

China's Nuclear Weapons Modernization: Intentions, Drivers, and Trends

Hui Zhang

*Project on Managing the Atom
Kennedy School of Government
Harvard University
79 John F. Kennedy Street
Cambridge, MA 02138*

ABSTRACT

Under the guiding principles of its nuclear policy-- maintaining a minimum deterrent with a no-first use pledge and avoiding a nuclear arms race-- the main purpose of China's nuclear modernization is to assure a limited, reliable, and effective counterattack nuclear capability for deterring a first nuclear strike. China's nuclear modernization has been focusing on the quality, rather than the quantity, of its nuclear arsenal in the past three decades. However, since the New START Treaty entered into force on 5 February 2011, growing concerns about Chinese nuclear modernization have arisen. Some are concerned that China would reach nuclear parity with the U.S. as it cuts down its arsenal with Russia. Such concerned voices are even louder, in particular, in the light of a study undertaken by Georgetown Prof. Phillip Karber, which also considers the question of why China has a vast network of underground tunnels—Referred to as China's "underground great wall"—3000 miles of complicated tunnels, which could host about 3000 nuclear weapons as suggested by Phillip Karbar's report. This piece will discuss the intentions and drive of China's nuclear weapons modernization, the meaning of Chinese minimum deterrence, and the trends of the Chinese nuclear weapons program.

China's Nuclear Policy

Since its first nuclear explosion in 1964, China has maintained a nuclear policy that features a minimum deterrent and a no-first use pledge, both aimed at avoiding a costly nuclear arms race.¹ China has repeatedly stated that it is pursuing a "self-defensive" nuclear strategy. As its 2006 White Paper on Defense states, the fundamental goal of China's nuclear strategy is "to deter other countries from using or threatening to use nuclear weapons against China. China remains firmly committed to the policy of no first use of nuclear weapons at any time and under any circumstances."² The country upholds the principles of "counterattack in self-defense and limited development of nuclear weapons," and aims at building "a lean and effective nuclear force capable of meeting national security needs." Furthermore, the government insists that "China exercises great restraint in developing its nuclear force. It has never entered into and will never enter into a nuclear arms race with any other country."

China's official policy has always called for "the complete prohibition and thorough destruction of nuclear weapons," as stated in its recent Defense White Paper.³ For Beijing, the first and most

important step toward nuclear disarmament would be a global agreement on no-first-use of nuclear weapons. China holds that,

before the complete prohibition and thorough destruction of nuclear weapons, all nuclear-weapon states should abandon any nuclear deterrence policy based on first use of nuclear weapons, make an unequivocal commitment that under no circumstances will they use or threaten to use nuclear weapons against non-nuclear-weapon states or nuclear-weapon-free zones, and negotiate an international legal instrument in this regard. In the meantime, nuclear-weapon states should negotiate and conclude a treaty on no-first-use of nuclear weapons against each other.⁴

Many experts and scholars suspect China's no-first-use pledge is insincere or claim that it is just a declaratory policy. However, it should be noted that, if a country really pledges a meaningful no-first-use policy, in practice, its force posture, including size, configuration, and readiness, would be significantly different from that with a first-use option. For instance, a force posture dominated by a meaningful no-first-use doctrine should have a much smaller and simpler arsenal with a much lower alert status. China has maintained a much smaller and simpler nuclear arsenal than the other nuclear weapon states and has de-mated its warheads from its missiles. The Second Artillery conducts war planning and training under the assumption that China will absorb a first nuclear blow and use its nuclear forces only to retaliate. All these facts indicate that China's no-first-use pledge is true.⁵ The increased stockpiling of China's conventional missiles by the Second Artillery could further enhance the credibility of its no-first-use pledge.

This policy has been consistently embraced by top Chinese leaders, from Mao Zedong to the current paramount leader, Hu Jintao, who believes a small arsenal capable of counterattack should be enough to deter a nuclear strike. As Mao stated a few months after China's first nuclear test, "We don't wish to have too many atomic bombs ourselves. What would we do with so many? To have a few is just fine."⁶ Similarly, Deng Xiaoping once emphasized that China's small number of nuclear weapons "is only to show that we also have what you have. If you want to destroy us, you yourself have to suffer some retaliation as well."⁷

It should be noted that China's nuclear force posture is determined primarily by its strategy, not financial or technological constraints.⁸ China's economic and technological development since the 1980s indicates that it could expand its nuclear force if it determined this to be in its strategic interest. Yet, China still has a very limited nuclear force and there is no evidence that it plans on changing it in the near future.

Before "the complete prohibition and thorough destruction of nuclear weapons," China will continue to modernize its nuclear force posture to maintain an "effective nuclear deterrent." However, the nuclear force will be kept at the minimum level Beijing feels is required to deter a nuclear attack. The following equation indicates the relationship between the "effectiveness" of China's nuclear force and the level of armament the government says it requires for a "minimum deterrent":

$$N_{\text{effectiveness}} = N_{\text{minimum level}} / [(\text{survivability from a first strike}) \times (\text{penetrability of a missile defense})]$$

$N_{\text{effectiveness}}$ represents an "effective nuclear force" to meet China's minimum requirement under different circumstance. The $N_{\text{minimum level}}$ is the minimum nuclear force that will reach the target after surviving a first nuclear strike and penetrating a missile defense system. It would be

relatively kept constant. Thus, the specific number of warheads required for an effective nuclear force ($N_{\text{effectiveness}}$) is dynamic and changeable, relying on a number of factors including survivability after the first strike and the penetration rate through an enemy's missile defense system (if deployed). The minimum nuclear force ($N_{\text{minimum level}}$) itself, however, is constant and does not need to change.

China's officials have never declared the specific number of weapons needed for its minimum nuclear force (i.e. the $N_{\text{minimum level}}$). Mao Zedong stated, "In any cases, we won't build more atomic bombs and missiles than others." He also said that "a few atomic bombs are enough (for China). Six are enough."⁹ While six warheads is likely not be the specific number in the mind of Chinese leaders, a minimum nuclear force with approximately ten warheads reaching a target country may be considered enough to inflict unacceptable damages. A Federation of American Scientists and Natural Resources Defense Council study,¹⁰ found that the average number of fatalities per assumed attacking weapon (e.g. the DF-5A intercontinental ballistic missile with a four- to five-megaton warhead) is about 800,000, if the warheads are detonated as airbursts; the average number of casualties per weapon would be about two million. Even a counterattack featuring 20 DF-31A intercontinental ballistic missiles, which carry a lower-yield warhead than the DF-5A, would result in some 12 million casualties in 20 US cities, including 3 million to 6 million fatalities. It is probable that Chinese officials would consider 10 warheads that can explode over an enemy's major cities enough to "deter" a nuclear first-strike.

The Intentions of Chinese Nuclear Modernization

The Chinese government insists that China continues to modernize its nuclear force only in order to maintain a reliable second-strike retaliatory capability. Chinese president Hu Jintao has emphasized that China's modernization programmes are designed to ensure that the "nuclear deterrent" is "safe, reliable, and effective" under "any" circumstance. Similarly, many Chinese officials and nuclear weapon experts argue that China's nuclear modernization programme is to be conducted under the guidance of China's nuclear policy. As Professor Hu Side, the former president of Chinese Academy of Engineering Physics (the Chinese Los Alamos) emphasized, "China's nuclear modernization [is conducted] under the guideline of China's nuclear policy, maintaining the principle of counterattack in self-defense and avoiding [an] arms race." He further emphasized that, the main features of China's nuclear modernization programme include the beliefs that it is impossible and unnecessary to accomplish China's nuclear modernization "requirements" through a simple increase of the number of nuclear weapons; that modernization will provide assurance of safety of its nuclear arsenal; that investment in modernization will be limited at very low level; and that modernization will be conducted under the Comprehensive Test Ban Treaty (CTBT) regime.¹¹

Under China's no-first-use doctrine and the principle of maintaining a "lean and effective" (*jinggan youxiao*) nuclear force, China initiated a nuclear modernization program in the 1980s, aiming to increase the survivability, reliability, safety, and penetrating ability of its small nuclear arsenal and, thereby, to maintain a limited but effective second-strike nuclear force to deter a nuclear attack. Unlike the United States' focus on counterforce targeting policy, which needs a large arsenal to eliminate the adversary's nuclear force, China has a retaliatory countervalue posture for which China believes a small force is enough. In 1978, Deng Xiaoping provided the

guidance for the future development of China's nuclear force. He emphasized that China's strategic weapons "should be updated (*gengxin*) and the guideline [for their development] is few but effective (*shao er jing*). Few means numbers and effectiveness should increase with each generation."¹² The *gengxin* (upgrade) means here mainly replacing the older ones by new, "better" ones. Mao Zedong once also remarked that one should "have a little bit (of nuclear weapon), keep (the weapons) a little bit, make (the weapons) a little bit better" (*you yidian, shao yidian, hao yidian*).¹³ This "yidian" (a little bit) policy has been kept by several generations of Chinese leaders.

To have a small arsenal capable of counterattack, China's nuclear modernization has been focusing on the quality over the quantity of its nuclear arsenal during the past three decades. Specifically, China's nuclear modernization has sought to increase the survivability of its nuclear force by replacing older, liquid-fueled missiles with solid-fueled, mobile ballistic missiles and constructing deep underground tunnels that can act as missile bases.

In practice, China's "underground great wall" project provides another evidence for Beijing's minimum deterrence posture.¹⁴ Given the fact that China has no reliable operational air-based (bomber) or sea-based (SSBN) nuclear forces, the main focus of the Second Artillery since 1980, when it initiated China's nuclear modernization, has been how to ensure that its limited land-based strategic missiles can survive a first nuclear strike. With the development of Soviet/Russian and U.S. satellite surveillance capabilities and the increased accuracy of their nuclear weapons, China became concerned about the vulnerability of its land-based missiles, in particular its silo-based DF-5s and its cave-based DF-4 missiles, which need to be pulled out and launched from pre-prepared above-ground launch sites. These liquid-fueled missiles usually take up to two hours of preparation for launch. In addition, unlike the US and Russia, China does not have a reliable early warning system and its missiles are not in a launch-on-warning posture.

Under its announced no-first-use doctrine, the Chinese government has stated it would launch a retaliatory nuclear attack only after it survived a first nuclear strike. To assure the survival of an adequate number of weapons for retaliation, China has just two primary options: One is to build more warheads and launchers, but to survive a US preemptive attack that could involve as many as a thousand warheads and extremely accurate targeting, so China would need a huge nuclear arsenal. In practice, China has chosen the second option, moving its small land-based missile force underground.

It is reported that the engineering unit of the Second Artillery began to construct the underground Great Wall in 1985 and finished it after a ten year effort. Thus, by the mid-1990s, China had a true, reliable second-strike capability. These tunnels are hundreds of meters underground, in deep mountainous areas, and are difficult to detect from space. They can withstand nuclear and conventional attacks. The missiles, personnel, and related equipment can be transported by rails and trucks within the network of tunnels to various locations. All the activities for launch preparation can be done in the tunnels without detection. Some of the tunnels could also be used for logistical support or as command and control facilities. While the road-mobile solid-fueled missiles (e.g. DF-31 and DF -31A) deployed around 2006 have significantly enhanced survivability relative to fix-based and silo-based missiles, the US is pursuing the capability of

long-range precise conventional strike, and its space monitoring capacity to track mobile targets could make Chinese road-mobile missiles vulnerable again.

China's underground Great Wall is converting its land-based ballistic missiles into "tunnel-launched ballistic missiles". Thus, China has moved its land-base missiles to underground-basing to ensure a limited and reliable second-strike nuclear force after absorbing a first nuclear strike.



Fig.1: A photo of China's Underground Great Wall. The Chinese text on top of the photo reads: "CCTV-7 Military Records—Traveling together with the Motherland, the sharp sword toward heaven, PLA Second Artillery." Text at bottom reads: "the modern underground great wall"

Chinese Nuclear Force

Based on China's minimum deterrence policy—it "will limit its nuclear capabilities to the minimum level required for national security,"¹⁵ and Western government and non-government estimates,¹⁶ this author estimates China has a total inventory of approximately 170 nuclear warheads including approximately 110 operationally deployed nuclear missiles (mainly land-based nuclear ballistic missiles, of which approximately 35 can reach the continental United States), approximately 60 warheads stored for its submarine-launched ballistic missiles (SLBMs), and bombers (see table 1).¹⁷ This estimate is significantly lower than previous appraisals. China could well have the smallest arsenal of nuclear weapons among the five original nuclear weapons states.

While some Western publications often expect an increase of China's nuclear arsenal, there is no evidence to show that China has a rationale to significantly increase it. It is true that since the Taiwan strait crisis of 1996, the Second Artillery Corps has modernized and significantly increased the size of its arsenal of conventionally armed missiles (in particular the medium-

range, mobile, DF-21C missiles). There has been, however, no obvious corresponding increase in nuclear warheads.¹⁸

It can be expected that as China deploys more mobile ICBMs (e.g. DF-31A and DF -31), more old ones (e.g. DF-5A, DF-4) would be phased out. Meanwhile, China develops and deploys the second generation Jin-class SSBN (Type-094) and the new JL-2 SLBMs to replace its old Xia-class SSBN (Type-092) and JL-1 SLBMs. Based on the 2011 DoD report and the FAS report, China built a maximum of three Jin-class SSBNs by 2010. US naval intelligence projected in 2007 that China might build five Jin-class SSBNs.¹⁹ However, China would have no rationale to have more than three new SSBNs under current security circumstance. It can be expected that, after its three-decade modernization programme, with a focus on increasing the survivability of its land-based missiles, China will speed up the modernization of its sea-based strategic force to secure a second-strike force in the coming years.

Table 1: China’s Nuclear Force, 2011

Type	NATO Designation	Year Deployed	Range (kilometers)	Yield (kilotons)	Number of warheads
Land-based ballistic missiles					
DF-5A	CSS-4	1990s	13,000+	4,000-5,000	<20
DF-31A	CSS-10 Mod 2	2007	11,200+	200-300?	15
DF-4	CSS-3	1980	5,400+	3,300	10
DF-31	CSS-10 Mod 1	2006	7,200+	200-300?	10
DF-3 A	CSS-2	1971	3,000+	3,300	5
DF-21	CSS-5 Mods 1/2	1991	1,750+	200-300	50
<i>Subtotal:</i>					<i>110</i>
Submarine-Launched ballistic missiles					
JL-1	CSS-NX-3	1986	1,000+	200-300	(n.a)
JL-2	CSS-NX-4	?	7,400	200-300 ?	(36)
Bombers					
H-6	B-6	1965	3,100	---	20
Total					166

Source: The US DoD annual report on Military Power of the People’s Republic of China ; the annual *Military Balance* reports of the International Institute of Strategic Studies; and FAS/NRDC “Nuclear Notebook” section on China’s nuclear force in issues of *The Bulletin of the Atomic Scientists*.

In addition, China could have about 20 bombers in its arsenal. However, there is no rationale for China to expend its air-based force due to geopolitical considerations. China will likely maintain a small arsenal of bombers in the near future, which will be consistent with its principle of a pursuit of “a small but inclusive” (*xiao er quan*) force. Zhou Enlai emphasized in 1970 that China “must build a certain number of [nuclear weapons] with a certain quality and a certain variety.”²⁰ “A certain variety” of weapons means here to support a strategic nuclear triad, which Chinese leaders view as a symbol of China’s great-power status. Thus, China’s small arsenal of strategic bombers mainly has symbolic meaning and a minor “deterrent” effect.

While there have been rumors for many years that China has tactical weapons,²¹ Chinese nuclear experts argue that the deployment of tactical nuclear weapons is not consistent with China's no-first-use policy. From the beginning of China's nuclear age, Mao Zedong and the following generation of leaders have viewed nuclear weapons as strategic tools to deter nuclear threats or the use of nuclear weapons against the country, not as war-fighting tools. In practice, while it should not be difficult for China to have tactical weapons, it does not.²²

Recently Western governments and media outlets have expressed growing concerns about Chinese nuclear buildup, in particular, Beijing pursuing nuclear parity with the US and Russia, when both reduce their arsenals under the NEW START. Such voices were amplified when Georgetown University professor Phillip Karber released a study indicating that a 3,000-mile-long network of underground tunnels—sometimes called China's "underground great wall"—could host as many as 3,000 nuclear weapons.²³

In practice, China's nuclear force and modernization would be determined mainly by its nuclear policy that features a minimum deterrence and a no-first use pledge. It would also be constrained technically by its inventory of fissile materials. China currently has a military inventory of about 1.8 tons of plutonium and 16 tons of weapon-grade HEU. The country stopped its production of highly enriched uranium in 1987 and plutonium production by 1990. All of its military HEU and plutonium production facilities have been closed or converted to other uses, or are being decommissioned.²⁴

China's current military inventory of fissile materials would not support an arsenal of more than 1000 warheads.²⁵ In practice, part of the fissile material stocks would be used as a reserve for future needs. The other four of the P5 states devote half or less of their fissile materials to their weapons. If this were the case for China, the upper-boundary on its arsenal would be around 500 warheads.

Drivers and Trends

China's nuclear modernization for the last three decades has focused on increasing the survivability of its strategic land-based missiles by measures such as developing new solid-fueled and mobile missiles and building underground tunnels to shield those missiles. These measures are mainly responses to the advance of military capabilities of other countries, particularly the United States. Those advances include improvements in space surveillance systems that can locate and target Chinese missiles, the increased accuracy of long-range nuclear missiles that could attack Chinese forces, and the development of long-range conventional weapons that can be delivered with high accuracy. As Professor Hu Side emphasized, "the sole purpose for Chinese maintaining a limited nuclear counterattack force is to deter a potential nuclear strike. However, the development of US missile defense and the long-rang strike capability with high accuracy to target mobile missiles is in practice to decrease the effectiveness of Chinese nuclear deterrence. Thus, it surely leads to Chinese attention."²⁶

Without concerns about US missile defense, China's modernization programme would likely continue to focus on quality over quantity. However, US missile defense plans will be a major driver for China's nuclear weapon modernization. Some Chinese officials are concerned that

even a limited missile defense system could neutralize China's smaller nuclear force. In its recent white paper, Beijing maintained that "the global missile defense program will be detrimental to international strategic balance and stability, will undermine international and regional security, and will have a negative impact on the process of nuclear disarmament." China further states that, "no state should deploy overseas missile defense systems that have strategic missile defense capabilities or potential, or engage in any such international collaboration."²⁷

China's current arsenal of longer-range ICBMs (about 35 ICBMs) could meet its "minimum nuclear deterrent" facing the current US deployed missile defense system. However, China's plans could change significantly if the United States were to deploy a more comprehensive or more operationally successful missile defense system. This might include building more warheads that can overcome missile defenses, in addition to developing decoys and missile defense countermeasures.²⁸ However, any expansion of the Chinese nuclear arsenal would still be constrained by its inventory of fissile materials.

Washington's strategic nuclear intentions toward Beijing could also influence China's nuclear modernization plans. In particular, China worries that the United States could use nuclear weapons against China in a potential Taiwan conflict. The Bush administration's 2002 Nuclear Posture Review specifically mentions the possibility of using nuclear weapons during a conflict in the Taiwan Strait and the possible use of tactical nuclear weapons.²⁹ From 1980 to 1995, China's nuclear modernization programme was conducted at a very modest pace because Beijing saw less of a nuclear threat from Washington. However, since the Taiwan crisis in mid-1990s, China has become more concerned about US threats. These days, many Chinese officials worry about the United States' strategic intention to shift the focus of its military strategy to the Pacific and East Asian region. The Pentagon's new strategic defense guidance states, "The U.S. military will invest as required to ensure its ability to operate effectively in anti-access and area denial (A2/AD) environments."³⁰ China and Iran are listed as the major targets.

To discourage Beijing from increasing the size of its nuclear arsenal, Washington should accept certain measures, including mutual deterrence with Beijing, limiting its missile defenses so they do not threaten the potential effectiveness of China's small arsenal, a U.S. pledge to adopt a bilateral no-first use policy toward China--particularly one in which both capitals agree to rule out the use of nuclear weapons during a Taiwan conflict, and excluding the possibility of conventional strategic strike against the Chinese nuclear force and other nuclear facilities. Meanwhile, if negotiations between Washington and Moscow proceed and those countries move forward to deeper cuts in their nuclear forces, China will likely have to reassure both capitals that it will cap its arsenal at a low level, perhaps 200 warheads.

To maintain an "effective nuclear deterrent," China will continue to modernize its nuclear force posture accordingly, along with other countries' military developments and the international security environment. However, China's nuclear modernization program will likely continue to be guided by its nuclear policy, which is characterized by a no-first-use pledge and a commitment to "minimum nuclear deterrence". The nuclear force will likely be kept at the minimum level Beijing feels is required to deter a nuclear attack.

Notes and References

-
- ¹ “China’s National Defense in 2010,” Information Office of the State Council of the People’s Republic of China, March 2011, www.gov.cn/english/official/2011-03/31/content_1835499.htm.
- ² Information Office of the State Council of the People’s Republic of China, “China’s National Defense in 2006,” 29 December 2006, <http://www.fas.org/nuke/guide/china/doctrine/wp2006.html>.
- ³ “China’s National Defense in 2010,” *op. cit.*
- ⁴ “China’s National Defense in 2010,” *op. cit.*
- ⁵ Hui Zhang, “China’s Perspective on a Nuclear –Free World,” *The Washington Quarterly*, 32 (2010) 2: pp.139–155, http://www.twq.com/10april/docs/10apr_Zhang.pdf.
- ⁶ *Mao Zedong’s Collected Works*, Vol. 8, Beijing: Xinhua Publisher, 1999, p. 407.
- ⁷ *Selection of Deng Xiaoping’s Discussions on Army Building in the New Period*, Beijing: Bayi Publisher, 1993, pp. 44–45.
- ⁸ Hu Side, “The Road toward China’s Nuclear Weapons,” *Global Science (Chinese version of Scientific American)*, No.12, 2007 (in Chinese).
- ⁹ John Lewis and Xue Litai, *China’s Strategic Seapower: The Politics of Force Modernization in the Nuclear Age*, Stanford University Press, 1994, p. 232.
- ¹⁰ Hans Kristensen, Robert Norris, and Matthew Mckinzie, *Chinese Nuclear Forces and U.S. Nuclear War Planning*, Federation of American Scientists and National Resources Defense Council, November 2006, <http://www.fas.org/nuke/guide/china/Book2006.pdf>.
- ¹¹ Hu Side, “The Road toward China’s Nuclear Weapons,” *op.cit.*
- ¹² *Selection of Deng Xiaoping’s Discussions on Army Building in the New Period*, *op.cit.* p. 99.
- ¹³ Lewis and Xue , *China’s Strategic Seapower: The Politics of Force Modernization in the Nuclear Age*, *op.cit.* , p. 232.
- ¹⁴ Hui Zhang, The Defensive Nature of China’s ‘Underground Great Wall.’ *Bulletin of Atomic Scientists*, January 16, 2012. Available at: <http://www.thebulletin.org/web-edition/features/the-defensive-nature-of-chinas-underground-great-wall>.
- ¹⁵ “China’s National Defense in 2010,” *op. cit.*
- ¹⁶ See, e.g. “Report to Congress: Military and Security Developments Involving the People’s Republic of China 2011,” Office of the Secretary of Defense, 2011, http://www.defense.gov/pubs/pdfs/2011_cmpr_final.pdf, hereafter referred to as the “DoD report”; annual *Military Balance* reports of the International Institute of Strategic Studies, referred to as the IISS report; and Hans Kristensen and Robert Norris, “Chinese nuclear force, 2011,” *Bulletin of the Atomic Scientist*, 67(6), 2011, referred to as the FAS report.
- ¹⁷ More details could be found in Hui Zhang, “Nuclear Modernization in China,” in *Assuring destruction forever: nuclear weapon modernization around the world*, edited by Ray Acheson , published by Reaching Critical Will, a project of the Women’s International League for Peace and Freedom, March 2012. Available at: <http://reachingcriticalwill.org/images/documents/Publications/modernization/assuring-destruction-forever.pdf>
- ¹⁸ Mark A. Stokes, “China’s Nuclear Warhead Storage and Handling System,” Report of Project 2049 Institute, 12 March 2010, http://project2049.net/documents/chinas_nuclear_warhead_storage_and_handling_system.pdf.
- ¹⁹ See, e.g. Hans Kristensen, “Pentagon China Report Ignores Five SSBNs Projection,” FAS Strategic Security Blog, 25 May 2007, http://www.fas.org/blog/ssp/2007/05/pentagon_china_report_ignores_.php.
- ²⁰ Zhou Enlai, *Zhou Enlai wenhua wenxuan* [Zhou Enlai’s selected works on cultural affairs], Beijing: Zhongyang wenxian chubanshe, 1998, p. 661.
- ²¹ For instance, Robert S. Norris and Hans M. Kristensen, “Chinese Nuclear Forces, 2008,” *Bulletin of the Atomic Scientists*, July/August 2008, Vol.64, No.3, pp. 42-45.

²² Communications with Chinese nuclear expert, Beijing, December 2011.

²³ Phillip A. Karber, *Strategic Implications of China's Underground Great Wall*, Georgetown University, 26 September 2011, http://www.fas.org/nuke/guide/china/Karber_UndergroundFacilities-Full_2011_reduced.pdf; William Wan, "Georgetown students shed light on China's tunnel system for nuclear weapons," *Washington Post*, 29 November 2011, http://www.washingtonpost.com/world/national-security/georgetown-students-shed-light-on-chinas-tunnel-system-for-nuclear-weapons/2011/11/16/gIQA6AmKAO_story.html; Bret Stephens, "How Many Nukes Does China Have? Plumbing the secret Underground Great Wall," *Wall Street Journal*, 24 October 2011. <http://online.wsj.com/article/SB10001424052970204346104576639502894496030.html>.

²⁴ See details in: Hui Zhang, "Chapter 7: China," *Global Fissile Material Report 2010: Balancing the Books: Production and Stocks*, Princeton, NJ: Princeton University, 2011, <http://belfercenter.ksg.harvard.edu/files/Hui-Zhang-China-Chapter-Global-Fissile-Materials-Report.pdf>; Hui Zhang, "China's HEU and Plutonium Production and Stocks," *Science & Global Security* 19, no. 1, January–April 2011, pp. 68–89, <http://belfercenter.ksg.harvard.edu/files/huizhangSGS2011.pdf>.

²⁵ For a compact thermonuclear warhead, assuming the average numbers for US and Russian warheads, about 4 kg of plutonium in the primary and about 20 kg HEU in the secondary, then 1.8 tons of plutonium, could produce about 450 warheads, which could also use about nine tons of HEU in their secondaries. The remaining seven tons of HEU might produce about 230 more warheads (assuming 10 kg of HEU for the primary and 20 kg for the secondary). Thus, a stockpile of 1.8 tons of plutonium and 16 tons of HEU could support about 680 thermonuclear warheads. Thus, even using all China's fissile material inventory would not support an arsenal of more than 1000 warheads.

²⁶ Hu Side, "The Road toward China's Nuclear Weapons," *op.cit.*

²⁷ "China's National Defense in 2010," *op. cit.*

²⁸ Hui Zhang, "Action/Reaction: U.S. Space Weaponization and China," *Arms Control Today*, December 2005.

²⁹ "Nuclear Posture Review [Excerpts]," 8 January 2002, p. 16, <http://www.globalsecurity.org/wmd/library/policy/dod/npr.htm>.

³⁰ *Sustaining US Global Leadership: Priorities for 21st Century Defense*, Department of Defense, January 2012. Available at: http://www.defense.gov/news/Defense_Strategic_Guidance.pdf.