive history of China's nuclear weapons program.[41] The Cox Report did not affect Lewis' relations with China's nuclear organizations.

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[40] Colin L. Powell, "Remarks at the Elliot School of International Affairs," George Washington University, Washington, D.C. September 5, 2003.
https://20012009.state.gov/secretary/former/powell/remarks/2003/23836.htm

[41] John Wilson Lewis and Xue Litai, *China Builds the Bomb*, Stanford University Press, 1988.

In late 2003, Lewis was invited by his North Korean interlocutors to visit its Yongbyon Nuclear Complex. Lewis asked me to accompany him as his nuclear expert.[42] Through his China contacts, I was able to arrange to meet with Dr. Hu Side in Beijing upon my return home from North Korea in January 2004. Hu also invited me to a conference the IAPCM (at the time, Hu's home organization as a senior advisor to the CAEP) sponsored in conjunction with ISODARCO (an international, non-governmental educational organization that sponsored conferences and advanced study courses on international security, arms control, disarmament, and conflict resolution). Whereas CAEP contact with the DOE laboratories was terminated after the Cox Report, it continued Track 1.5 meetings with academics like Prof. Lewis and with the U.S. National Academies' CISAC via the Chinese Scientists Group on Arms Control (CSGAC).

In Beijing, Hu told me that he supported resuming technical cooperation with Los Alamos and the DOE weapons laboratories. We discussed cooperation in three general areas: 1) countering nuclear terrorism and nonproliferation, 2) nuclear materials security and safeguards, and 3) general scientific and technical collaborations. He was especially interested in jointly addressing potential terrorism problems for the upcoming 2008 Beijing Olympics. However, Hu said that since cooperation with the laboratories was officially suspended after the Cox Report, it will require an official letter from a senior official of the DOE to General Qian Shaojun (who was then in charge of China's nuclear weapons R&D and manufacturing program as a standing member of the Science and Technology Committee) to formally express the DOE's willingness to resume cooperation. Linton Brooks, the administrator of the DOE/National Nuclear Security Administration (NNSA)[43] had sent such a letter in late 2003, but Gen. Qian informed Hu that the letter must also specifically state two conditions – that "past cooperation between the DOE labs and the CAEP was (1) legal and (2) mutually beneficial."

These conditions became the stumbling block to resuming lab-to-lab cooperation. Whereas Administrator Brooks favored the resumption, he was not able to get Bush administration officials to put the two key conditions in a new letter. He reported that he could gain agreement that the cooperation was legal but could not overcome the belief that it could not have been beneficial because of the insinuations of the Cox report. Cox himself was by then the chairman of the Security and Exchange Commission and thus continued to be well regarded in Republican circles. After several attempts in 2005 and 2006, Brooks told me that the Chinese will just have to get over this. They should focus on the future, not the past. Dr. Hu explained to me why Gen. Qian would not budge. It turned out that whereas the Cox Report was very damaging for Los Alamos and the DOE laboratories, Dr.

[42] The visit to North Korea and my subsequent visits and analysis of North Korea's nuclear program are detailed in my book *"Hinge Points: An Inside Look at North Korea's Nuclear Program,"* with Elliot Serbin, Stanford University Press, January 2023.
[43] The NNSA, created in 1999, is a semi-autonomous agency within the U.S. Department of Energy responsible for maintaining the safety, security, and reliability of the U.S. nuclear stockpile, advancing nonproliferation efforts, and managing naval nuclear propulsion.

Hu told me that it was also very damaging for the CAEP, and to him and Gen. Qian personally.

At the time, the general Chinese public knew very little about the country's nuclear weapons program. The Cox Report accusations that espionage about the U.S. weapons systems was essential to advances made by China were widely circulated in the Chinese media—and generally believed by the public. So the main pioneers in the nuclear, missile, and satellite programs who may well have benefitted from some of the alleged espionage information, were discredited in the public's eyes. They even became the object of what amounted to snickering and near contempt from the populace. These pioneers felt personally wounded when even family and friends appeared to believe the Cox Report accusations. The Chinese government tried to help by arranging a gala meeting to give the nuclear specialists well-publicized honors and medals.[44]

At Los Alamos, I viewed the CAEP's interest to resume cooperation as a positive sign and began to prepare potential programs. In January 2004, DOE Secretary Spencer Abraham signed an agreement to cooperate with China in countering nuclear terrorism. I involved the lab's veterans from the 1990s cooperative programs with Russia to craft proposals to the DOE/NNSA. We developed a proposal that featured cooperation in the three areas listed above. In a return visit to China in July, I heard from Dr. Hu that whereas cooperation in all these areas was of interest, they wanted to extend collaboration much beyond counter terrorism and nuclear materials security and safeguards.

Dr. Hu said that whereas those areas were important for China's security, they were not the primary responsibility of the CAEP (and the IAPCM). Of the 20,000 CAEP employees, Hu told me that only about 100 were involved in MPC&A and related activities, most of them in the Beijing IAPCM. The primary responsibility of the CAEP, he said, was much like that of the DOE defense labs—namely, nuclear weapons stockpile stewardship. Hence, they were much more interested in developing collaborations in fundamental areas of science particularly now that they were observing the CTBT (although like the U.S., China signed the treaty but had not ratified it). Hu believed that fundamental science collaboration could be done without getting into classified areas. He added candidly that China's fundamental science program is much smaller than that of the United States. Cooperation would allow them to improve their science base and do it less expensively. I believed that cooperation in fundamental science would also be beneficial to us based on our experience of working with the Russian nuclear weapons institutes, even though China's science base was much smaller than ours or the Russians'. And as we found with Russian scientists, collaborating in fundamental science may open the door to more sensitive nuclear security areas such as nuclear terrorism and nonproliferation.

By August 2004, we proposed a slow and deliberate process for potential areas of collaboration with the CAEP. These included MPC&A, export control and second line-of-

[44] These comments were relayed to me in personal conversations with Chinese nuclear scientists.

defense against nuclear smuggling,[45] counter terrorism, arms control and nonproliferation, energy and environment, and fundamental science. For each area we evaluated the potential benefits, potential risks, and mitigating actions. Examples of areas of cooperation in fundamental science were computer modeling, dynamic deformation of materials, and superconducting materials. The benefits/risk matrix was informed by over 10 years of experience in the U.S.-Russia lab-to-lab program. It was important to recognize that whereas we could learn a lot from the Russia experience, substantial differences existed for collaborations with China.

The Chinese lagged the U.S. in nuclear weapons knowledge and experience as well as in most areas of science and technology. For example, China had conducted only 45 nuclear tests before the CTBT, whereas the U.S. did 1054 and the Soviet Union 715. With Russia, our nuclear collaboration was conducted as peers. China would clearly have more to learn. Collaborations would have to be structured to gain security benefits in the short term (improved nuclear safety and security for Chinese nuclear weapons and compliance with the CTBT, for example) and develop a long-term relationship with China. Because of the damage caused by the Cox Report, collaborations would have to be tightly controlled with strong guidelines. Dr. Hu expressed similar concerns, stating that any future collaborations between the laboratories would not be in a lab-to-lab mode. Although collaboration would be between the scientists at the labs, government officials would play a key role in future cooperation, he said.

That is exactly how we at the DOE labs were able to re-engage our Chinese counterparts. However, without Gen. Qian's conditions being met on the American side, the collaboration was limited to areas such as nuclear security and safeguards, and primarily with the Chinese civilian institute, the CIAE. In May 2005, Los Alamos led a DOE/NNSA sponsored Tech Demo Workshop showcasing integration of nuclear materials control and accountability (MC&A) and physical protection and safeguards technologies and methods at the CIAE. Administrator Linton Brooks was present at the opening ceremony along with Mr. Qin Sun, chairman of the China Atomic Energy Authority (CAEA).

With the positive political environment established by President George W. Bush and Premier Wen Jiabao, it was possible for the DOE/NNSA laboratories to forge other collaborations. For example, under the Global Threat Reduction Initiative[46] the labs worked with CAEA and other Chinese agencies to implement radiation source recoveries and physical security system upgrades at facilities near the 2008 Olympic venues. This effort resulted in physical protection upgrades of 11 facilities at eight sites that had radioactive materials inventories totaling 7 million Curies. Furthermore, other radiation sources were removed or transported to more secure locations and thousands of radiation sources were

[45] The Second Line of Defense program is a U.S. effort to detect and interdict illicit nuclear and radiological materials at borders, ports, and transit points outside the United States.
[46] The Global Threat Reduction Initiative is a U.S.-led program to identify, secure, remove, and eliminate vulnerable nuclear and radiological materials worldwide to prevent their use in weapons or terrorism.

removed from 13 sites. I was pleased because this activity resulted in part from collaboration of the Los Alamos lab and Dr. Du Xiangwan, at the time deputy head of the CAEP and later as vice president of the China Academy of Engineering.

Additional collaborations continued between several DOE labs and the Chinese civilian institutes and organizations.[47] The CAEP and IAPCM scientists stayed mostly on the sidelines because the conditions for resuming lab-to-lab cooperation had not been met. In fact, our Chinese counterparts were explicitly told not to use the lab-to-lab term. In essence, we were never able to develop a program like the U.S.-Russia lab-to-lab collaboration that we had first envisioned. This is even though key people in the Bush administration favored lab-to-lab cooperation, and incoming president Barack Obama in 2008 stated, "I support the continuation of military-to-military exchanges with China, including efforts by the Bush administration to sustain a dialogue on strategic nuclear issues and resume laboratory-to-laboratory exchanges that were terminated in the 1990s."[48] Yet, neither of the U.S. administrations was willing to put in writing Gen. Qian's two conditions for resuming exchanges and lab-to-lab ceased to exist. Nevertheless, our efforts to resume lab-to-lab cooperation in the early 2000s resulted in significant improvements in nuclear security practices in China's civilian nuclear complex. We are not sure how much of that was adopted by the defense nuclear complex because we lost the direct connection after the Cox Report.

China-Russia lab-to-lab cooperation.
Although we did not know at the time, China also pursued collaboration with Russia's nuclear institutes. The initial outreach likely came in early 1992, immediately after the breakup of the Soviet Union and the same time the Russian nuclear weapons leadership opened dialogue with the American nuclear weapons laboratories. At that time, Russia's civilian nuclear power enterprise finalized a deal to bring their light-water VVER power reactors to China. The Russian civilian nuclear institutes also began collaborating with China on civilian fast-reactor technologies and facilities.

Very little information is available in the open literature about cooperation between the CAEP and the Russian nuclear weapons complex. I was closely involved in the Russia-U.S. lab-to-lab program as described in *Doomed to Cooperate*.[49] During some of my dozens of visits to the Russian nuclear institutes and facilities, Russian colleagues mentioned recent visits to the CAEP Mianyang Center and reciprocal Chinese visits to the Russian nuclear weapons institutes. During my visits to China, CAEP officials told me that they collaborated with the Russian institutes. A thorough review of Russian open-source literature shows that collaboration between Chinese and Russian nuclear weapons institutes began in 1992. An Agreement between the Government of the Russian Federation and the Government of the People's Republic of China on Scientific and Technical Cooperation was signed on

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[47] These are reviewed in the report by Arian Pregenzer, O*p. cit*.
[48] http://www.armscontrol.org/2008election
[49] Siegfried S. Hecker, ed. *Doomed to Cooperate, Op. cit*.

December 18, 1992 laying out a framework for S&T cooperation (without a specific reference to nuclear cooperation).[50] In May 1993, a working group from RFNC-VNIITF (the Russian equivalent of the Lawrence Livermore National Laboratory) traveled to the CAEP institute in Mianyang to conduct experiments on calibrating manganin pressure sensors. Such sensors are used in conducting high-pressure experiments useful for nuclear weapons development.

A Chinese delegation led by CAEP President Hu Renyu visited Russia from 7 to 11 July 1993 at the invitation of the Minister of Atomic Energy, Viktor Mikhailov.[51] That visit was a year after I first visited VNIIEF (the Russian equivalent of the Los Alamos lab) and VNIITF, which marked the beginning of the U.S.-Russia lab-to-lab program. It was also one year before the Chinese delegation including the then president of the CAEP, Hu Side, visited the Los Alamos, Lawrence Livermore and Sandia national laboratories.

Thus, we find that in the early 1990s, shortly after the dissolution of the Soviet Union, the nuclear weapons enterprises of each of the three countries, Russia, China and the United States, reached out to the others to develop bilateral cooperation. The Russian nuclear complex was under enormous financial stress and greatly dispirited by the political and economic chaos resulting from the breakup of the Soviet Union. The U.S. Cooperative Threat Reduction programs assisted the Russian complex to avoid a nuclear security nightmare. The Russian civilian nuclear complex benefitted by exporting nuclear power technologies and reactors to China.

We do not know if China provided financial assistance to the Russian nuclear weapons enterprises. On the American side, the driver for cooperation with Russia as well as China was primarily “threat reduction” —that is to enhance the security and safety of the nuclear enterprises in both countries during times of transition and turmoil. Indeed, I expected similar turmoil in China’s nuclear enterprise, but that was not what I observed during my visits. Security and safety in the Chinese nuclear facilities, instead, were challenged by years of international isolation and lack of expertise. That is one of the reasons China reached out to both American and Russian nuclear institutes in the early 1990s. The primary reason for China reaching out was likely to establish scientific collaborations with other, more experienced, nuclear weapons states.

Little is known about cooperation between China’s and Russia’s nuclear weapon complexes. Our thorough review of Russian open-source information points to a robust collaboration from the early 1990s to today. The collaboration was focused primarily on scientific topics relevant to nuclear weapons rather than topics such as nuclear security and safety, export control, nuclear terrorism, and nuclear materials control and safeguards that we tried to pursue with U.S.-China lab-to-lab cooperation. Russia and China did also

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[50] Shanghai Institute for International Studies, Guoji Xingshi Nianjian 1993 [SIIS yearbook: survey of international affairs] (Shanghai Education Publishing House, 1993), p. 107.
[51] https://elib.biblioatom.ru/text/kb-1-vospominaniya-veteranov_2015/p222/

examine strategic issues at meetings such as "Russian-Chinese seminar on strategic stability in the world and arms control" held in China in 2003.[52]

One specific reference to the deep and long-term cooperation between Russia's nuclear weapons enterprise and the CAEP came in a letter from CAEP president Liu Cangli to the leadership of VNIIEF and VNIITF in June 2020 accompanying a CAEP humanitarian shipment of medical supplies to help the Russian cities cope with the COVID-19 pandemic.[53] The letter referenced their long-term and continuing cooperation and deep friendship, demonstrating that this cooperation was still ongoing some 25 years after it began. So, whereas collaboration between American and Chinese nuclear weapons institutes was terminated by the Chinese government because of the Cox Report, cooperation with the Russian nuclear weapons institutes continues to this day.

The turn to broader non-governmental nuclear collaboration.

After retiring from the Los Alamos National Laboratory at the end of summer 2005, I joined the faculty of the School of Engineering at Stanford University and its Center for International Security and Cooperation (CISAC). That move united me with Prof. John Lewis, who had arranged my first trip to North Korea and return to China in January 2004.

The move to Stanford University allowed me to renew collaboration with key people in China's nuclear weapons program, namely Hu Side and his colleagues at the CAEP and IAPCM. My affiliation with Stanford University made it possible to pursue nuclear security issues outside the lab-to-lab framework. Over the next two decades we organized seminars and workshops on topics focused on nuclear security, nonproliferation and nuclear power. The meetings were initially held in Beijing and at Stanford University. However, foreign travel was severely restricted for the Chinese participants after 2013, so the seminars were limited to China, although we were still able to host some senior Chinese colleagues at Stanford. In China, we met at the Stanford Center at Peking University under the auspices of what we called the China element of CISAC's Nuclear Risk Reduction (NRR) Project funded by the Carnegie Corporation of New York and the MacArthur Foundation.[54]

I also joined Track 1.5 meetings convened by Prof. Lewis with Chinese think tanks and universities. With counterparts at the China Institute for International Studies, Lewis held annual conferences on Sino-U.S. Security Relations and Cooperation. These conferences attracted both Chinese government officials and non-governmental experts from think tanks and universities. They provided insight and fostered discussion about China's nuclear weapons capabilities and policies. The meetings also provided a forum to compare

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[52] G. N. Rykovanov, Brief Impressions of a Trip to Tibet, In: "The Flight of the "Hawk": Memoirs of Viktor Nikitovich Mikhailov", Snezhinsk, 2015, p.125-138. https://elib.biblioatom.ru/text/polet-yastreba_2015/p1/?hl=рыкованов

[53] https://vniitf.ru/article/pomoshch-kitayskikh-kolleg

[54] The other elements of the NRR project included significant efforts on collaboration with Russia, India, Pakistan and North Korea.

different governmental assessments of the proliferation challenges posed by countries such as North Korea and Iran.

The non-governmental nature of the China-Stanford Nuclear Risk Reduction Project and the use of Stanford Center at Peking University for our workshops allowed us to tackle many of the key issues that were central to the lab-to-lab cooperation. We returned to collaborating on nuclear materials security. Whereas the MPC&A demonstrations in the late 1990s involved the CAEP, the Cox Report resulted in China restricting subsequent MPC&A collaborations to DOE laboratories and the Chinese civilian sector. That cooperation prospered during the 2000s and China took a big step to enhance its nuclear security training and operations with the establishment of a Center of Excellence on Nuclear Security, a product of collaboration with the United States early in the Obama administration.[55] It opened as a national training, cooperation, and research hub focused on nuclear security, safeguards, physical protection, and related areas. This collaboration resulted in China operating one of the most modern and sophisticated training centers, not only for China but also for the region. And, fortunately, the CAEP defense facilities were able to benefit from collaboration with China's own civilian sector, specifically with the CIAE. Consequently, I believe that the collaboration between Los Alamos and Chinese nuclear specialists on MPC&A in the 1980s, our initial efforts to forge similar cooperation with the CAEP facilities in the 1990s, and the significant follow-on collaboration between China's civilian facilities and additional DOE laboratories greatly enhanced nuclear security, protection and safeguards at all Chinese nuclear sites.

In 2004, I began to develop collaborations on the broader concerns of nuclear terrorism, triggered by the 9/11 attacks in the United States. My Chinese colleagues initially responded that this was not a problem in China. Nuclear terrorism was seen as a low-probability, largely foreign problem. It required several visits to China and China-Stanford NRR workshops reflecting on American experience during 9/11 and the DOE collaboration with Russia and Kazakhstan focusing on the potential problem of nuclear materials left by the Soviets at the Semipalatinsk nuclear test site to convince our Chinese colleagues that it must do more to assess nuclear terrorism risks and to take actions to prevent nuclear terror in the upcoming 2008 Summer Olympics. The Chinese nuclear and other governmental offices worked closely with the DOE, its laboratories and the U.S. NRC to secure nuclear sites and to dispose of significant inventories of radiological waste.

Our Chinese colleagues at the IAPCM were especially interested in analytical approaches to assess and respond to nuclear terrorism and enhance nuclear security. They also showed great interest in nuclear forensics to assist in nuclear terrorism analysis. Hence, much of our NRR collaboration focused on developing systems analysis approaches and to sponsor nuclear forensics discussion. We were fortunate to be able to interest subject-

[55] The Center of Excellence on Nuclear Security was established per agreement with the Obama administration in 2011 because of President Obama's Nuclear Security Summit process. The Center was completed in December 2015 and formally began operation on March 18, 2016 in Beijing's Fangshan District.

matter experts in systems analysis with deep experience in nuclear terrorism analysis from the Sandia National Laboratories.

Our engagements emphasized the application of systems analysis and scenario-based planning techniques over a period of nearly ten years until interrupted by the Covid pandemic. The Chinese analysts for the most part represented the IAPCM, but with significant participation from other centers, such as the CIAE and CINIE (China Institute of Nuclear Information & Economics). One of the highlights of the workshops was that both sides decided it was important to involve young professionals. On the American side, these came primarily from Stanford and several other universities and DOE laboratories. On the Chinese side, the young professionals were from the IAPCM and universities such as Peking and Tsinghua universities. In nuclear forensics, I was able to recruit participation of faculty and graduate students from Washington State University and Florida State University. A detailed description of the China-Stanford NRR workshops at the Stanford Center at Peking University from 2014 to 2022 is provided by L. Brandt and S. Hecker.[56]

A topic of intense interest to the Chinese participants was North Korea's nuclear program, with much of the focus on technical assessments of the program. I made seven trips to North Korea, each year from 2004 to 2010. Since visits to North Korea involved transit through Beijing on the way in and out (including picking up an entry visa at the North Korean embassy in Beijing), I visited with Hu Side and his colleagues after each trip. These discussions helped each side and our governments make better assessments of North Korea's capabilities.

I had the benefit of having access to North Korea's nuclear sites and its nuclear specialists[57] and the Chinese were able to assess North Korea's progress by comparing it to the beginning of China's nuclear program. These discussions were especially helpful in deciphering North Korea's nuclear test program.[58] My visits to North Korea and discussions there and in China convinced me that China gave little, if any, assistance to North Korea's nuclear program. There are indications, however, that over the years North Korea did receive Chinese assistance with its missile program, particularly with transporter erector launcher vehicles. During the North Korea sessions, we also compared notes on open-source data on its nuclear programs.

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[56] L.D. Brandt and S.S. Hecker, "Technical Cooperation on Nuclear Risk Reduction with China: Summary of 2014-2020 Initiatives of the Stanford Center for International Security and Cooperation and Collaborating China Agencies", December 2023, Available from the author on request.

[57] The Chinese hosts made a convincing case that they had no access to North Korea's nuclear facilities nor their technical personnel. There was only one exception in September 2007. During a period of North Korea cooperation with the U.S. on disablement of the Yongbyon nuclear facilities, a team of American, Russian and Chinese technical experts were given access to some Yongbyon facilities as part of a verification exercise. The Chinese nuclear specialist was Dr. Zhu Xuhui, who became one of our closest collaborators in the China-Stanford NRR project.

[58] I provide several relevant observations about Chinese assessments of North Korea's nuclear tests in *Hinge Points: An Inside Look at North Korea's Nuclear Program,* with Elliot Serbin. Stanford University Press, January 2023.

The workshops also covered China's progress in civilian nuclear energy. Our focus was primarily on how China's choices of nuclear reactors and fuel cycles may present challenges for nuclear security and the international proliferation regime. These collaborations included professionals from Xiamen University and a visit of our delegation to the reactor complex in Zhejiang. We were impressed with the speed and professionalism of the nuclear power plant construction in China.

The visits to China and the nature of the workshops, held primarily at the Stanford Center at Peking University, resembled what we initially had hoped to achieve in the lab-to-lab collaboration. The significant technical exchanges gave us a good view of how the Chinese specialists analyzed key nuclear risks and we were able to have the Chinese think more deeply about potential nuclear terrorism scenarios and take a systems analysis approach to assess nuclear risks. Both sides shared this information with their governments. I believe that we contributed to developing better national perspectives on threats and responses to radiological terrorism, nuclear forensics, and the North Korean nuclear program.[59] We also believe that the relationships between the defense communities in China and the United States were strengthened and we both were able to interest and inform the next generation of nuclear and analytical specialists in these areas.

The lab-to-lab nuclear cooperation in the 1990s and the follow-on China-Stanford Nuclear Risk Reduction program were part of a much larger outreach by China's nuclear community, especially under the leadership of Hu Side in his role as head of the IAPCM and then the Center for Strategic Studies, associated with the IAPCM and the CAEP. Together with the international group ISODARCO, Hu organized biennial conferences in China on nuclear weapons policy and nuclear proliferation. Hu also participated in the recurring meetings of the U.S. National Academy Committee on International Security and Cooperation (NAS-CISAC) with a similar group from the Chinese Academy of Sciences. These meetings focused on broad areas of international security and science have continued for several decades. In addition, other Chinese agencies, such as the China Arms Control and Disarmament Association (CACDA) participated in numerous Track 1.5 dialogues with American counterparts.[60]

Brad Roberts provides a realistic assessment of several such Track 1.5 engagements with China.[61] He concludes that Track 1.5 dialogues have been valuable but limited: they

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[59] For example, I briefed every administration beginning with the George W. Bush administration through the Biden administration on my trips to North Korea and my analysis of its nuclear capabilities. Although I had good access to all administrations, my assessments had little impact on U.S. government policies as chronicled in *Hinge Points: An Inside Look at North Korea's Nuclear Program*.

[60] These included the Center for Nonproliferation Studies at Monterey, Council of Foreign Relations, Center for Strategic and International Studies, Pacific Forum, Institute of Defense Analysis, Nuclear Threat Initiative, Institute of Geophysics and Planetary Physics, MIT, and others.

[61] Brad Roberts, *Taking Stock: U.S.-China Track 1.5 Nuclear Dialogue,* Center for Global Security Research, Lawrence Livermore National Laboratory, December 2020.

improved mutual understanding of doctrines, terminology, and risk perceptions, but did not produce sustained policy change or significantly reduce strategic mistrust between the United States and China. The report argues that future progress will require more consistent engagement, clearer official buy-in, and a sharper focus on practical risk-reduction measures, rather than broad conceptual exchanges alone.

China's modern nuclear weapons enterprise.

The Chinese nuclear weapons enterprise has evolved significantly since I first interacted with Chinese scientists during their visits to the United States in the 1980s. As much as Americans wished otherwise, China's nuclear weapons complex as well as its nuclear power industry have risen from the backwaters to world-class capabilities. The common view in the United States is that China acquired its nuclear weapons expertise primarily through espionage and it built its civilian nuclear power base through imitation and technological theft. That view is not consistent with my experience with China's nuclear weapon enterprise nor with a thorough examination of China's civilian nuclear industry.[62] Coming from behind, China built a world-class nuclear enterprise. We downplay its impressive indigenous capabilities at our own peril.

Following the Sino-Soviet split in the late 1950s, China was determined to develop nuclear weapons on its own. When it lost Soviet assistance, it quickly assembled a talented team including many of the leading scientists who returned to China after completing their physics education in Europe or the United States.[63] The development of nuclear weapons was a strategically supported government effort in keeping with the early teachings of Deng Xiaoping and Zhou Enlai—to actively acquire foreign scientific and technical knowledge, keep all channels open and innovate at home.

China's nuclear weapons program was primarily an indigenous effort using legal and illicit foreign acquisitions while developing its own capabilities. Surely, intelligence collection helped, as it does for China's competitors. So did bringing back native Chinese intellectuals from overseas tenures (predominantly in the United States) in academe and scientific institutions. What is generally not appreciated is that China's objectives were primarily directed at attracting the people and establishing the institutions necessary for a first-class nuclear weapons program. The Chinese government was more interested in how the United States built and nurtured scientific intellectual nuclear weapons capabilities than in getting specific weapons information. In other words, China was much more after the "how" rather than the "what." After all, any information about "what" has a short half-life, whereas learning the "how" could last forever. China was playing the long game.

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[62] As demonstrated in the forthcoming companion Center for Nonproliferation Studies at Monterey report authored by Y. Pan, S. Hecker and W. Potter, which provides an extensive history of cooperation in civilian nuclear power.

[63] John W. Lewis and Xue Litai, *China Builds the Bomb*, August 1988, Stanford University Press.

That much of China's nuclear focus was directed at building institutional capacity fits with the efforts of Professor Yang Fujia, the academic with close ties to China's nuclear weapon establishment, to pursue cooperation with Los Alamos scientists and officials as soon as China and the United States normalized relations. In hindsight, it is now apparent that both he and the CAEP scientists he brought to visit Los Alamos and other DOE defense laboratories were here to see how the American system worked. What they found was a U.S. nuclear weapons enterprise based on university-centric research laboratories. The early Chinese visits to American laboratories and universities organized by the National Academy of Sciences were also aimed at understanding and learning about scientific institutions and cultures in the United States. Joint projects were aimed as much at learning how the Americans did research as they were at solving specific scientific problems.

China pursued this learning process along several paths. Chinese scientists visited U.S. laboratories including the nuclear laboratories, such as the Los Alamos National Laboratory in the 1980s. Chinese science and engineering students came en masse to America's best universities in the 1990s. Although many stayed in the United States to become leading American technologists, some returned to China to build a stronger science and technology base, both for civilian and defense industries.

As described above, Chinese nuclear weapons scientists reached out to their American counterparts. On the American side, we reciprocated by developing the U.S.-China lab-to-lab cooperation in the mid-1990s, which was limited to collaborating on issues of nuclear materials security and safeguards, not nuclear weapons technologies. In the process, we, the American participants, got an early, unprecedented look at China's fledgling nuclear weapons R&D enterprise before the doors were shut by the Cox Report.

In the 1990s, the Chinese conducted six or seven additional nuclear tests while Russia and the United States observed a testing moratorium before the signing of the CTBT in September 1996. After the end of nuclear testing, which the Chinese appeared to accept more readily than the American or Russian nuclear enterprises, China was determined to develop a nuclear weapon stockpile stewardship program based on a strong science base.

During my 1994 visits, the CAEP had primitive facilities at Mianyang and a fledgling computational capability at the IAPCM in Beijing. In the subsequent nearly thirty years, the best we can tell at a distance from open-source information is that China's nuclear weapons enterprise has developed a rigorous stockpile stewardship program.

The United States and Russia developed different versions of stockpile stewardship. The American version was built around science-based stockpile stewardship with a focus on greatly enhanced computational and modeling capabilities plus state-of-the-art scientific facilities. The Russian version was focused more on retaining a robust manufacturing capacity. Both did much to archive their enormous nuclear testing experience (as noted, 1,054 nuclear tests for the United States and 715 for Russia). The United States had used significantly more sophisticated test diagnostics and hence had a huge data base. China had little with only 45 (possibly 46) nuclear tests.

The Chinese nuclear weapons complex (specifically the CAEP) apparently decided to emulate the American system. The U.S. approach to confidence without testing — "science-based stockpile stewardship," as widely described in the open literature— integrates past nuclear test data, high-performance simulation, and new experimental data to fill knowledge gaps and manage uncertainty. That appears to be the direction China took—the CAEP was rebuilt as a modern, science-driven laboratory system, not just a weapons design bureau, through a massive science investment. The Chinese had hoped that they could develop scientific collaborations with the Americans through lab-to-lab cooperation, much as was done in the U.S.-Russia lab-to-lab program,[64] but that was derailed by the Cox Report. The Chinese proceeded on their own and the United States was left with losing one of the few windows it had into China's nuclear weapons enterprise. The American nuclear laboratories were able to continue to work with the Chinese civilian nuclear enterprises to enhance their nuclear security and safeguards practices.

During the past two decades China has put its nuclear weapons program on a solid scientific footing. It realized that it needed exciting scientific challenges and a pipeline of young talent interested in the intersection of science and security. That appears to be why the CAEP established its own Graduate School—the GSCAEP located in Beijing. The mission of GSCAEP is stated, "to provide tailored, strategically guided graduate education, conduct fundamental research aimed at both scientific frontiers and national strategic needs, and integrate scientific research with education to strengthen CAEP's basic research capabilities."[65]

The GSCAEP was also designed to help solve the weapon scientists pipeline problem. It ended China's dependence on just a few universities to channel scientists to the CAEP. At the Graduate School, the students enter inside the security fence, their research topics are closely aligned with CAEP needs, and their faculty/advisors are nuclear weapons program leaders. China and the CAEP recruited Western-trained returnee scientists over a couple of decades. What they brought back to China was not so much specific information about weapons science or weapons systems, but an understanding of how scientists in American institutions think and work—the DNA of those institutions. The returnees had learned how science is done at American universities and how the laboratories work. They brought with them the importance of computer codes, their verification and validation, and how experiments should be tied to the codes. They brought greater experimental discipline than existed in the Chinese complex. In other words, the value of the returnees was primarily institutional and epistemic, not just informational. The GSCAEP reduced the need to recruit returnee talent—this came at a time when it was becoming more difficult for China to do so

[64] S.S. Hecker, Op. cit. "Doomed to Cooperate."
[65] https://en.gscaep.ac.cn/about/description

because of the greater concerns in the United States about Chinese recruitment at American universities and institutions.[66]

The Graduate School was also aimed at helping China address what it considers its greatest long-term vulnerability in a no-test regime—the loss of tacit knowledge over generations by formalizing graduate education inside the CAEP. In 2021, for example, GSCAEP admitted 170 master's students, 191 doctoral students, and 18 jointly trained doctoral students. As of December 2021, there were a total of 1,266 students, including 806 doctoral students and 460 master's students.[67]

Besides establishing the Graduate School, the CAEP also learned important institutional lessons from the Russian nuclear weapons laboratories through their lab-to-lab cooperation. The Chinese witnessed the brain drain of Russian weapon scientists migrating to other jobs within Russia or into the "gray" area of staying at the labs but moving into civilian work to continue to get paid. The state pushed defense institutes themselves toward civilian products—superconductors, lasers, medical devices, materials, computing—partly to keep people paid. This became a survival theater—enough to get paid, but insufficient to keep a highly talented workforce. This was particularly severe during the financially disastrous 1990s.

The CAEP also learned about the challenges of a closed city environment from the Russians, with whom they continued in lab-to-lab cooperation. The closed environments work only if the funding is stable, the prestige is protected, and a career pipeline is sustained. In Russia's case all three were challenged after the dissolution of the Soviet Union. It took decades to recover.

The CAEP today is a multidisciplinary national laboratory system with a strong focus on high-energy density physics, materials under extreme conditions, large-scale simulation with applied mathematics and AI-assisted modeling. It has a staff of 23,000 including scientists, engineers, technical professionals, administrators, and support personnel, with roughly 10,000 being technical professionals. The primary scientific site of the CAEP is the Mianyang Science City site. The Institute of Applied Physics and Mathematics in Beijing focuses mainly on applied theoretical research, study of fundamental theories and modeling and computations on nuclear warhead design and computations. It has 400 specialized technical staff and over 100 researchers.[68]

The CAEP has also made significant progress in building the scientific facilities and computing power to support its stockpile stewardship program. Much like the American laboratories, China has constructed the full-spectrum of modern stewardship facilities —

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[66] https://global.mit.edu/wp-content/uploads/2022/11/FINALUniversity-Engagement-with-China_An-MIT-Approach-Nov2022.pdf
[67] *Op. cit.* https://en.gscaep.ac.cn/about/description
[68] *Ibid*.

multi-axis flash radiography facilities (such as the Dual-Axis Radiographic Hydrodynamic Test Facility at the Los Alamos lab), a laser-driven inertial confinement fusion facility (such as the National Ignition Facility at the Lawrence Livermore lab), and a pulsed power facility (such as Sandia's Z Machine).[69] The CAEP has also made massive investment in supercomputing and may be close in raw computer power but the United States is still believed to lead in the tight coupling of experiments and validated computer codes. It appears that China is no longer a generation behind—it is functionally competitive in most stewardship technologies.

With the focus on science and the addition of the GSCAEP, the CAEP's external publications have changed dramatically over the past 20 years. These make large, diversified contributions to high-impact journals, strong in the physical sciences, particularly in materials science and chemistry. CAEP publications have shown strong gains in the Nature Index during the past 25 years.[70]

China has built a strong, well-supported intellectual foundation for its nuclear weapons program after the Cox Report effectively ended cooperation between Chinese and American nuclear weapons enterprises in 1999.

What's next for China's nuclear weapons program?
During the past decade, China has changed its nuclear weapon strategy significantly. After years of following the principles of minimal deterrence with a declared no-first-use policy underscored by keeping its nuclear arsenal small,[71] on the order of a few hundred strategic weapons, it has mounted a serious campaign to increase the size of its nuclear arsenal, perhaps as large as 600 today.[72] The U.S. government claims China is on track to have over 1,000 nuclear warheads by 2030.[73] In its latest White Paper on "Arms Control, Disarmament and Nonproliferation in the New Era," China claimed that its nuclear strategy is still defensive in nature, committed to no first use of nuclear weapons and to maintaining a minimal nuclear force required for national security.[74]

As troubling as China's expansion of its nuclear arsenal may be, it is not surprising. It also pales in comparison to the early American buildup in the 1950s and 60s topping out at

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[69] China's facilities appear to still lag the capabilities of their American counterparts. For example, its laser inertial fusion facility has apparently not yet reached the mega-Joule class of the NIF facility. However, recent reports indicate that China is building a new laser facility that may exceed the laser power ofNIF (https://www.republicworld.com/world-news/china-building-bigger-massive-laser-nuclear-fusion-research-facility-than-us-national-ignition-facility)
[70] https://www.nature.com/nature-index/institution-outputs/generate/all/countries-China/government
[71] Jeffrey Lewis, *The Minimum Means of Reprisal: China's Search for Security in the Nuclear Age,* MIT Press, 2007.
[72] Federation of American Scientists. https://fas.org/publication/nuclear-notebook-china-2025/
[73] Thomas DiNanno, Feb. 6, 2026, Conference on Disarmament, https://www.state.gov/releases/2026/02/statement-to-the-conference-on-disarmament/
[74] China's White Paper, Nov. 27, 2025, https://www.fmprc.gov.cn/mfa_eng/xw/wjbxw/202511/t20251127_11761653.html

31,000 in the mid-1960s. It was the Wild West of American nuclear armament, not only in large numbers but a nuclear weapon for almost all types of military confrontations—from nuclear artillery-fired projectiles to landmines and backpack nukes. And in the 1970s, it was not uncommon for the Rocky Flats plutonium factory to turn out more than a thousand plutonium pits per year. The Soviet Union played catchup and eventually its arsenal reached 41,000 nuclear weapons.[75]

The 2010 New START treaty with Russia, renewed in 2021, limited the number of deployed strategic nuclear warheads for the United States and Russia to 1,550 each. Washington and Russia allowed the treaty to expire this year. As of January 2026, the United States has a total inventory of roughly 5,200 weapons (including deployed weapons and those waiting disassembly); Russia has 5,450.[76] With a purported inventory of 600 nuclear weapons, China has publicly rejected calls to be included in trilateral nuclear arms control negotiations, arguing that because its arsenal is far smaller and its strategy defensive, "one should not ask the restrained to do more."[77]

China has risen to near-peer status with the United States economically, technologically and militarily, although it faces challenges in all three. China has roughly the same land mass as the United States, four times the U.S. population and about two-thirds of its gross domestic product. It has the scientific and economic means to increase its nuclear arsenal to match the United States numerically if it chooses to do so. Washington must turn to arms control and strategic stability dialogues with Beijing to limit China's nuclear arsenal, much as it had to do with the Soviet Union and then Russia. Official relations between China and the United States have not engendered such dialogue. Moreover, military and technical cooperation in the nuclear arena is essentially nonexistent and Track 2 dialogue is limited. China has shown little interest in trilateral arms control negotiations with Russia and the United States nor with recent attempts by Washington to engage in a multilateral strategic stability dialogue. It will require a much more concerted governmental and non-governmental effort to find a mutually acceptable path forward.

As discussed above, China has launched a science-based stockpile stewardship program to retain confidence without nuclear testing. It integrates past nuclear test data, high-performance simulation, and new experimental data to fill knowledge gaps and manage uncertainty. China is moving from a small, relatively simple deterrent to a large, diverse, and technologically advanced missile force with greater survivability, flexibility, and readiness. The stockpile stewardship program enables the effective coupling of nuclear warheads with delivery systems.

Whereas China can eventually match the size of the U.S. nuclear arsenal if it decides to so, its stockpile stewardship program is limited by its nuclear testing experience, which

[75] Federation of American Scientists, *Op. cit.*
[76] Federation of American Scientists, https://fas.org/initiative/status-world-nuclear-forces/
[77] https://english.news.cn/20260207/bfc472d46205448094066a20eb5a1fcd/c.html

shapes the sophistication of the arsenal and assures its safety and reliability. The United States has conducted 1,000 more nuclear tests than China. Recent claims that China has conducted very small nuclear tests in violation of the zero-yield expectation of the CTBT,[78] if confirmed, may help the CAEP to assure safety and reliability, but will likely not lead to more sophisticated warheads. I consider it unlikely that China will follow Russia's example and attempt to field dramatically new weapon systems.[79] China is constrained by its limited test history. Russia has the benefit of the Soviet 715-test campaign which may well have included tests that could provide the necessary confidence to field such systems.

With its limited nuclear testing history, China will find it difficult, if not impossible, to field nuclear warheads that differ much in sophistication from the designs it validated with its nuclear test series in the 1990s.[80] The lack of nuclear test data, especially from highly instrumented nuclear tests, remains the greatest limitation of its stockpile stewardship program. A return to a robust nuclear testing program that would be required to compile such test data is unlikely. Washington could constrain China's nuclear capabilities by making the barriers to resume nuclear testing as high as possible. That includes ratifying the 1996 CTBT and attempting to agree on a commonly observed definition of zero-yield.[81]

In retrospect, I believe that American efforts to promote cooperation with the Chinese nuclear enterprise in the 1990s was the correct course. The 1999 Cox Report followed by bipartisan hype about China's alleged grand theft of nuclear secrets were counterproductive and restricted cooperation with China's nuclear defense sector. It curtailed American efforts to assist China's nuclear weapons complex to rapidly improve its nuclear security and safeguards practices. Fortunately, China and the United States found some mutually acceptable mechanisms in the civilian nuclear sector to cooperate on such matters as well as preventing nuclear terrorism and supporting international nonproliferation norms and initiatives.

The lab-to-lab program also gave Americans some access to Chinese nuclear specialists and facilities. It initiated dialogue on nuclear materials security and safeguards in China's defense sector. It also led to fledgling discussions about nuclear weapon safety and the means to verify a comprehensive nuclear test ban. That was lost. Such discussions along with other Track 2 activities could have built a foundation for more productive official discussions on arms control and other restraints.

Looking ahead, increased cooperation in the nuclear sphere—both civilian and defense—is essential to preserve the global nuclear order that is threatened by Russia's invasion of

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78 DiNanno, *Op. cit.*
79 https://www.armscontrol.org/act/2025-11/news-briefs/russia-tests-nuclear-powered-cruise-missile-torpedo
80 Zhang, *Op. cit.*
81 Siegfried Hecker, "Lessons from Los Alamos: America has the Most to Lose From Restarting Nuclear Testing," *Foreign Affairs*, Nov. 26, 2025. https://www.foreignaffairs.com/print-article/node/1134065

Ukraine and the recent unraveling of arms restraint agreements.[82] However, there is little support in the American political system for increased cooperation with China. In fact, a recent Congressional Report "Containment Breach"[83] sounds alarmingly like the Cox Report. The report claims that the DOE has failed to adequately secure its research, allowing collaborations that enable the Chinese Communist Party to access and exploit American taxpayer-funded advancements to fuel China's military and technological rise.

The Congressional Report fails to acknowledge that China has already risen—technologically, economically and militarily. The areas of technology in which the United States still leads should certainly be protected and engagement with Chinese industry and institutions should be pursued with “eyes wide open.”[84] However, American technological leadership strategy must be designed to do more than just slowing down an adversary. The longer-term strategy must be to keep U.S. technology ahead in performance and adoption.[85] In other words, the United States must be able to outrun the competition, rather than focusing primarily to slow it down. With China, Washington must learn to steer a course between the paranoia found in government circles and the naiveté of some American institutions.

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[82] https://thebulletin.org/2022/04/siegfried-hecker-putin-has-destroyed-the-world-nuclear-order-how-should-the-democracies-respond/#post-heading

[83] Containment Breach: A Report by the House Select Committee on the Chinese Communist Party and Intelligence Committees, https://chinaselectcommittee.house.gov/sites/evo-subsites/selectcommitteeontheccp.house.gov/files/evo-media-document/doe_report_containment_breach_final_v4_compressed-1.pdf

[84] A 2021 Stanford University Hoover Institution report makes that case effectively. https://www.hoover.org/sites/default/files/research/docs/stoff-tiffert_eyeswideopen_web_revised.pdf

[85] This point is made effectively in the recent Council on Foreign Relations task force report “U.S. Economic Security: Winning the Race for Tomorrow’s Technologies.” https://www.cfr.org/task-force-reports/us-economic-security.

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