STUDY OF INNOVATION AND TECHNOLOGY IN CHINA

POLICY BRIEF

2014-12 January 2014

China's Nuclear Weapons Program and the Chinese Research, Development, and Acquisition System

Michael S. CHASE, Stephanie LIEGGI,
Andrew S. ERICKSON, and Brian LAFFERTY

Historically, China's nuclear program developed a significant level of indigenous innovation. Although the activities and processes within the nuclear weapons program may be difficult to reproduce in more typical defense acquisition programs, the case of the nuclear complex indicates that China's RDA process is capable of overcoming major technical hurdles and deficiencies. When Beijing provides sufficient financial and human resources, affords well-trained scientists autonomy, and creates a system that facilitates cross-discipline cooperation, innovation and self-sufficiency are possible. Studying the nuclear weapons program is thus useful not only because of its importance in shaping China's nuclear future, but also because it provides broader insights into trends in the development of China's defense industries, some of which may be applicable to other high-priority programs.

The Study of Innovation and Technology in China (SITC) is a project of the University of California Institute on Global Conflict and Cooperation. SITC Research Briefs provide analysis and recommendations based on the work of project participants. This material is based upon work supported by, or in part by, the U.S. Army Research Laboratory and the U.S. Army Research Office through the Minerva Initiative under grant #W911NF-09-1-0081. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the U.S. Army Research Laboratory and the U.S. Army Research Office.

Understanding China's nuclear future requires a detailed assessment of issues such as the organization of China's nuclear weapons complex and how the Chinese research, development, and acquisition process applies to Beijing's nuclear weapons program. While China's initial work on nuclear technology was directly assisted by the Soviet Union and indirectly through the programs of other countries that Chinese scientists studied and attempted to imitate, Beijing's program developed a significant level of indigenous innovation.

Prior to the 1964 nuclear test, the leadership of the Chinese program used a combination of adaptation and innovation to build a successful program. China persevered despite limited overall industrial capability, limited capital resources and facilities, and political campaigns that often targeted the scientists and experts who constituted the program's core human resources. After the initial test, the nuclear weapons program continued to progress towards self-reliance and to increase its level of innovation.

When viewed through the defense RDA process framework, China's nuclear weapons program increases the understanding of how China's defense acquisition apparatus was able to develop a full-fledged weapons system with available foreign and indigenous resources. This program moved through the development process, from importing and imitation of foreign programs, to adaption of relevant technologies, resulting ultimately in a program that relied on indigenous innovation.

The process that China's nuclear weapons program followed was heavily influenced by Beijing's threat perceptions and a drive to remain "self-reliant" whenever possible. Yet Beijing demonstrated willingness to receive assistance—as from Moscow—when it benefited the program.

UNDERSTANDING DOMESTIC CAPABILITIES AND REQUIREMENTS

China's efforts to master certain aspects of the nuclear fuel cycle began prior to the establishment of the People's Republic of China (PRC) in 1949, as numerous young scientists and students went abroad to study nuclear issues. These individuals, many of whom would return to China and form the backbone of Beijing's nuclear weapons program, spent significant time in the Soviet Union, Europe, and the United States. The contacts they developed with some of the world's leading scientists helped the nascent Chinese system identify and acquire materials and knowledge.

Among the most important factors relevant to the RDA process framework, particularly as it relates to the conceptualization of the need for defense systems, are what a country's leadership sees as the most likely threats and the extent to which it sees outside assistance as helpful or reliable. The threat perceptions that prompted Mao and other Chinese leaders to develop nuclear weapons hinged largely on their concerns that the United States would use its nuclear arsenal to threaten and coerce China. Beijing also hesitated to rely on foreign assistance, even from fellow communist states. At the start of China's nuclear program, Beijing therefore made the choice to create a program that would allow cooperation with foreign powers when needed while enabling China to ultimately proceed independently as necessary.

China's military and scientific communities began to seek Soviet assistance on many programs, including strategic systems like nuclear weapons. Moscow showed a willingness to support Beijing. The introduction of Soviet technology and the return to China of foreign trained scientists assisted China's nuclear progress significantly. Particularly in the initial phase of the program, these factors allowed for an increase in China's technical maturity that helped develop the indigenous aspects of its program.

As China moved past the pre-program stage in the early 1950s, it began to identify more clearly program requirements and capability and resource gaps. In this stage, China began to constitute a nascent program and made efforts to create a management system sufficient for further development.

FROM DUPLICATIVE IMITATION TO CREATIVE ADAPTION

Although China's leadership, including Mao, recognized the importance of Soviet aid in the 1950s, they also understood the value in creating a parallel system to enhance domestic capacity. Looking at this period from the perspective of the RDA framework, this parallel system began to materialize when China was moving away from duplicative imitation of foreign systems towards creative adaption. Prior to the formal Sino-Russian agreement on nuclear cooperation, Chinese scientists actively studied Soviet efforts with a view to imitating them. By the mid- to late-1950s, as Soviet cooperation began, Beijing recognized that it was starting from scratch. Chinese leaders increased funding for key nuclear research and development institutions and emphasized developing a workable scientific infrastructure. Although Mao preferred a road to nuclear weapons based on his vision of "self-reliance," he realized that without Soviet assistance the time frame for nuclear development would be significantly longer. It was in this period that Beijing decided to maintain a dual-track approach, one that relied heavily on Soviet assistance and another that focused on developing

indigenous capabilities. At about the same time, the Central Committee began establishing the bureaucratic organization for managing the nuclear weapons program.

In this period, some aspects of China's program were at a duplicative stage, but others were at the creative imitation stage of the RDA process. As the program's more "self-reliant" side progressed, China's scientific leadership refined the vision for their program and how to manage progress toward the desired outcome. With Soviet assistance under the aegis of four bilateral nuclear energy agreements, China's nuclear development progressed steadily during the late 1950s. However, Chinese scientists and leaders, clearly wanting more advanced assistance, pressed their Soviet partners for additional information and resources related to key aspects of nuclear weapons development, like warhead design and fuel fabrication. The utility of China's dual approach became evident as it emerged that Moscow was withholding key information that would allow China to become more independent.

Following the suspension of Soviet nuclear weapons assistance on June 20, 1959, most aspects of the Chinese nuclear program still relied on Soviet designs and plans made at the height of Sino-Soviet cooperation. The scientists and technicians working on the program were familiar with these technologies and did not automatically begin their efforts from scratch. In this period, those working on China's nuclear program typically used Soviet resources until they encountered obstacles to continuing development. In most cases, they handled the challenges by exploiting indigenous technical and engineering skills and building upon existing technology.

The production of fissile material for the first nuclear test provides a clear example of the Chinese program's movement from imitation to creative adaption. The Chinese system created a new methodology to meet its development goals for its nuclear weapons program based on inspiration taken from foreign designs.

Throughout its nuclear weapons development, Beijing focused on creating a supportive infrastructure and furnishing sufficient human resources. In the late 1950s, Beijing prioritized providing sufficiently trained personnel for the program's key facilities. They mobilized financing and resources to create a large-scale infrastructure. Soviet assistance helped the Chinese program avoid some difficult hurdles, but Beijing did not follow Moscow's model completely. In part, this was because Chinese leaders did not see the necessity of matching the Soviet program's scope. Beijing remained far more moderate in its approach and scale, and as a result likely saved considerable money. China's system was noteworthy for its maximal exploitation of limited resources.

Nonetheless, the withdrawal of Soviet advisors, combined with concomitant political upheaval, imposed hardships on China's nuclear weapons program in the early 1960s. China's disadvantageous international position further frustrated efforts to acquire foreign technology. However, China's focus on training and infrastructure allowed the program development to proceed through the RDA process into adaption and ultimately towards innovation.

TAPPING INNOVATION IN THE SYSTEM

As for the human factor, China's nuclear program benefited from leadership by knowledgeable scientists who, while inspired by nationalist fervor, were generally realistic about the limitations they faced. Political upheaval also had a major impact on the programs, even when senior political leaders made efforts to protect it. These problems spurred China's scientific leadership to reconsider the program's structure to further buffer it from political vicissitudes.

Although decisions about how to organize the program generally came from the top, many of the departments involved enjoyed significant autonomy. This allowed for greater internal innovation, but there were fears that lack of cooperation among different departments would slow development. In October 1962, the Central Committee established the Central Special Commission (CSC) to strengthen coherence of the strategic weapon programs.

As a part of an effort to strengthen indigenous capacity, experts worked together to fully grasp the fundamentals of the nuclear program; according to Chinese analysts this organizational effort created conditions for making breakthroughs and thus improving indigenous capabilities. Scientific community leaders stressed that long-term development hinged on creating a cadre of individuals who fully grasped the relevant technological fundamentals. This methodology, which allowed China's program to assimilate available technologies and indigenous capabilities, appeared to foster increased innovation. Indeed, as China moved closer to testing its first nuclear warhead, evidence of more domestic innovation across key sectors emerged.

However, the path ahead for many parts of the program appeared daunting. From the perspective of the RDA framework, this removal of additional foreign input marked a point where China's program was forced into a much higher level of innovation.

The decision by the Ninth Academy's leadership to form high-level technological committees that specialized in specific aspects of nuclear weapons production assisted efforts to overcome the challenges encountered after Soviet experts departed. These committees worked closely together and shared information across disciplines. This level of cooperation appeared to increase the Chinese system's indigenous development capacity.

MEETING DEVELOPMENT GOALS AND ADVANCING FURTHER

The development of the bomb design exemplifies how China's system progressed into higher levels of innovation in the post-Soviet assistance era. The scientists working on this issue increased their understanding of bomb design fundamentals by researching other nuclear programs and the limited information remaining from Soviet assistance. China undertook development of vital subsystems for the bomb design by using indigenous knowledge with little dependence on foreign assistance or technology, one indicator of a process that is incorporating architectural innovation.

In January 1964, the CSC submitted a nuclear weapon development report, which was subsequently approved by the top leadership. On this basis, China planned the following milestones: 1) develop and test an air-dropped atomic bomb; 2) test launch a ballistic missile carrying a live nuclear warhead; and 3) strive to conduct a hydrogen-bomb test.

In the fall of 1964, China finalized its efforts to test its first nuclear weapon and on October 16, China became the fifth nuclear weapons state. The preparations for the first test demonstrated a growing level of innovation within China's nuclear program, and other indicators appeared to further suggest that China's RDA system was moving toward modular innovation.

China's work on thermonuclear designs, nuclear-capable ballistic missiles, and the related miniaturization of warheads exhibited a level of development capable of generating sophisticated capabilities. Building on the existing framework, infrastructure, and ongoing research, China tested its thermonuclear design within two years of the first nuclear test, a relatively fast pace by any account. Although the speed with which China developed the thermonuclear design was related to indigenous capacity and knowledge, previous Soviet assistance and studying of earlier programs also generated momentum.

Another of China's goals—testing an airdropped atomic bomb—was accomplished successfully on May 14, 1965. Subsequently, China began to focus on nuclear missile development. Just two years after the first nuclear test, on October 27, 1966, China successfully tested launched a Dong Feng-2 (DF-2) short/medium-range ballistic missile carrying a live nuclear warhead. China thus achieved all the major nuclear milestones stipulated by the CSC.

CHINA'S LEVEL OF SELF-RELIANCE

For many aspects of China's nuclear program, as seen in thermonuclear research, a level of external assistance—whether through lingering benefits of Soviet support or studying other nuclear states—remained helpful throughout the process.

But as China's nuclear program progressed, indicators point to a system moving into the modular innovation stage, and China became increasingly capable of developing its own R&D apparatus. As development efforts further matured in the 1970s and 1980s, and especially as the political upheaval of the 1960s subsided, the program began to take a systematic approach to operations and management of the key systems, including the related ballistic missile arsenal. In this period, the Chinese system began moving toward true self-sufficiency, as defined in the RDA framework. In the area of nuclear weapons and delivery system development, China's most recent activities have been aimed at modernizing their current systems and further improving their forces' survivability.

CONCLUSION AND IMPLICATIONS

Chinese scholars hold China's development of nuclear weapons in high esteem as the quintessential "two bombs, one satellite" program, but it is of much more than historical interest. Accordingly, this section briefly considers some potential implications for future programs and highlights areas worthy of further research and analysis.

China's nuclear weapons program is a very mature part of Beijing's overall defense structure, and the system has progressed to advanced stages of the RDA process. It must be recognized that the nuclear weapons program is unique in China's defense acquisition process. The program began with a significant amount of patriotic fervor and overcame significant obstacles, particularly during the Cultural Revolution, to develop into what is now a technologically advanced system.

Even with the unique nature of China's nuclear weapons development, the program's RDA process does exhibit a number of indicators which indicate China's capacity as a technology developer in defense-related areas. This understanding of the Chinese scientific and technical community's ability to innovate and create systems that are seen as vital to national security can potentially be used in the future to predict the process Beijing would use to develop other key programs.

Throughout this review of China's nuclear weapons program, China moved from relying on acquisition and assistance from other countries to relying heavily on domestic capacity and innovation. Much of its success rested heavily on the extent to which nuclear and missile development represented a top national priority in the 1950s and 1960s and Beijing's ability to mobilize national resources, both physical and human. While it is not

impossible for China to undertake another one of these campaigns for building a different defense system, it would likely need to be a program that stirred the same excitement and carried the same significance as the nuclear weapons program. Something like the space program, for instance, might exhibit similarities in the process followed and level of innovation achieved. In general, however, it may be difficult to garner this level of investment from top leadership on most programs.

Although the activities and processes within the nuclear weapons program may be difficult to reproduce in more typical defense acquisition program, this review illustrates that China's RDA process does allow for overcoming major technical hurdles and deficiencies in the defense industrial base if Beijing is willing and able to provide sufficient financial and human resources. When Beijing affords well-trained scientists autonomy and creates a system that facilitates cross-discipline cooperation, innovation and self-sufficiency are possible. This highlights the fact that the importance of studying the nuclear weapons program is not limited to understanding the future of China's nuclear force, but also offers the potential to provide insights into broader trends in the development of China's defense industries, particularly in cases of programs that are accorded the highest priority by the Communist Party and military leadership.

Michael S. CHASE is a senior political scientist with the RAND Corporation in Arlington, Virginia.

Stephanie LIEGGI is a senior research associate in the East Asia Nonproliferation Program at the Monterey Institute for International Studies.

Andrew S. ERICKSON is an associate professor in the Strategic Research Department at the U.S. Naval War College and a core founding member of the department's China Maritime Studies Institute.

Brian LAFFERTY is the China Project Manager at Defense Group Inc.